ABSTRACTS

20th Annual Meeting of ESMAC

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Tursday 15.09.2011

09:00-10:00 UPPER EXTREMITY I

O01

3D KINEMATIC ANALYSIS OF UPPER EXTREMITY FUNCTION IN CHILDREN

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Introduction: A new evaluation method of upper extremity function even in children is presented. It is a three dimensional optoelectronical system providing accurate and reproducible 3D kinematic data by tracking movements. It is supposed to overcome the deficiencies of subjective investigations

Patients/ Material and methods: A 3-dimensional optoelectronic camera system with passive markers was used to capture the possible active range of motion. 27 markers coated with a retro reflective tape were applied over anatomical landmarks on both upper limbs. These markers were recorded simultaneous by 6 cameras. A 3-dimensional reconstruction of the position of the marker was done by special designed software. Joint centres and joint movements were calculated by using the Expert Vision and ORTHOTRAK software (Motion Analysis Corporation). Healthy probands including children were investigated to obtain normal values. Patients suffering from congenital forearm deformities (Madelung`s deformity, radioulnar synostosis) and from waiter`s tip posture due to obstetrical brachial plexus lesion were investigated before and after surgical correction.

Results: Investigation of the healthy probands allowed not only to establish normal values for ROM of shoulder, elbow and wrist but also to develop an easy to read graphical presentation of the results. Pre and post operative evaluation of the patients did produce static data representing the position of the parts of the upper extremity in relation with their neighbouring parts and the healthy extremity respectively. Dynamic data could show the influence of procedures to the kinematics of the whole upper extremity.

Discussion & Conclusion: Because of the more complex nature of upper limb kinematics the transfer of the system from lower to upper extremity involves still unsolved problems. Simplifications of the biomechanical model and limitations in accuracy are detailed and discussed. However, the method enabled analysis of upper extremity motion concerning shoulder-, upper- and forearm and wrist function. Measured angles were reliable and reproducible. The collected data allowed an objective analysis of the results of surgical procedures and will allow further follow up, which is especially important in growing children. Furthermore the derived data can be used to plan surgical interventions, eg the amount of required rotation for an osteotomy.

References: no references

Disclosure: No significant relationships.

O02

ESTIMATION OF REQUIREMENTS FOR AN UPPER EXTREMITY SUPPORT USING INVERSE DYNAMICS AND MOTION ANALYSIS

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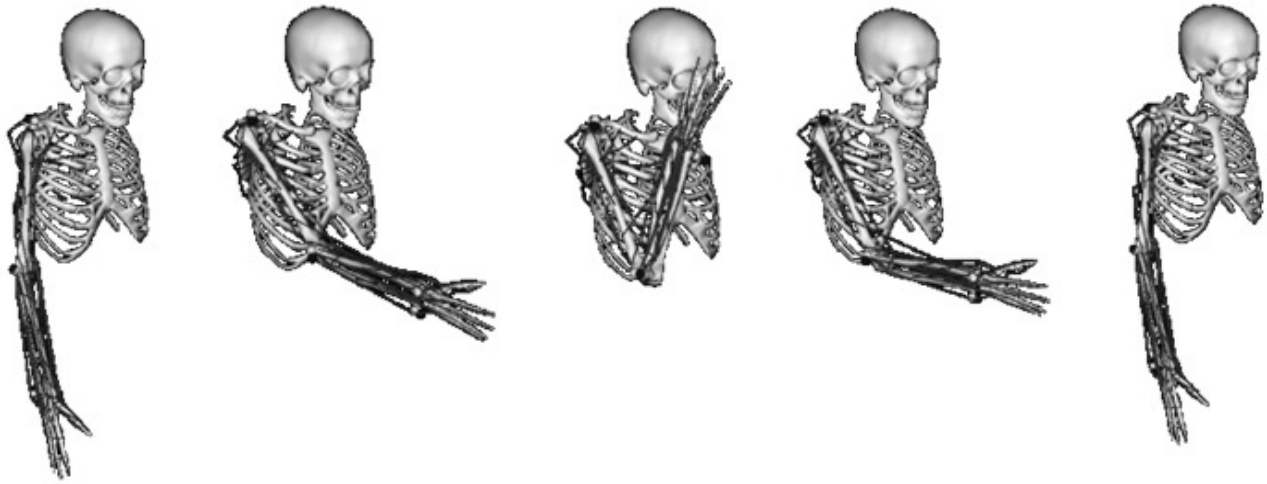
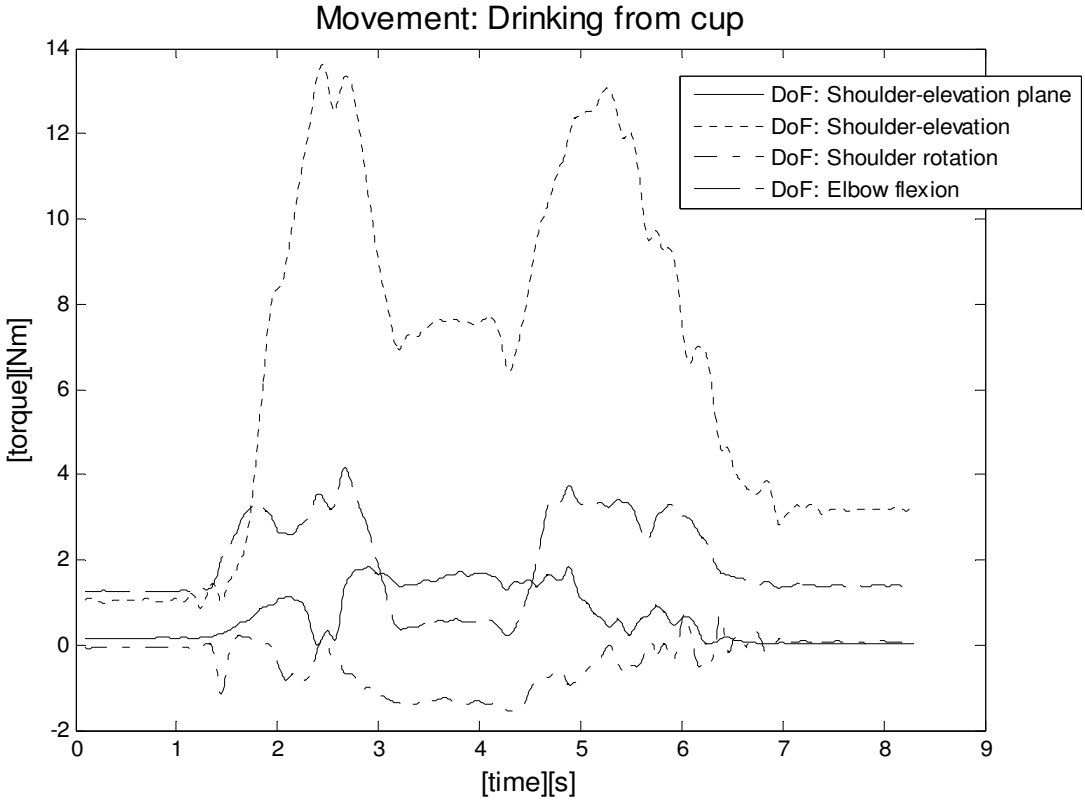
Introduction: The European project MUNDUS aims at developing an assistive framework for recovering direct interaction capability of severely motor impaired people based on arm reaching and hand function. MUNDUS actuators modularly combine a lightweight exoskeleton (exo) with weight compensation, a wearable neuroprosthesis for arm motion and a lightweight mechanism to assist grasping. Within this framework the present work defines the requirements for the brace. On the one hand the useful range of motion could be defined and on the other we could estimate the external torques at different degrees of freedom.

Patients/ Material and methods: In this study the kinematics and kinetics of a group of 16 unimpaired subjects (8 female and 8 male) were analysed during performing four tasks associated with daily living and three tasks to estimate the overall motion (Table 1). The kinematic data were collected using the motion analysis system LUKOtronic (Lutz Mechatronic Technology, Austria), custom written software in Matlab (The MathWorks, Inc., USA) and the simulation software Open Sim (1). The dynamic analysis was performed using a biomechanical model of the upper extremity (2) in Open Sim. During the simulation a vertical load of 5N was attached to the hand. All activities were performed in a seated position within the working space of a wheel chair user. The locations of five markers were chosen as proposed from Anglin (3) together with the model from Rab (4).

1-Elevation (elevation plane 0°)	2-Elevation (elevation plane 90°)
3-Elbow flexion	4-Drinking
5-Touching own body	6-Combing
7-Changing the posture of the other arm	





Results: A data set with upper extremity joint angles and torques has been obtained. Large moments were determined in the “drinking task” (Figs. 2/3). The range of motion of the first three tasks helped to estimate the required joint angle range for each degree of freedom of the exo. The tasks associated with daily living showed the characteristics of the ranges of motion. In the main working plane large torques in the shoulder and elbow joint were found. The maximum moment in the axial rotation of the humerus was also found in the main working plane.

Discussion & Conclusion: This study shows how motion analysis and a simulation tool can be usefully combined to estimate requirements for upper extremity support. Furthermore, activities of the arm have been analysed and so data on the range of motion and the external joint torques are provided.

Acknowledgment: This work was supported by the European Project MUNDUS, funded by the call EC FP7 ICT 2009-4 in the topic Accessible and Assistive ICT.

References: 1. Delp SL et al. 2007, IEEE Trans Biomed Eng, 54, 11, 1940-1950. 2. Holzbaur K et al. 2005, Annals of Biomedical Engineering, Vol. 33, No. 6, June, 829-840. 3. Anglin C. And Wyss U. P. 2000, Proc Instn Mech Engrs, Vol 214-Part H, 541-555 4. Rab Georg et al. 2002, Gait and Posture 15, 113-119

Disclosure: No significant relationships.

O03

UPPER EXTREMITY MOTION IN ADULTS WITH CEREBRAL PALSY

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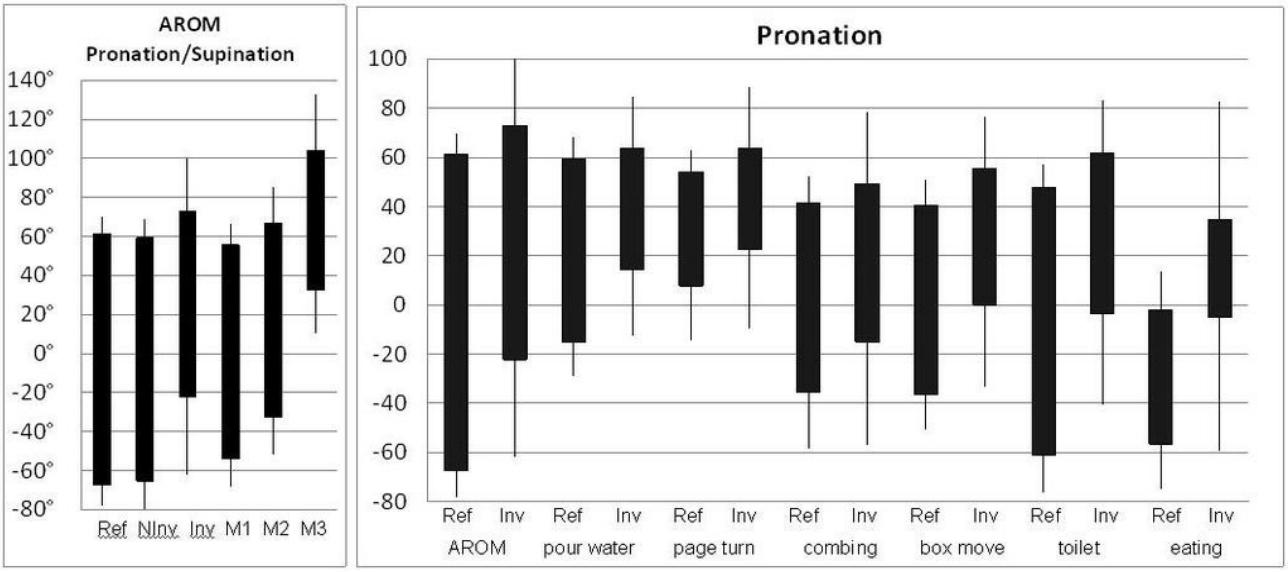
Introduction: There is increasing interest in monitoring the upper extremity in patients with CP. Unlike in the lower extremity, the upper extremity enables to perform diverse and complex functions in daily living. Investigations so far were typically limited to the performance of children where functional impairment always has to be assessed according to age and maturity level. Here the functional deficits are investigated in adults.

Patients/ Material and methods: 15 adult patients with hemiplegic CP (28.2±10.9yrs) and 15 healthy controls (29.7±10.0yrs) underwent instrumented 3D movement analysis with a 12-camera Vicon-System monitoring 10 everyday tasks in a seated position. Markers were applied to measure trunk position and joint motion of shoulder, elbow and forearm according to the model described by Rettig et al. [1]. Activity related range of motion (AROM) was analysed as described by Kasten et al. [2]. Further, the functional MACS score [3] was applied.

Results: Of the 15 patients, 5 were classified MACS1 (little), 6 as MACS2 (moderate), and 4 as MACS3 (severe involvement). AROMs of most of the joint angles of the involved side were reduced or shifted compared to the sound side and to normal reference, respectively. Compensation movements were found in the trunk and showed prominent deviations from reference in the AROM of forearm pro-/supination which correlated well with MACS levels.



Discussion & Conclusion: In clinical tests typically only qualitative changes in upper extremity performance can be determined. In situations where subtle functional changes may be questioned and which are out of scope for these tests, this quantitative method may be sensitive for functional improvements as it is accurate to better then 5° in most joint angles. The objective and quantitative measurement of upper extremity function correlates well with established clinical measures (MACS) and may be suitable to also monitor subtle changes due to conservative treatments such as forced use. Analysis of EMG data which had been measured in all subjects may further elucidate causes of impairment and distinguish structural malfunction from spasticity effects.

References: [1] Rettig O et al (2009): Gait Posture 30:469–476 [2] Kasten P et al (2009): J Orthop Sci 14:307–312 [3] Eliasson AC et al (2006): Dev Med Child Neur 48: 549–554

Disclosure: No significant relationships.

O04

NEW METHOD FOR DETECTION OF SHOULDER MOVEMENT DURING DAILY ACTIVITY

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Introduction: Wearable inertial system was proposed to provide an objective evaluation of the shoulder function, based on the detection and characterization of arm movement in daily condition [1]. However, current methods do not exclude concomitant movements of the trunk that can be faultily detected as arm movement. This study proposed a new approach aiming at providing a robust detection and classification of arm movement (i.e. abduction-adduction, flexion-extension or axial rotation) during daily activity.

Patients/ Material and methods: 3D gyroscopes were attached to each humerus and on the sternum of 10 participants (6 controls, 4 patients suffering from a rotator cuff tear). Subjects were asked to perform activities during which the thorax was free to move (displace objects) as well as imposed arm movements: abductions, flexions, extensions and rotations. Functional calibration [2] was performed to express the angular velocities in the anatomical frame of humerus and thorax.First, periods where the norm of humerus angular velocity was larger than an adaptive threshold [1] were extracted. If the norm of humerus angular velocity was larger than the one of thorax, the period was detected as arm movement. Otherwise, if the two norms were similar along the period, the period was classified as a motion induced by the thorax and no arm movement was detected. Second, the mean direction of the angular velocity vector of the humerus over the period was computed. The arm movement was classified as abduction-adduction, flexion-extension or axial rotation, if the largest component of the direction vector was frontal, lateral or vertical, respectively.The proposed method (method I) was compared to the current method [1] (method II) by calculating the sensitivity and specificity for the detection and classification of movement.

Results: The sensitivity and specificity of both methods for the detection and the classification of movement are displayed in Table 1.

	Movement detection (N = 1436)		Movement classification (N = 561)					
			Abductions		*Flexions*		*Rotations*	
	Sensi.	Speci.	Sensi.	Speci.	Sensi.	Speci.	Sensi.	Speci.
method I	96.1 %	97.8 %	88.5 %	99.8 %	90.9 %	92.3 %	96.5 %	94.6 %
method II	96.3 %	76.0 %	82.2 %	99.5 %	91.0 %	89.4 %	86.4 %	93.3 %

Table 1: Sensitivity and specificity for the detection and the classification of movement using methods I and II

Discussion & Conclusion: The proposed method detected and classified robustly the movements of the shoulder during functional activities by excluding the false detections induced by trunk motion. The specificity of movement detection was considerably increased from 76% to 98%. Moreover, the sensitivity was increased for movement classification, particularly for rotations. Based on data recorded by wearable gyroscopes, the methodology improves the reliability of shoulder monitoring, which can be applied to assess the everyday mobility of the arm in case of shoulder pathology and treatment.

References: [1] Coley B et al (2009) Med Biol Eng Comput 47: 467-74 [2] de Vries WH et al (2010) J Biomech 43: 1983-8

Disclosure: No significant relationships.

O05

DEVELOPMENT AND RELIABILITY OF THE OXFORD TRUNK MODEL

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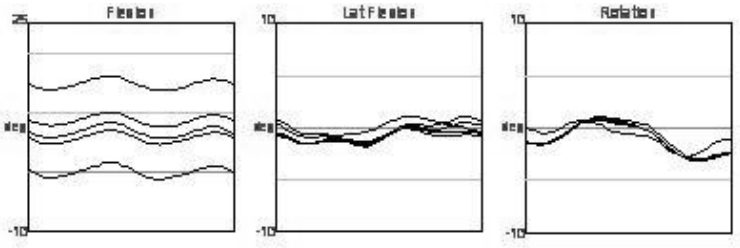
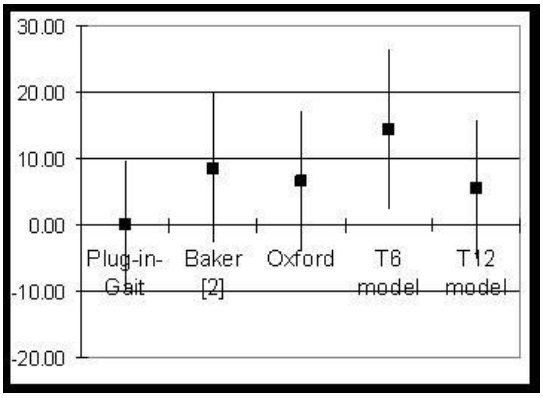
Introduction: The Oxford Trunk Model (OTM) is a single segment kinematic trunk model which was developed to provide a clinically practical and useful tool for the measurement of trunk motion during gait. Previous work has described its initial development using 4 adults and 22 children [1]. This study compared the use of different trunk models and assessed the repeatability of the OTM.

Patients/ Material and methods: Data were collected using a 12 camera Vicon MX system (Vicon, Oxford, UK) from 74 typically-developing children aged 5 to 16 during level walking at self-selected speed. Trunk kinematics using 5 different models were calculated, including PlugIn Gait (Vicon, Oxford), Baker [2], OTM [1], and 2 variations on the OTM (T6 and T12 models). The inter-subject variability and patterns were compared using means and 95% confidence intervals. Repeatability of the OTM was assessed by collecting data from a single healthy adult during level walking over 12 sessions (6 clinicians each applying markers on 2 separate occasions). The mean trunk (OTM and T6 only model) and pelvic (Plug-in-Gait) angles in each plane were calculated. The distance between the spinal vertebrae markers in the static trial was measured to determine repeatability of marker placement.

Results: The repeatability data showed that the range of the means and the standard deviation (SD) of trunk kinematics (OTM) was similar to that of the pelvis, showing satisfactory comparison with the established Plug-in-Gait model. The T6 model also had similar range and SD. The distance between the markers showed some variation both intra- and inter-clinician. The 5 models had very similar mean values, 95% confidence intervals (CI) and pattern in the coronal and transverse planes. In the sagittal plane, the pattern of motion and 95% CI was similar across all 5 models. The mean trunk flexion differed between models, with the Plug-in-Gait model lower and the T6 model higher than the other 3.





Discussion & Conclusion: The OTM has similar repeatability compared to the well established pelvic kinematics from the Plug-in-Gait model, which indicates that it is a suitable tool for clinical gait analysis. This is despite some variation in the distances between the markers, which suggests that the model is robust to errors in marker placement and useful in clinical practice. The similarity of the different models in the transverse and coronal planes suggests that any of these models would be appropriate for clinical use. The inter-subject variation in the sagittal plane was much less pronounced between the different models than the original analysis had suggested, again showing similar performance of all models. The OTM has the advantage over the other models that the marker positions are more patient-friendly and also allow easier tracking. The OTM is therefore an appropriate model for use in clinical gait analysis for the measurement of trunk motion.

References: [1] Bates J et al. Proceedings of JEGM, Miami 2010, p509 [2] Baker R. 2006. from seminar at JEGM meeting, Amsterdam

Disclosure: No significant relationships.

CLINICAL OUTCOME I - 15.09.2011, 11:00-12:00

O06

THE KINEMATIC EFFECTS OF COMMON PERONEAL FUNCTIONAL ELECTRICAL STIMULATION (FES) IN CHRONIC STROKE (CVA) AND MULTIPLE SCLEROSIS (MS) USING A 3-D MODEL OF THE SHOE

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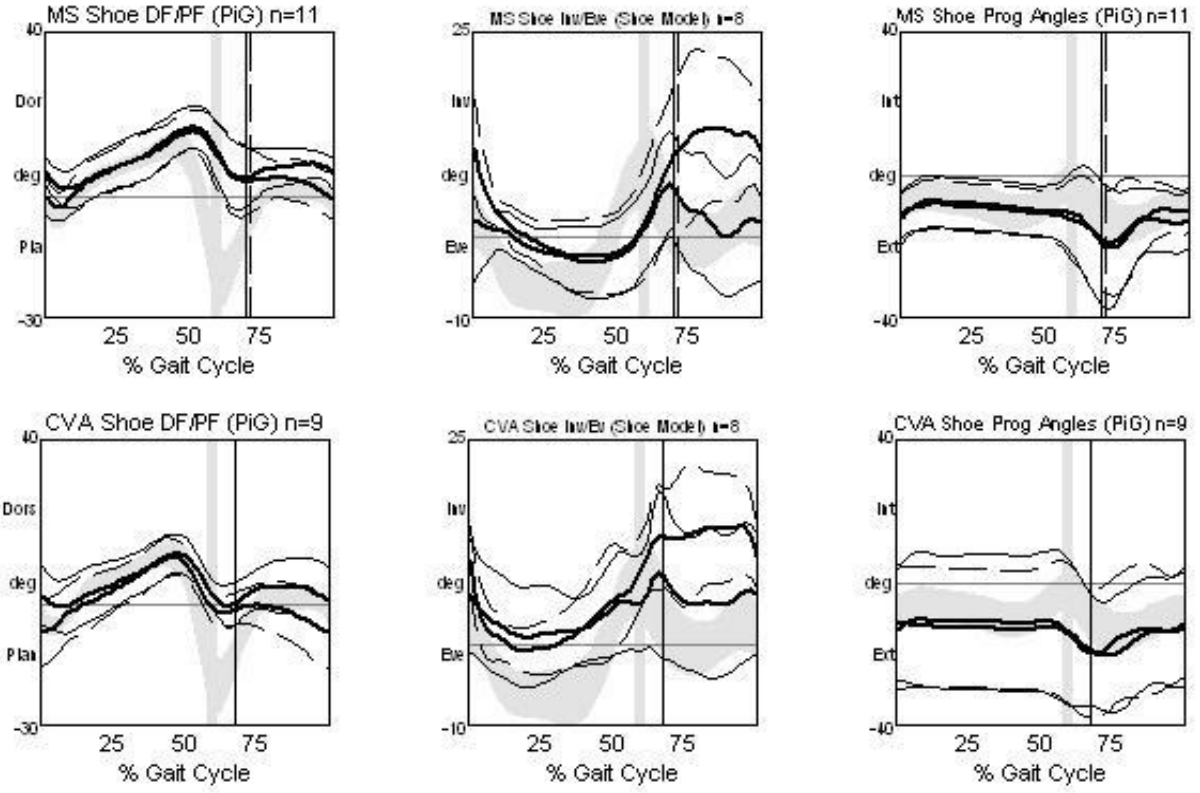
Introduction: Measurements of foot inversion/eversion during gait are of particular interest in people using common peroneal Functional Electrical Stimulation (FES). In addition to addressing excessive equinus in swing, FES systems are commonly prescribed to improve stability at initial contact and/or forefoot clearance in swing, in the presence of excess inversion. To date, the direct effects of FES on foot movement in 3-D have not been published, as available 3-D clinical foot models such as the Oxford Foot Model (Stebbins et al. 2006) require additional markers to be applied to the foot in an accurate manner, preventing their use when footwear is donned. The aim of this project was to characterise gait kinematics with and without FES in 3-D for existing FES users at Sheffield Teaching Hospitals (STH) gait laboratory, using an in-house developed 'shoe model'. In addition to the standard Vicon PlugIn Gait (PiG) marker set, this model required additional markers on the medial and lateral aspect of the distal first and fifth metatarsal heads respectively. It was preliminary validated through comparison of outputs from barefoot kinematic data processed with the Oxford Foot Model, from the normal database available at Sheffield Childrens Hospital (SCH) gait laboratory.

Patients/ Material and methods: Data with footwear was collected using 8 Vicon MXF40 cameras (Vicon Ltd, Oxford UK) capturing at 100Hz from existing unilateral FES users at STH (n=20, n=9 CVA, n=11 MS). The electrode sites and the pulse width were selected by the patient to reflect their usual response. Patients walked at self-selected normal speed, until two representative traverses were completed with both FES on and off (randomised order). For both MS and CVA groups, the non-parametric Wilcoxon test (level of significance $p \leq 0.05$) was calculated to investigate the null hypotheses of no difference with or without stimulation at the following events: DF/PF at initial contact and maximum DF in swing for all subjects; inversion/eversion at initial contact and inversion/eversion in mid-swing, for subjects with shoe model data.



Results: Median speed (25th-75th percentile) was calculated from 3D data: MS (n=11) = 0.60m/s (0.37-0.96) without FES, 0.63m/s (0.52-1.10) with FES; CVA (n=9) = 0.70m/s (0.41-0.80) without FES, 0.74m/s (0.63-0.90) with FES. At the events chosen, all differences were found to be statistically significant with the exception of coronal plane movements in the CVA population.

Discussion & Conclusion: Direct improvements in 3-D kinematics were found with FES applied, with increased dorsiflexion and reduced inversion during swing and at initial contact, therefore improving ground clearance and pre-positioning of the foot. Improvements in the coronal plane were only statistically significant for MS patients, perhaps due to the variable and often increased tone seen in the CVA population. The 'shoe model' was practical to use in a clinical environment.

References: Stebbins J et al. (2006). Gait & Posture, 23: 401–410.

Disclosure: No significant relationships.

O07

PATELLAR TENDON SHORTENING IMPROVES KNEE EXTENSION IN CEREBRAL PALSY

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Introduction: Flexed knee gait is a common problem in patients with bilateral spastic cerebral palsy (BSCP). Increased knee and hip flexion progressively lead to fixed knee flexion contractures and to patella alta with functionally insufficient knee extension. It has recently been described that inclusion of patellar tendon advancement is necessary to achieve optimal results in the surgical management of persistent crouch gait [1]. The aim of this study is to evaluate the outcome of patellar tendon shortening (PTS) in BSCP.

Patients/ Material and methods: Retrospective cohort study: A total of 24 patients (8 female/16 male) with a mean age of 16.1 ± 5.8 years (range 10.5 – 40y at time of surgery) were included. 19 patients had additional surgery and 10 had supracondylar extension osteotomies (SEO). Two patients had unilateral surgery. 18 patients had GMFCS level II and 6 patients had GMFCS level III. All participants had pre- and postoperative 3D gait analysis including a thorough clinical assessment and collection of 3D gait data. From the 3D gait data temporal parameters (cadence, stride length, and walking speed) and joint angles for the sagittal, coronal and transverse planes were calculated. All data was uploaded into Gaitabase [2].

Results: The temporal parameters did not change postoperatively. Clinical assessment of joint angles revealed statistically significant changes in the following parameters (Table 1):

	Internal hip rot. in stance *	Knee flex. at initial contact*	Max. knee ext. in stance*	Knee flex. in mid stance*	Max. knee flex. in swing §	Range knee flex. §	Average pelvic tilt §
Preop	13.9±15.2°	51.1±18.2°	42.5±22.8°	46.0±24.4°	71.9±16.5°	55.0±19.0°	14.1±6.8°
Postop	7.2±11.3°	32.4±1.8°	20.5±13.9°	22.9±14.5°	57.8±10.0°	37.6±12.2°	21.6±6.6°
p-value	0.02	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

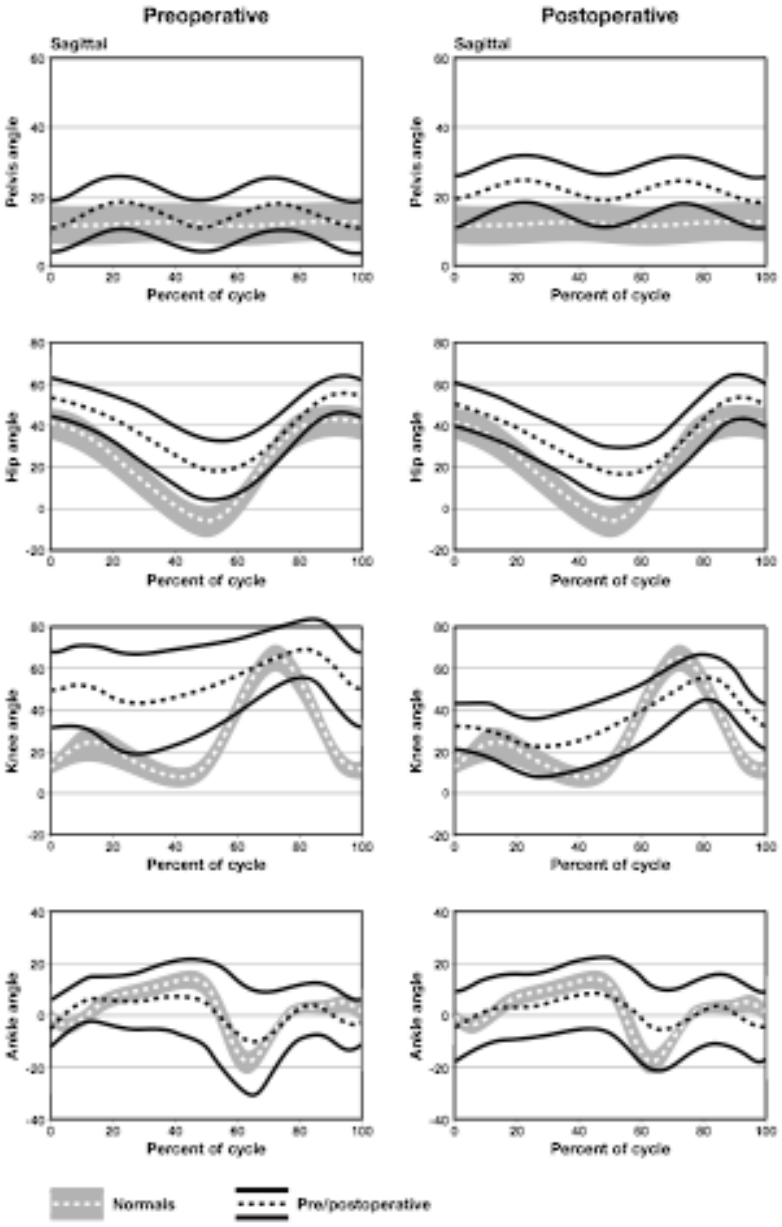

Table 1:* shows an improvement and § makes a deterioration.

The graph (Figure 1) of knee flexion-extension kinematics is approximately 20° shifted towards more extension.

Discussion & Conclusion: PTS has shown significant improvement in four highly relevant gait parameters and is elegantly demonstrated by the shift in the kinematic knee curve towards normal. The improvements of hip internal rotation is explained by concomitant femoral derotation osteotomies. The deterioration of anterior pelvic tilt is explained by concomitant medial hamstings lengthening procedures. Flexed knee gait can be corrected effectively by PTS in cerebral palsy (CP) but maximum knee flexion in swing and the range of knee flexion are reduced by this procedure. For correction of flexed knee gait in CP we recommend PTS although the range of knee flexion during the gait cycle is reduced. The trace for knee flexion-extension kinematics is shifted approximately 20° towards extension during the whole gait cycle.

References: [1] Stout JL et al., J Bone Joint Surg Am. 2008;90(11):2470-84 [2] Tirosh O et al., Comput Biol Med. 2010;40(2):201-7

Disclosure: No significant relationships.

O08

BIOMECHANICAL STUDY ON THE FUNCTIONAL PERFORMANCE OF A NEW MICROPROCESSOR-CONTROLLED PROSTHETIC KNEE JOINT

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Introduction: Due to microprocessor-controlled prosthetic knee joints, the fitting quality of transfemoral amputees has been effectively increased in the past years (1, 2, 3). The high functionality and the safety potential of the C-LEG have been scientifically proven in extensive studies (1, 2). Equipped with an improved sensor system and control algorithms, the newly developed GENIUM prosthetic knee joint increases the functional possibilities of the C-LEG considerably. The article presents the results of a biomechanical study that aimed at examining the new functions of the GENIUM compared to the C-LEG and their advantages for the patient.

Patients/ Material and methods: For the study, 10 patients of mobility grade 3 and 4 with unilateral transfemoral amputation could be recruited. All of them were fitted with the C-LEG. On the first day of the procedure, the following situations were biomechanically analyzed (C-LEG): standing on a slope (10°), walking on a level surface as well as ascending and descending ramps and stairs. Then all subjects were fitted with the GENIUM. After a familiarization phase of one day, all tests were repeated with this joint (G1). In the following three months, the patients used the GENIUM every day and then they were tested again (G2). Measurements were performed by means of an optoelectronic camera system (VICON460) in combination with 2 force plates (KISTLER 9287A). The WILCOXON test was used for the statistical test procedure.

Results: C-LEG – G1: The new standing mode of the GENIUM makes standing significantly more constant and safe (30s test: load on prosthetic side 44%BW (G1) vs. 31%BW (C-LEG). With the GENIUM, the initial contact during walking is characterized for the first time by physiological pre-flexion of the knee of approx. 4°, which supports the subsequent possible stance phase flexion. With the GENIUM, the velocity-dependent maximum knee flexion angle increase during the swing phase is lower (< 1°/1m/s) than with the C-LEG (approx. 11°/1m/s). Both findings are reflected in a more physiological gait pattern. On the ramp, the GENIUM allows for significantly increased knee flexion (downwards: flexion increased by 9°, upwards: flexion increased by 7°) and higher foot clearance. The kinematic characteristics come closer to that of healthy persons. The results of stair descent show only slight differences between the C-LEG and G1. Due to the new stair mode of the GENIUM, walking up stairs step-over-step is made possible for the first time even with a passive system, which is more natural than asymmetric ascending with the C-Leg (usually 2 steps at once with the contralateral side). G1 – G2: For movements with the GENIUM that require only slight performance changes compared to the C-LEG, no significant differences of the biomechanical parameters were identified (walking on a level surface, walking up and down a slope, walking down stairs). After 3 months, the adaptation effects observed in the subjects with regard to the new function of walking up stairs step-over-step with the GENIUM were significant (e.g. increase of power generated in the hip joint on the affected side during stance phase extension from 105W to 144W).

Discussion & Conclusion: Compared to the C-LEG, the new, intuitively useable functions of the GENIUM contribute to the further approximation of natural movement patterns in all investigated situations; overloading of intact parts of the locomotor system is reduced further. Both effects are confirmed by biomechanical parameters and provide considerable functional benefits for the prosthesis user.

References: [1] Bellmann et al. Arch Phys Med Rehab 91 (2010), 644-652. [2] Blumentritt et al. J Prosthet Orthot 21 82009), 2-15. [3] Bunce et al. J Prosthet Orthot 19 (2007), 7-14.

Disclosure: The authors are employees of the Research Department of Otto Bock Healthcare GmbH.

O09

PREDICTIVE FACTORS TO DETERMINE THE OUTCOME AFTER SINGLE EVENT MULTILEVEL SURGERY FOR GAIT CORRECTION IN CHILDREN WITH CEREBRAL PALSY USING THE GAIT PROFILE SCORE

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[1]Murdoch Childrens Research Institute, The Royal Children's Hospital, Parkville/Australia, [2]Clinical Epidemiology And Biostatistics Unit, The Royal Children's Hospital, Parkville/Australia, [3]Hugh Williamson Gait Laboratory, The Royal Children's Hospital, Parkville/Australia, [4]Orthopaedic Department, The Royal Children's Hospital, Parkville/Australia

Introduction: The natural history of gait in children with bilateral spastic cerebral palsy (BSCP) is one of deterioration. Single event multilevel surgery (SEMLS) is performed in order to prevent deterioration and to improve gait in patients with BSCP. The Gait Profile Score (GPS) [1] measures how different a gait pattern is from that of typically developing children. The aim of this study is to investigate which factors most predict change in GPS after SEMLS.

Patients/ Material and methods: All 121 diplegic patients with GMFCS level II or III (48 girls; age 11 ± 3 years at time of surgery) who had SEMLS at our hospital between 1995 and 2008 were included. We hypothesised that the following factors might have a bearing on SEMLS outcome: age at surgery, number of operative procedures during SEMLS, insurance status: private versus public insurance (as a surrogate for socio-economic status), surgical adverse events, pre-operative GMFCS level, pre-operative GPS (GPS-pre op). Bivariable linear regression was used to identify factors, which might be predictors of the change in GPS from baseline to one year follow-up at a level of $p<0.05$. Variables thus identified were subject to a multivariable linear regression.

Results: The mean GPS change was 4.3º (SD 4º) from 15.5° (SD 4°) pre-operatively to 11.2° (SD 3°) post-operatively. Bivariable linear regression suggests three factors were related to GPS change. These were: GPS pre-op ($b=0.73$, $p<0.001$), age at surgery ($b=-0.33$, $p=0.009$) and surgical adverse events ($b=-3.17$, $p=0.005$). Multivariable linear regression revealed that once GPS pre-op had been taken into account the other two variables are not predictors of GPS change ($p>0.1$).

Discussion & Conclusion: Apparent correlations of outcomes with age at sugery and surgical adverse events appear to be a consequence of correlations of these variables with pre-op GPS. This suggests that the small number of adverse events (12 out of 121 children) were also more common amongst the milder children and that milder children have surgery later. GMFCS was not a sufficiently sensitive measure to reveal the relationship between outcome and pre-operative gait pattern. Over 90% of children exhibit an improvement in gait pattern as result of SEMLS. The most severly affected children (high GPS) show the greatest improvements which can be considerably higher than the 4.3º change recorded for the cohort as a whole. Incidents of deterioration after surgery in these children are very rare. More mildly affected children show only modest improvments in gait pattern on average and a higher incidence of deterioration after surgery. Gait dysfunction in children with BSCP can be effectively corrected by SEMLS. Not only is the GPS an excellent method to assess the direction and magnitude of change after SEMLS, in itself it is the major predictor of surgical outcome.

References: [1] Baker R et al., Gait Posture 2009;30-3:265-9

Disclosure: No significant relationships.

O10

THE EFFECT OF DISTAL RECTUS FEMORIS TRANSFER AS A PART OF MULTILEVEL SURGERY IN SPASTIC DIPLEGIA - A RANDOMIZED CLINICAL TRIAL

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Introduction: Various studies reported satisfying results after distal rectus femoris transfer (DRFT)[1]. However different authors brought into question the effects of DRFT as a procedure suitable for all patients[2,3]. This is underlined by MRI studies showing failure of knee flexion augmentation and persistent extensor momentall patients[4]. This may explain unpredictable development of knee kinematics following DRFT in many patients. Due to the complexity of gait disturbances and the combination of surgical procedures during SEMLS, the direct effects of DRFT cannot be evaluated sufficiently in a retrospective analysis.

Patients/ Material and methods: In a randomized clinical trial 48 children with spastic diplegia (age 6-16 years) and stiff gait are planned to be treated in SEMLS with or without DRFT. The patients are allocated into two groups (DRFT- and non-DRFT-group) using a balanced randomization. Standardized 3-D gait analysis and clinical exam are carried out pre-, one and two years postoperatively. Hardware removal surgery is done 1 year after SEMLS, where Non-DRFT patients may receive DRFT as a secondary procedure if needed. All patients are planned for another evaluatio two years after SEMLS.

Results: Presently, SEMLS was performed in 38 patients. 29 of those patients (13 DRFT, 16 Non-DRFT) were evaluated 1 year after surgery. The overall outcome showed significant differences between the two groups. While a significant increase of ROM in swing and knee flexion velocity was found in DRFT group, Non-DRFT group showed only a little and not significant increase of both variables. A significant decrease of peak knee flexion in swing was found in Non-DRFT group.

		DRFT		Non-DRFT		
Parameters		pre-op	post-op	pre-op	post-op	Group diff.
Range of knee flexion in swing	degrees	22.8 (7.5)	32.7 (9.5) *	19.3 (8.8)	22.4 (8.9)	#
Peak knee flexion in swing	degrees	56.2 (11.9)	55.9 (6.8)	55.4 (9.0)	47.8 (9.0) *	#
Timing of peak knee flexion swing	% GC	82.6 (6.3)	79.8 (5.4) *	82.1 (5.4)	79.9 (6.9)	n.s.
Knee flexion velocity	degr./%GC	0.75 (0.39)	1.1 0(0.49) *	0.72 (0.44)	0.85 (0.43)	#
Minimum knee flexion in stance	degrees	25.3 (16.2)	12.2 (10.3) *	22.6 (17.3)	12.7 (13.5) *	n.s.
Gait velocity	m/s	0.77 (0.26)	0.74 (0.32)	0.74 (0.26)	0.79 (0.32)	n.s.

Table 1. two-way ANOVA $p<0.01$; # significant differences between groups, * significant differences between examinations; knee flexion velocity: increase of knee flexion from mid-stance to mid-swing divided by % Gaitcycle

Discussion & Conclusion: This is the first study evaluating the effects of DRFT in a randomized clinical trial. The results indicate that on average the patients profit from a concomitant DRFT by increasing range of knee flexion and knee flexion velocity as well as increasing or preserving peak knee flexion during swing. However, a secondary DRFT transfer was needed only in about 35 percent of the cases. Furhter detailed evaluation of subgroups, especially those patients with crouch gait is needed for a more precise outcome prediction.

References: [1] Saw A et al. J Pediatr Orthop. 2003;23:672-8. [2] Dreher T et al. Gait & Posture 2007;26:S48-9. [3] Delp SL et al. J Biomech 27:1201-11. [4] Asakawa DS et al. J Bone Joint Surg 2004;86:348-54.

Disclosure: No significant relationships.

O11

KNEE KINETIC PATTERN DURING GAIT AND ANTERIOR KNEE PAIN BEFORE AND AFTER REHABILITATION IN PATIENTS WITH PATELLOFEMORAL PAIN SYNDROME

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Introduction: Patellofemoral pain syndrome (PFPS) is likely due to compressive force acting on the patella related in turn to knee extension moment. In patients with PFPS, it has been reported at beginning of stance phase during walking a decrease in the peak KEM compared to healthy subjects [1]. The peak KEM was hypothesized to be reduced during gait to limit pain and increased after therapeutic pain improvement.

Patients/ Material and methods: Peak KEM at beginning of stance phase was recorded by 3D gait analysis in 22 controls and in 23 patients with patellofemoral pain before (T0) and after (T1) rehabilitation of knee extensors and flexors to reduce pain. Pain was quantified by the anterior knee pain scale [2].

Results: In the patients at T0 (n = 23), the peak of KEM and peak knee flexion at beginning of stance and the dimensionless walking speed was significantly ($p<0.05$) lower than in controls (respectively, mean 0.50(SD 0.30) versus 0.66(0.18) Nm/kg, 14°(7°) versus 17°(4°) and 0.43(0.07) versus 0.47(0.04)). Among the 17 patients with significant improvement of pain at T1 compared to T0 (increase of at least 10 points in the AKPS [4]), the peak of KEM and peak knee flexion were significantly increased at T1 compared to T0 (respectively, 0.67(0.26) versus 0.58(0.28) Nm/kg and 17°(6°) versus 15°(7°), $p<0.05$) without significant change in the dimensionless walking speed (0.44(0.07) versus 0.42(0.08)).

Discussion & Conclusion: In patients with PFPS, the peak of KEM, lower than in controls, did normalize after significant improvement of knee pain after rehabilitation. The peak KEM appears to be a sensitive kinetic variable which is altered to limit or avoid anterior knee pain as a result of compensatory mechanism. Further research is needed to analyze the mechanical factors associated to knee pain improvement after rehabilitation.

References: 1 Heino Brechter J, Powers CM. Patellofemoral stress during walking in persons with and without patellofemoral pain. Medicine and science in sports and exercise. 2002;34(10):1582-93. 2 Crossley KM, Bennell KL, Cowan SM, Green S. Analysis of outcome measures for persons with patellofemoral pain: which are reliable and valid? Archives of physical medicine and rehabilitation. 2004;85(5):815-22.

Disclosure: No significant relationships.

14:30-15:30GAIT DISORDERS I

O12

GAIT ANALYSIS AFTER GROWTH ARREST IN PATIENTS WITH SLIPPED CAPITAL FEMORAL EPIPHYSIS (SCFE)

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Introduction: SCFE is the most common disorder of the hip in adolescents. Residual changes can lead to the development of secondary osteoarthritis. Therefore SCFE is regarded as a deformity presenting a preliminary stage of degenerative joint disease. So the development of reliable tools for evaluating therapy and its outcomes is necessary in order to prevent persisting defects in the long term. There are no studies evaluating the correlation between gait analysis data and clinical examination.

Patients/ Material and methods: 39 SCFE patients after growth arrest (18.8 years; BMI 26.5 kg/m²) were included. Exclusion criteria: bilateral SCFE, other disorders leading to gait alterations, status after total hip replacement. All patients underwent clinical follow-up examinations. Findings were evaluated according to the score of Heyman and Herndon [1] and the Harris Hip Score (HHS) [2]. 3D-GA was performed at self-selected speed with a VICON 512 system. Spatiotemporal, kinematic and kinetic parameters were evaluated and compared to the non-involved side and to a group of 40 healthy adults (28.0 years; 21.9 kg/ m²). Subgroup analysis was performed in order to detect the influence of the clinical outcome on gait. Patients with Heyman Herndon Score ≤ 2 were assigned to the better subgroup (n=17), patients with Heyman Herndon Score > 2 were assigned to the worse (n=22). Statistical analysis was performed (Wilcoxon and Mann Whitney U test, $p<0.05$ was considered to indicate statistical significance)

Results: Clinical results according to the HHS and the Heyman Herndon Score were very good on average. Nevertheless a differentiation between good and rather poor clinical results could be accomplished using the clinical Heyman Herndon Classification. In the worse subgroup a reduction in step length/body height (p=0,029), of sagittal ROM of hip (p=0,040) and maximal pelvic obliquity (p=0,018) on the slip side was seen. Negative mechanical work decreased in the worse subgroup (p=0,015). For the whole study population GA could detect significant changes of spatiotemporal (walking speed↓ (p=0.022), step frequency↓ (p<0.001), single support↓ (p<0.001), step width↑ (p=0.014), double support↑ (p=0.004),stance time↑ (p=0.001)) and kinematic (sagittal: ROM (range of motion) pelvis↑ (p= <0.001), ROM hip↓ (p=0.002), knee flexion↓ (p<0.001) , ROM ankle↓ (p=0.003), transverse: outward rotation of ankle↑ p=0.011) parameters that indicate sustained functional impairments.

Discussion & Conclusion: Clinical examination revealed good to excellent results on average. With the help of GA it was possible to detect even small alterations. To increase the accuracy of predicting the development of osteoarthritis in SCFE patients by GA studies with a longer follow-up time and a control group with identical BMI are needed.

References: 1. Zahrawi F.B. et al. Clin Orthop Relat Res 1983 2. Harris W.H., J Bone Joint Surg Am 1969

Disclosure: No significant relationships.

O13

INTERJOINT COORDINATION OF THE LOWER EXTREMITY IN PATIENTS WITH JUVENILE IDIOPATHIC ARTHRITIS (JIA). A LONGITUDINAL STUDY.

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Introduction: Juvenile idiopathic Arthritis (JIA) is a form of chronic Arthritis in childhood and adolescence characterized by joint inflammation, pain, swelling and restriction in function. Apart from anti-inflammatory treatment one of the main goals in therapy is the complete re-establishment of joint functions and –axes. A well established technique to analyze functional sequences of joints is an angle-angle plot, called cyclogram (fig.1). It "provides information about the posture of the leg and the coordination of two joints" (Goswami 1998, p.18). JIA patients suffer from joint restrictions affecting gait function as well (Hartmann et al. 2010). The perimeter of the cyclograms should be smaller in patients with a diminished range of joint motion compared to healthy controls.

Patients/ Material and methods: The kinematic data for the hip and knee joint were captured with a 6 camera Vicon motion analysis system (120Hz). The patient group (pg) includes 15 subjects with JIA (12.5 ±2.8yr, 1.47 ±0.1m, 38.8 ±13.8kg (all data at t1)) and the control group (cg) consists of 14 subjects (10.7 ±1.9yr, 1.47 ±0.13m, 38.1 ±9.9kg). On average there were 17 months between the measurements (t1 and t2) of the pg. During this period the patients had to perform individualized physiotherapy and drug therapy. To generate cyclograms hip angle (x-axis) was plotted against knee angle (y-axis). The perimeter was calculated using a linear integrative approximation procedure. Gaussian distribution was tested with Kolmogorov-Smirnov-test. Means were compared using appropriate t-tests (for independent and dependent samples). Statistical significance was set to a p-value lower .05.

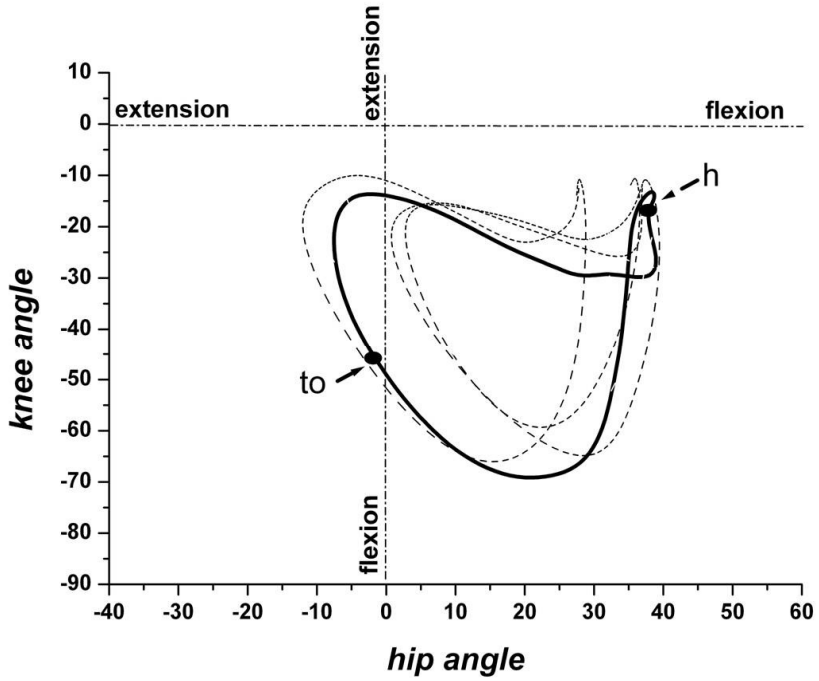

Fig.1: shows a cyclogram of a hip and a knee angle. It starts with (h)eelstrike and is to be read counterclockwise. (to)e off marks the end of stance phase. The solid black line shows the plot of a healthy person and the dotted graphs are from patients to see the differences in shape.

Results: There is a statistical significant smaller perimeter of the cyclograms for patients with JIA in comparison to the healthy control group (left 186.4 ±15.0°, right 189.8 ±16.4°) ($p<.01$). The patients show no changes from t1 to t2 ($p>.05$). t1: left 166.2 ±22.3°, right 160.7 ±28.0°; t2: left 164.2 ±18.8°, right 157.7 ±17.2°.

Discussion & Conclusion: The results confirm the hypothesis that smaller range of motion leads to a smaller perimeter in patients with JIA. There were no differences found for intra-individual lower limb coordination during a gait cycle. Cyclograms seems to be a good technique to get additional information on multi segmental movement. Extended physiotherapy concentrating on more than the inflamed joints may integrate additional functional exercises. Especially clinicians or physiotherapists can qualitatively see precise movement patterns of certain joints.

References: Goswami, A. (1998). Gait Posture 8(1): 15-36. Hartmann, M., et al. (2010). Int J Pediatr. Epub 2010 Sep 2.

Disclosure: No significant relationships.

O14

PRELIMINARY RESULTS OF TRANS-FEMORAL AMPUTEES WALKING WITH A MICROPROCESSOR CONTROLLED PROSTHETIC FOOT

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Introduction: Prosthetic alignment is typically performed for level walking. In conventional prosthetic feet, the lack of adaptation to slopes may lead to compensation mechanisms in gait due to inappropriate lever-arms [1]. The aim of this study was to evaluate if trans-femoral amputees (TFA) could benefit from an adaptation in ankle angle of the prosthetic foot.

Patients/ Material and methods: 6 unilateral trauma induced TFA (46.3y±6.2y) were investigated using a microprocessor controlled prosthetic foot Proprio-Foot™ (PROPRIO / Fig. 1) and a reference foot Variflex-EVO ™ (VARI), combined with a Rheo-Knee 2 ™ (Fig. 1) prosthetic knee (all Ossur, Reykjavik, IS) and their existing sockets. All TFA and 20 healthy controls (30.2y±9.3y) underwent a conventional instrumented gait analysis (CGA) for level ground and for walking up and down a ramp of 7.5°. Each TFA was randomly fitted with either one of the two feet in question. An accommodation-period of at least one month was ensured previous to first CGA. Subjects then were provided with the other foot and again given 4 weeks for accommodation. CGA was captured by a 12 camera system (Vicon, Oxford, UK) operating at 120Hz and two force-plates (Kistler, Winterthur, CH). Force-plate data during ramp-walking was recorded as described by Simon et al. [4]. Kinematics and kinetics were calculated according to the Plugin-Gait model [3]. The adaptation of PROPRIO for the ramp used in this study was 7.5° dorsiflexion on the incline and 2.1° plantarflexion on the decline. In swing, the foot offered further a 4° dorsiflexion (Toe-lift).

Results: Level Walking: Kinematics and kinetic results for both sides showed no major changes between both feet. Ramp up: During terminal stance, hip moments and powers of the involved side were reduced with PROPRIO. Ramp down: Using PROPRIO reduced external flexion moments of the knee and higher external flexion moments of the hip were captured for the involved side. For the sound side only external extending knee moments during stance were observed.

Discussion & Conclusion: Minor differences between both feet during level walking are most likely linked to mechanical differences. Hansen et al. described, the ankle angle adapts while walking up a ramp [2]. PROPRIO acts accordingly which leads to reduction of hip moments and powers. Plantar-flexion of PROPRIO during decline walking results in extending knee moments and reduced propulsion. The sound side has to adapt to this “breaking mechanism” and only extending knee moments throughout stance appear. Results confirm that users benefit from PROPRIO adaptation especially during ramp ascent. PROPRIO users should attend an additional gait education with focus on the reduction of compensation mechanism assuring adequate toe-clearance. Such mechanisms like e.g. "early heel rise" were still present in tested users, though PROPRIO offers an enhanced toe-clearance. The current adaptation of PROPRIO on declines is in contrast to Hansen et al.[2] who propose increased knee-flexion instead.

References: [1] Fradet, L. et al. (2010) Gait Posture 32-2, 191-198 [2] Hansen, A. H. et al. (2004) Hum.Mov.Sci 23-6, 807-821 [3] Kadaba, M. P. et al. (1989) J Orthop Res. 7-6, 849-860. [4] Simon, J. R. et al. (2007) Gait Posture 26, 11.

Disclosure: No significant relationships.

O15

JOINT KINEMATICS FOLLOWING BI-COMPARTMENTAL KNEE REPLACEMENT DURING DAILY LIFE MOTOR TASKS

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Introduction: In many cases knee osteoarthritis leads to total knee replacement surgery however the lateral compartment is not involved. More recently, a bi-compartmental knee replacement system (BKR) (Journey Deuce System, Smith & Nephew Inc., Memphis, TN, USA) has been developed that replaces the medial tibiofemoral and patellofemoral compartments while retaining the lateral compartment and the cruciate ligaments. Until now, very little information can be found on the effect of BKR on knee joint kinematics. Therefore, the purpose of the present study was to analyze knee joint kinematics in patients with BKR for a broad spectrum of relevant daily life activities.

Patients/ Material and methods: We analyzed to what extent normal knee motion is preserved following BKR in a group of 10 patients (patient's involved side (PIS)) trough comparison with their non-involved side (PNIS) as well as a group of matched controls (Ctrls). Kinematic data were statistically compared for seven different motor tasks, with three repetitions each: walking (W), W followed by a cross-over turn (WCO), W followed by a sidestep turn (WSS), stair ascent (SA), stair descent (SD), chair rise (CR) and mild squat (MS). Finally, coefficients of multiple correlation (CMC) [1] were calculated to assess the consistency of knee joint kinematics both within and between subject groups.

Results:

	Flex/Ext		Varus/Valgus		Endo-/Exorot.	
	CMC_i	CMC	CMC_i	CMC	CMC_i	CMC
W	0.949	**0.945**	0.260	**0.257**	0.263	**0.216**
WCO	0.864	**0.860**	0.309	**0.297**	0.572	**0.503**
WSS	0.887	**0.875**	0.276	**0.279**	0.558	**0.450**
SA	0.897	**0.896**	0.447	**0.452**	0.177	**0.148**
SD	0.908	**0.903**	0.311	**0.283**	0.287	**0.221**
CR	0.948	**0.936**	0.219	**0.236**	0.512	**0.411**
MS	0.859	**0.825**	0.000	**0.024**	0.342	**0.247**

When compared to Ctrls and PNIS, PIS shows differences indicative of retention of the pre-operative gait pattern and remaining compensations: performing motor tasks at a lower cadence, decreased range of knee flexion/extension for all motor tasks resulting in a flattening of the first bump in the typical double-bump flexion/extension pattern, a shift towards increased varus angles as well as towards decreased internal rotation for all motor tasks performed. Nevertheless table 1 shows that, for all motor tasks and all three planes of motion, kinematic curves of patients who received a BKR demonstrate a consistency with the knee kinematic curves in the Ctrls (as quantified by CMC) very similar to the consistency measured within these group individually (as quantified by CMC_i). In other words, compared to the variability within groups, combining kinematic curves from PIS with healthy limbs, only introduces very limited additional variability.

Discussion & Conclusion: This study demonstrated that, for a large range of motor task with high relevance during daily life, knee joint kinematics in BKR limbs are as kinematically consistent with the healthy controls as the consistency within this group, despite the presence of differences indicative for retention of pre-operative motion patterns and/or remaining compensations. As such this study presented a framework for an objective and detailed analysis of the post-operative performance of knee replacement patients.

References: [1] Kadaba MP, et al., J Orthopedic Research. 7: 849-860, 1989.

Disclosure: L. Scheys and L. Labey are both employees of Smith & Nephew, Memphis, TN. J. Bellemans and A. Franz are both consultants of Smith & Nephew, Memphis, TN.

O16

COMPENSATORY MECHANISMS OF UPPER AND LOWER BODY MOVEMENTS FOR ANATOMIC LEG LENGTH DISCREPANCY

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Introduction: Patients with an anatomical leg length discrepancy (aLLD) commonly show a gait asymmetry. Several compensatory strategies are observed: toe walking on the short side (TW), limb flexion on the long side (LF), vaulting and circumduction [1]. Moreover, it is suggested that people with an aLLD are at greater risk for the development of spinal disorders [2]. The goal of this study is to determine if the observed compensatory (TW, LF) and asymmetrical 3D movements of the pelvis, thorax and spine correlate with the amount of the aLLD and if correlations exist between those 3D angles.

Patients/ Material and methods: 29 neurologically normal patients with an aLLD greater than 2 cm were retrospectively selected for this study (mean age 17.1±4.0 years, mean aLLD 3.6±1.6 cm with a range from 2.0 to 8.5 cm). All patients underwent a 3D gait analysis (Vicon 460, two Kistler force plates, Plug-in-Gait marker set). Mean and standard deviation were calculated for three representative trials within each patient. The TW and LF compensatory strategies were defined according to Song et al. [1]. For pelvis, thorax and spine 3D angles significant differences (paired t-test, $p<0.05$) between short and long side within each patient were determined. The group distribution of these differences was then tested with a chi-squared test. A Spearman Rank Correlation test was used to investigate the influence of the amount of aLLD on all analysed parameters and the correlation between each of the upper body parameters. The correlation between the absolute value of pelvic obliquity and the amount of aLLD were analysed with a Pearson Correlation test.

Results: The TW compensatory strategy was observed in 4 patients, 2 patients showed toe walking on both sides and 23 had a normal heel strike on both side. The LF compensatory strategy was observed for 10 patients. For pelvic, thorax and spine tilt no significant differences between the short and long side were observed. For the frontal and transversal plane: pelvic obliquity on the short side, spine lateroflexion on the long side and pelvic rotation on either side were tested significant. There also existed a significant correlation ($r=0.523$, with $p<0.01$) between the amount of aLLD and the absolute value of pelvic obliquity. The sets of parameters which had a significant correlation are shown in table 1. Table 1: The Spearman Rank Correlation test shows significant correlations ($p<0.05$) between these sets of parameters.

	aLLD versus TW	LF versus spine lateroflexion	Pelvic obliquity versus spine lateroflexion	Pelvic rotation versus thorax rotation
r_s	0.416	0.393	0.381	0.433
p	0.025	0.035	0.042	0.019

Discussion & Conclusion: Our results show that the TW compensatory strategy correlates with the amount of aLLD whereas the LF compensatory strategy correlates with spine lateroflexion. From the upper body data we found that a correlation exists between pelvic obliquity and spine lateroflexion and between pelvic and thorax rotation. It can be concluded that not only the lower body but also the upper body shows compensatory strategies for an aLLD.

References: [1] Song K.M. et al. J Bone Joint Surg Am. 1997;79:1690-8 [2] Kakushima M. et al. Spine 2003;28:2472-6

Disclosure: No significant relationships.

O17

ABNORMAL LOADING OF THE MAJOR JOINTS IN KNEE OSTEOARTHRITIS AND THE RESPONSE TO KNEE REPLACEMENT

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Introduction: Patients with knee osteoarthritis frequently complain that they walk abnormally and subsequently develop pain in other joints due to 'over-loading'. However, there have been no previous studies examining the effect of knee arthritis on the weight bearing joints of the other leg. The aim of this study was to examine the loading of the hips and contra-lateral knee during gait in a cohort of patients pre- and post knee replacement.

Patients/ Material and methods: Twenty patients with single joint, medial compartment knee osteoarthritis were recruited from the knee arthroplasty waiting list of the North Wales NHS Trust. Twenty healthy age-matched volunteers were recruited from the community. Gait analysis during level gait was performed using a 12 camera Vicon Mx motion analysis system with 3 AMTI force plates and processed using Plug in Gait (Vicon, Oxford). EMG electrodes attached to the medial and lateral hamstrings and quadriceps bilaterally were used to record muscle activity and a co-contraction index was calculated. Patients were invited to return 12 months post-operatively and the analysis was repeated. Statistical analysis was performed using t-tests with Bonferroni correction and stepwise multiple regression using SPSS v16.0.

Results: The mean age of the patients was 69 (range 53-82) and the controls was 68 (range 60-83). Mid-stance moments and knee adduction moment impulses were elevated at both hips and both knees in patients compared to normal individuals (adduction moment impulses: OA knee=1.45Nms; opposite knee=1.16Nms; controls=0.82Nms; $p<0.05$ bilaterally) whilst peak moments were not significantly different. Co-contraction was elevated in both knees compared to normal ($p<0.01$ for both knees). Coronal plane alignment, gait speed and knee extension were all significant factors using multiple regression analysis. Ten patients have so far returned for follow up. Substantial improvements in mid-stance moments were seen at the replaced knee (mean decrease in moment 0.97N.m/Bw.Ht) with smaller improvements in the peak moment (mean decrease in moment 0.56N.m/Bw.Ht). Changes in loading in the contra-lateral knee were very variable, and did not always normalise. Peak moments at the contra-lateral knee increased in some patients as gait speed increased (mean increase in moment 0.27N.m/Bw.Ht) but mid-stance moments and waveform shape varied considerably between patients (mean decrease in mid-stance moment 0.11Nm/Bw.Ht). Improvements were seen at mid-stance moments for both hips in the majority of patients. Persisting co-contraction was a common feature post-operatively, particularly in the contra-lateral knee (mean decrease in co-contraction: lateral affected side 0.08; lateral unaffected side 0.04; medial affected side 0.07; medial unaffected side no change in mean).

Discussion & Conclusion: Patients with single joint knee osteoarthritis have abnormal loading of both knees and both hips, potentially leading to further disease and disability. The gait pattern appeared to be consistent with the adoption of a stable, safe pattern of gait. Recovery following knee replacement is variable, and abnormal biomechanics often persist, especially in the unaffected knee. Therapies to treat persisting biomechanical abnormalities following knee replacement may be of benefit in preventing future disease in these patients.

References: [no references]

Disclosure: No significant relationships.

16:00-17:00 - CEREBRAL PALSY I

O18

WHAT ARE THE MOST IMPORTANT CLINICAL MEASUREMENTS AFFECTING GAIT IN PATIENTS WITH CEREBRAL PALSY?

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Introduction: Clinical measurements are used to interpret gait analysis in patients with cerebral palsy (CP). Our hypothesis is that some of the clinical parameters, or their combinations, are more important than others in explaining the severity of gait alterations in CP. Identifying these parameters could support the interpretation of gait analysis. Authors have already tested the relationship between clinical measurement and gait analysis and found poor correlations [1-2]. We can speculate that these poor correlations are due to the only use of linear regression. Fuzzy Decision Trees (FDT) is a method that seems particularly appropriate for identifying and explaining gait alterations. This method has been employed in machine learning, but is rarely used in gait analysis [3]. It combines fuzzy logic, which simplifies the knowledge extraction process and increases the interpretability, with the automatic induction of easy, readable rules from a dataset. Consequently, this study aimed to determine which of clinical parameters or their combinations would most influence a gait index for patients with CP.

Patients/ Material and methods: A retrospective search, including clinical and gait assessments, was conducted from August 2005 to September 2009. 155 patients with a clinical diagnosis of CP (mean age: 11 ± 5.3 y; range: 3-30 y) were selected. A decision-tree induction, adapted to fuzzy data coding, was employed to predict the Gait Deviation Index (GDI) from a dataset of clinical assessments (i.e., range of motion (ROM), force and spasticity).

Results: Seven rules that could explain a low GDI (<77) were induced. Overall, FDT method was highly accurate (90%) and permitted to predict GDI values with a mean error of 2.35±0.4. The three most important clinical parameters used to predict the severity of gait alterations are the hip extensor strength, tibialis posterior spasticity and tibialis posterior strength.

Discussion & Conclusion: The accuracy of the FDT method indicates that the chosen clinical measurements provide a good explanation of the severity of gait alterations in patients with cerebral palsy. Among clinical parameters, hip extensor strength has been already identified to play an important role in CP classification according to the Gross Motor Function Classification System [4]. The spasticity of tibialis posterior lead to equinovarus of the foot [5], moreover, the equilibrium of inversor and eversor muscle strength is primordial for a good foot position. There is an important relationship between clinical parameters and the severity of gait alterations. Forces and spasticity parameters are more involved than ROM to predict gait severity.

References: [1] Desloovere K. et al., 2006, Gait Posture, 24, 302-313. [2] McMulkin M.L. et al., 2000, J Pediatr Orthop, 20, 366-369. [3] Armand S. et al., 2007, Gait Posture, 25, 475-484. [4] Eek M.N. et al., 2008, Dev Med Child Neurol, 50, 759-764. [5] Michlitsch M.G. et al., 2006, J Bone Joint Surg Am, 88, 1764-1768.

Disclosure: No significant relationships.

O19

DISCRIMINATION OF THE ABNORMAL GAIT PARAMETERS DUE TO INCREASED FEMORAL ANTEVERSION FROM THE OTHER CEREBRAL PALSY RELATED EFFECTS

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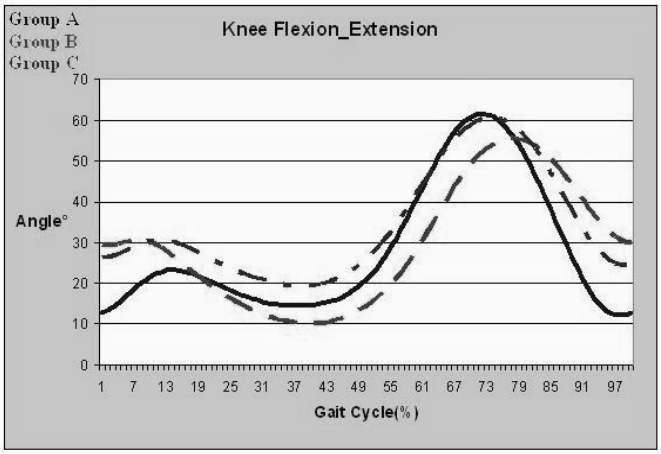
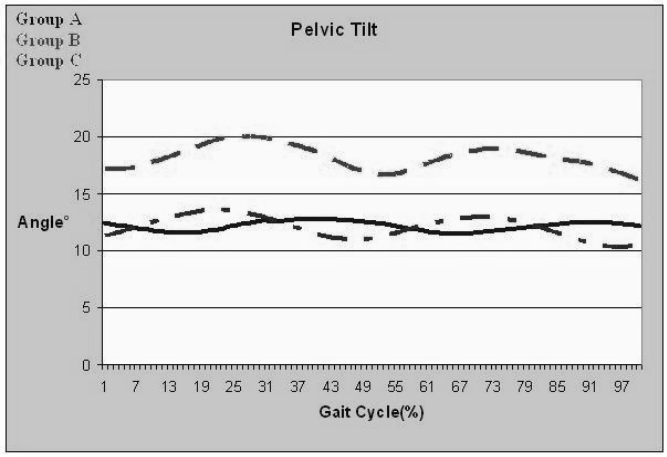
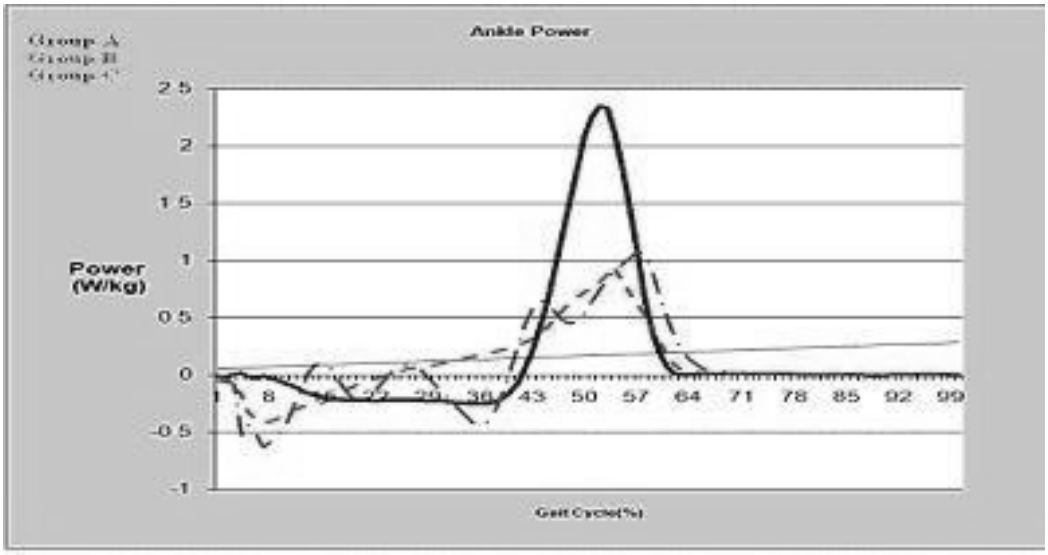
Introduction: The affects of increased femoral anteversion (IFA) are complexly involved with the other orthopedic and neurological abnormalities of children with cerebral palsy (CP) which causes misinterpretation, deficient treatment and end up with pre-operative gait pattern after the surgery [1,2,3]. The aim of the study is discrimination of the affects of IFA from the other CP related abnormalities such as motor control problems, abnormal tonus, and sensory motor problems on gait patter.

Patients/ Material and methods: 14 neurologically intact children with IFA (mean age: 7.4 ± 1.8) (Group-A), 10 spastic diplegic children with IFA (7.8 ± 1.7) (Group-B), 11 diplegic children with nearly normal femoral anteversion (10.5 ± 4.5) (Group-C), participated in to this study. Both gropus' subjects had similar GMFCS scores (Level 2). The hip internal rotation angles for all the children with IFA groups were ≥70° and external rotations were ≤20° bilaterally. Pelvis, hip, knee and ankle kinematics, kinetics and temporal-spatial parameters were analyzed in gait analysis laboratory. ANOVA and post-hoc tests were performed to analyze parametric data. The significantly different parameters between Group-B and C considered as the femoral anteversion (FA) affects and diffrences between Group-A and B were assumed as the other CP affects .

Results: Knee flexion at initial contact, mean and excursion of pelvic tilt, peak hip flexion and in GC and Peak ankle plantar flexor moment in 0-30% of gait cycle (GC) and peak knee power absorbsion in 0-30% GC significantly increased and power generation between 30-60% GC decreased significantly in Group-B relative to Group-A (Figure 1,2,3). Mean value of pelvic tilt during entire gait cycle (Figure 3) and knee valgus value during stance, peak hip flexion in GC and Pelvic rotation excursion increased and peak knee extension in stance decreased in Group-B relative to Group-C. Stance-time(%), double-support time(ms), step-width significantly increased and swing-time(%), anterior step length, stride length, velocity significantly decreased in Group-B relative to Group-A. Only increased swing time was found as significant in Group-C relative to Group-B.







Discussion & Conclusion: Increased pelvic tilt in GC and augmented knee valgus in stance were the obvious gait parameters directly related with IFA. Increased knee flexion, enlarged peak knee power absorbsion in early stance phase (K1) and decreased ankle power generation in late stance seem to be directly related with disease of cerebral pasly. Derotational femoral ostetotomy procedure may decrease abnormal anterior pelvic tilt and increased knee valgus itself. Orthopedic surgeons should previously focus on correcting lever arm dysfunction on femur for cerebral palsy children with increased femoral anteversion.

References: [1] J.R. Gage, The Treatment of Gait Problems in Cerebral Palsy, Mac Keith Press, London, UK (2004). [2] Arnold et al., Gait and Posture 23 (2006), pp. 273–281. [3] Akalan N.E.,Effects of increased Femoral Anteversion.. Turkish JPM& Rehab. 55(4), 135-40 (2009).

Disclosure: No significant relationships.

O20

THE RELATIONSHIP BETWEEN ARM POSTURING AND GAIT DEVIATION IN TEENAGERS AND YOUNG ADULTS WITH SPASTIC UNILATERAL CEREBRAL PALSY

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Introduction: Patients with spastic unilateral cerebral palsy (CP) have pronounced individual variety in movement pattern in the upper and lower extremity depending on the brain lesion which rules the degree of involvement. Previous studies addressing both upper and lower limb kinematic analyses are few, e.g. in rehabilitation and walking speed, addressing arm-swing and force (vertical free moments) difference in age/sex, or classifying gait patterns. The aim of this study was to assess the upper and lower extremity deviations and movement pattern during walking.

Patients/ Material and methods: Forty-seven patients with mild spastic hemiplegic CP, 17.1 years (range 13.1 to 24.0 years), and 15 healthy matched controls had their gait recorded using kinematics from three-dimensional analysis, including the upper and lower extremities. Data were collected for the pelvic and hip in three dimensions, knee flexion/extension, ankle dorsi/plantar flexion and foot progression. For the upper extremity shoulder- elbow- and wrist flexion/extension, and shoulder abduction/adduction were included. The Gait Profile Score (GPS) (1) and Arm Positioning Score (APS) (2) on the hemiplegic side were calculated from these variables and used as a measure of deviation. The range of motion (ROM) through the gait cycle was also measured. A classification was made based on the GPS and APS scores on the affected side. The thresholds for being similar or deviant from the control with respect to GPS or APS were the maximal values in the control group (GPS ≤ 6.8, and APS ≤ 9.3).

Results: Four groups were identified; Group 1 similar GPS and APS, Group 2 similar GPS but not APS, Group 3 non-similar GPS but not APS and Group 4 non-similar GPS or APS. (group 4). Group 1 and 2 had a lower GPS (p=0.000) compared to group 3 and 4, while group 1 and 3 had a lower APS (p=0.000) compared to group 2 and 4. Although GPS and APS were in line with controls several variables indicated difference in ROM (Figure), e.g. decreased hip flex./ex p=0.028/p=0.002 group 1 and 2, increased pelvic tilt p=0.000/p=0.001; group 1 and 2. The GPS were lower in hip ab./ad. group 3 and 4 (p=0.009, 0.015) without any ROM difference. The ROM in elbow flex./ext. were decreased in group 1 and 3 (p=0.004 and p=0.001), group 2 and 4 showed both increased APS and decreased ROM (APS; p=0.000 and p=0.000, ROM; p=0.000 and p=0.000).

Discussion & Conclusion: It is of clinical importance to identify different groups of cases as to differentiate impairment, needs and possible treatment. The ability to monitor and follow the natural progression of development over time determines the treatment strategy. The groups outlined in this paper serve as indicators of the functional impairment. The functional impairment of and the consequences of impairment with less activity and participation in society is perhaps shown at its highest in teenagers and young adults.

References: (1) Baker R et al. The gait profile score and movement analysis profile. Gait Posture. 2009 Oct;30(3):265-9. (2) Riad J et al. Arm posture score and arm movement during walking: a comprehensive assessment in spastic hemiplegic cerebral palsy. Gait Posture. 2011;33:48–53.

Disclosure: No significant relationships.

O21

PATELLAR TENDON SHORTENING IN COMBINATION WITH SUPRACONDYLAR EXTENDING OSTEOTOMY PROVIDES THE BEST CORRECTION OF SEVERE KNEE DYSFUNCTION IN CEREBRAL PALSY

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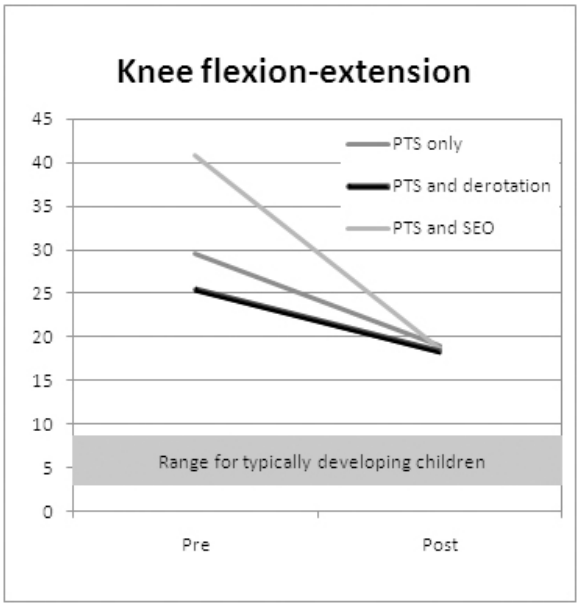
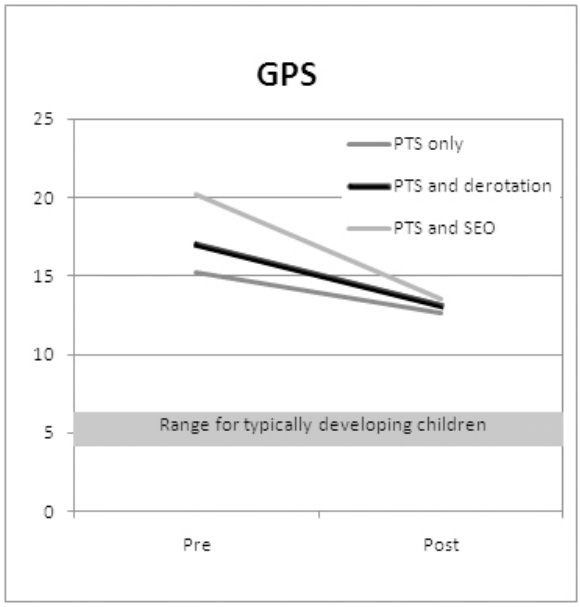
Introduction: Flexed knee gait is a common problem in patients with bilateral spastic cerebral palsy (BSCP). Increased knee and hip flexion progressively lead to fixed knee flexion contractures and to patella alta with functionally insufficient knee extension. It has recently been described that inclusion of patellar tendon advancement is necessary to achieve optimal results in the surgical management of persistent crouch gait [1]. The aim of this study is to evaluate these procedures in relation to outcome regarding correction of knee dysfunction.

Patients/ Material and methods: Retrospective cohort study: A total of 24 patients (8 female/16 male) with a mean age of 16.1 ± 5.8 years (range 10.5 – 40y at time of surgery) were included. 19 patients had additional surgery and 10 of them had supracondylar extension osteotomies (SEO). Two patients had unilateral surgery. 18 patients had GMFCS level II and 6 patients had GMFCS level III. All participants had pre- and postoperative 3D gait analysis including a thorough clinical assessment and collection of 3D gait data. From the 3D gait data Movement Analysis Profile (MAP) and the Gait Profile Score (GPS) was calculated [2]. All data was uploaded into Gaitabase. For statistical analysis the legs were put into three different groups: A) patellat tendon shortening (PTS) only, B) PTS and femoral derotation osteotomy (FDO), C) PTS and SEO.

Results: The numbers in each group were: A) 14 knees PTS only (blue), B) 14 knees PTS and FDO (red), and C) 18 knees PTS and SEO (green).





Discussion & Conclusion: The three groups of patients studied were not similar at baseline, and therefore different combinations of surgical procedures were selected. FDO was indicated for the correction of hip dysfunction. The results demonstrate very elegantly that the more severely affected patients in terms of knee dysfunction can have a similar outcome to the less affected by combining SEO with PTS. Flexed knee gait in cerebral palsy is best corrected by a combination of PTS and SEO in the more severely affected patients. For best correction of knee dysfunction in severe flexed knee gait we recommend the combined procedures of PTS and SEO. The surgical procedure needs to be tailored to each patient's individual needs: for mild knee dysfunction PTS (alone or with FDO) is indicated and for cases with fixed knee flexion, PTS in combination with SEO is required.

References: [1] Stout JL et al., J Bone Joint Surg Am. 2008;90(11):2470-84 [2] Baker R et al., Gait Posture 2009;30-3:265-9

Disclosure: No significant relationships.

O22

THE PHENOMENON OF BEN LOMONDING IN CEREBRAL PALSY GAIT.

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Introduction: Children with cerebral palsy (CP) often experience significant problems supporting their bodyweight (BW). This is seen as a decreased second vertical peak force or GRF_{FZ2}. This study categorises gait data by the degree of reduced GRF_{FZ2} and more importantly raises awareness of the scale of the problem in this patient group. 'Ben Lomonding,' is the term we used to describe this phenomenon as the shape of the graph resembles the Scottish mountain which has two peaks, the second being smaller than the first. The published definitions and pre-requisites for normal gait [1, 2] fail to consider the process of transferring weight from the trailing limb to the leading limb. This study begins to consider this mechanism in greater detail. Stansfield et al. indicated that while there is wide variation in GRF_{FZ1}, GRF_{FZ0} and GRF_{FZ2}, the typical values are in the region of 120% of bodyweight (BW), 70% and 110% respectively [3].

Patients/ Material and methods: Kinetic data were acquired using a Vicon® system and Kistler® platforms. Data from 48 diplegic children were analysed. The force data were normalised to BW. A total of 308 legs were classified based on the magnitude of GRF_{FZ2}. The classifications are shown in Table 1.

Results:

Magnitude of GRF_{FZ2}	Type	Count	%	%	%	%
≥110% BW	0	29	9			
=106 -109.99% BW	1	67	22			22
= 100-105.99% BW	2	91	30		30	30
= 91-99.99% BW	3	84	27	27	27	27
= 81-90.99% BW	4	23	7	7	7	7
= 71-80.99% BW	5	9	3	3	3	3
<70% BW	6	5	2	2	2	2
Total		308	100	39	69	91

Table 1

Discussion & Conclusion: A total of 39% failed to achieve GRF_{FZ2} of at least BW. By including those around the 100% BW mark, this rises to 69%. By Stansfield's criteria only 9% achieved a normal GRF_{FZ2} [3]. Types 0 and 1 could be considered normal due to variability in normal range. However this does not disguise the fact that the majority of these children are struggling to support their BW in late stance. The majority of CP children referred to the gait laboratory exhibited some degree of reduced GRF_{FZ2} and can be categorised as having a 'Ben Lomonding' gait pattern. Crucially, almost 40% of these CP children were unable to support their BW in late stance and a further 30% were in difficulty supporting BW. This questions the philosophy of treatments aimed at improving function in the early stance phase. Perhaps the focus should be on the late stance of the trailing limb in preparing the body for weight transfer to the leading limb.

References: [1] Perry J, Burnfield J 2010, Gait Analysis: Normal and Pathological Function, SLACK Inc, Thorofare. [2] Gage JR (2004). Patient assessment: The treatment of gait problems in cerebral palsy. J. Clinics in Developmental Medicine; 164: 71-80. [3] Stansfield B, Hillman S, Hazlewood EM, Lawson AM, Mann AM, Louden I (2001). Sagittal joint kinematics, moments and powers are predominantly characterised by speed of progression, not age, in normal children. J. J Pediatr Orthop; 21: 3: 403-411

Disclosure: No significant relationships.

O23

ADDRESSING HOMOGENEITY BETWEEN AFFECTED AND UNAFFECTED SIDES AND UPPER AND LOWER EXTREMITIES IN UNILATERAL CEREBRAL PALSY

D. Lundh[1], S. Coleman[2], J. Riad[3]
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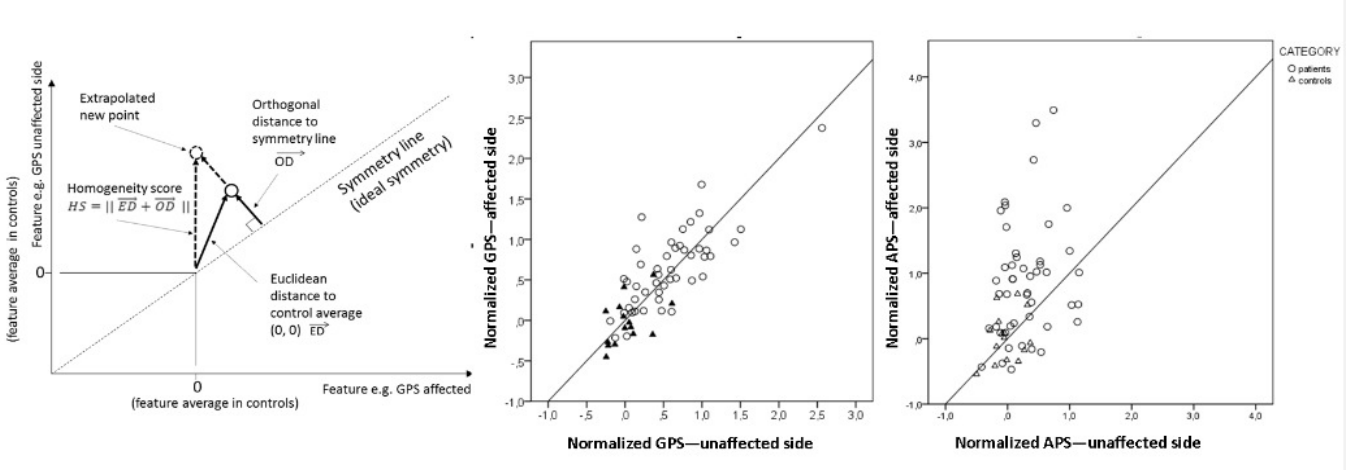
Introduction: In spastic unilateral cerebral palsy (CP) the degree of involvement in the upper and lower extremity with movement deviations in gait have a pronounced individual variety. It can be difficult to define the movement pattern deviation and the often noticeable asymmetry. In this paper we address both the affected and unaffected sides, as well as upper and lower extremities in patients with mild spastic unilateral CP. The aim was to assess the homogeneity (uniformity) in movement pattern during walking.

Patients/ Material and methods: Forty-seven patients, mean age 17.1 years (range 13.1 to 24.0 years), 24 females and 23 males and 15 matched healthy controls had their gait recorded using kinematics from three-dimensional analysis, including the upper and lower extremities. Data were collected for the pelvic and hip in three dimensions, knee flexion/extension, ankle dorsi/plantar flexion and foot progression. For the upper extremity shoulder- elbow- and wrist flexion/extension, and shoulder abduction/adduction were included. The Gait Profile Score (GPS) [1] and Arm Positioning Score (APS) [2] on both sides could be calculated from these variables and were used as a measure of deviation.

Results: The patients' GPS was not different between sides (p=0.207), but the APS revealed higher (p=0.000) deviations on the affected side compared to the unaffected side There was no difference of left and right side in the control group (GPS; p=0.475, APS; p=0.601). The GPS and APS on the affected side was higher (p<0.002) compared to the control group. To address the homogeneity we used an asymmetry index based on normalizing the deviation by the average control deviation.



The homogeneity score (HS) was derived by superimposing two vectors; the vector representing the Euclidean distance (ED) from the control group average and the vector representing the orthogonal distance (OD) to the symmetry line. A classification was made based on the HS similarity to the controls by comparing affected and unaffected sides for lower and upper extremities, respectively. The controls maximal value was used for classification (for lower extremity the threshold was 0. 81 and for upper extremity 1.17).

Discussion & Conclusion: We present a measure to calculate homogeneity for movement in all four extremities operating on any set of variables, which is necessary for comparing different limb variables of the upper and lower extremity. By testing this measure on this population four groups emerged; Group I very little deviation overall, Group II lower extremity affected only (lower limb monoplegia), Group III upper extremity affected (upper limb monoplegia) and Group IV with essential the same degree of deviation on the lower and upper extremity (classic hemiplegia). These measurements can help identify patterns that can be of importance in treatment planning and in prognosis.

References: [1] Baker, R., et al., The gait profile score and movement analysis profile. Gait Posture, 2009. 30(3): p. 265-9. [2] Riad, J., et al., Arm posture score and arm movement during walking: a comprehensive assessment in spastic hemiplegic cerebral palsy. Gait & Posture, 2010. 33(1): p. 48-53.

Disclosure: No significant relationships.

16:00-17:00 - IMAGING METHOD, RUNNING, PRESSURE DISTRIBUTION

O24

PLANTAR FLEXOR MUSCLE VOLUME AND CONCENTRIC WORK IN UNILATERAL CEREBRAL PALSY

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Introduction: In children with spastic unilateral cerebral palsy (CP) the far most common surgical procedure is lengthening of the Achilles tendon. About half of the patients with unilateral CP will require a lengthening at 5 -8 years of age and of these around a third will need another lengthening in adolescence (Miller). With muscle lengthening there is always a concern about losing strength. The involved side is already shorter and smaller and the influence of muscle volume differences on muscle work capacity is not well known in CP. The aim of this study was to assess muscle volume and concentric muscle work differences of the plantar flexors in a group of teenagers and young adults with and without previous surgery.

Patients/ Material and methods: Thirty patients, 15 females and 15 males, mean age 18.2 years (range 13.0-24.0 years) were included. Eighteen had previous surgery and 12 not. All were GMFCS I and according to the modified Winters classification type 0 or type 1 (Riad). Three-dimensional gait analysis and Magnetic resonance imaging was performed.

Results: The surgical group had lower ($p<0.001$) muscle volumes on the affected side compared to the non-surgical group. There was no difference on the un-affected side and no difference between the surgical and non-surgical group regarding muscle work.

Plantar flexor muscle, volume (cm^3) and work (Joule/kg)

	Non surgical group mean and standard deviation	Surgical group	p-value
Volume affected side	900 (191)	605 (171)	<0.001
Volume un-affected side	1146 (312)	958 (249)	0.092
Work affected side	0.22 (0.06)	0.20 (0.07)	0.389
Work un-affected side	0.36 (0.08)	0.31 (0.07)	0.063

Discussion & Conclusion: In unilateral CP concentric muscle work (contraction with shortening) from the plantar flexors, normally the main source for propulsion in walking, is decreased compared to the un-affected side. This is caused by inability of adequate and well-timed contraction and often because of equinus positioning of the ankle joint, due to muscle contracture. We conclude that surgical Achilles tendon lengthening in unilateral CP not adversely decreases muscle work performance even though there are differences in muscle volumes comparing surgical and non-surgical groups. Even in mild unilateral CP a good positioning of the foot is of greater importance than muscle volume in the plantar flexors for the ability to perform muscle work during walking.

References: Miller F. Cerebral palsy. New York, NY: Springer, 2005 and Riad J, Haglund-Akerlind Y, Miller F. Classification of spastic hemiplegic cerebral palsy in children. J Pediatr Orthop. 2007;27:758–764.

Disclosure: No significant relationships.

O25

THE INFLUENCE OF DIFFERENT IN-SHOE INSERTS ON THE PLANTAR PRESSURE DURING THE GAIT OF HEALTHY ELDERLY PEOPLE

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Introduction: The shoe inserts have been widely used in the management of the foot and lower limbs positioning alterations as well as relief the high pressure zones on the foot plantar surface. However, it is not well established the effect of different in-shoe inserts position and height on the plantar pressure distribution during gait. Besides, considering that 11% of the elderly population has problems with mobility (1), and that the use of in-shoe inserts can influence decisively the quality of his gait (2), the purpose of this study was to compare the effect of six different in-shoe inserts on the plantar pressure distribution during the gait of healthy elderly people.

Patients/ Material and methods: It were enrolled in this study 21 people (68.3 ± 9.4 years old and 66 ± 9 kg) with any gait disorder. To baropodometric gait characterization a pressure plate (Footscan, RsScan, Olen, Belgium) was used. The participants walked with self-selected speed over an 8 m walkway and seven conditions were tested: the normal gait (CC) and wearing six different in-shoe inserts: two lateral with height of 1cm (1L) and 2 cm (2L), placed under the 5º metatarsal; two medial placed with height of 1.1 cm (1M) and 2.2 cm (2M) under the longitudinal foot arch and; two posterior with height of 0.9 cm (1P) and 1.8 cm (2P), placed under the calcaneous. For the acquisition of the pressure plate data, the FootScan 7 gait 2nd generation (RsScan, Olen, Belgium) software was used. The plantar surface was divided in six regions: medial and lateral rearfoot, medial and lateral midfoot, and medial and lateral forefoot. The pressure peak was calculated for each region and to compare the conditions the one-way ANOVA test was used with a significance level of α=0.05, the SPSS (v.17; SPSS Inc, Chicago, IL, USA) software was used.

Results: Mean and Standard deviation (SD) of the peak pressure of each plantar region

	Medial FF		Lateral FF		Medial MF		Lateral MF		Medial RF		Lateral RF	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
CC	172.8	47.6	179.0	59.4	115.1	53.6	154.5	78.2	223.6	59.6	222.9*	61.5
1L	195.8	70.1	180.7	46.1	129.1	52.8	145.1	63.7	259.9	72.0	256.7	61.9
2L	200.4	78.4	198.7	50.0	131.6	41.4	127.9	63.5	284.6	73.7	330.4*	113.2
1M	182.9	60.8	176.2	50.2	116.9	47.8	124.3	59.2	199.2	47.5	195.1	53.3
2M	201.5	82.5	190.2	64.7	139.6	47.3	149.4	59.1	207.4	60.3	221.8	73.8
1P	192.4	65.6	174.1	63.9	108.9	49.9	140.0	77.0	218.6	77.3	213.1	63.4
2P	193.4	64.2	182.7	58.3	113.3	52.6	148.8	71.2	222.0	39.2	230.1	35.2

Pressure unit: %BW/cm^2*100; RF: rearfoot; MF: midfoot; FF: forefoot; * statistical difference from normal condition with $p<0.05$.

Discussion & Conclusion: The results showed no differences between the control condition and the tested shoe inserts, with exception of 2L on the medial forefoot region. We hypothesized that healthy individuals have the ability to adapt their gait in order to keep the normal pattern, consequently, no differences would be found in the pressure distribution. However, this assumption could not apply to populations with special gait conditions where these inserts might affect their gait.

References: [1] Kerrigan DC, Lelas JL, Goggins J, Merriman GJ, Kaplan RJ, Felson DT. Effectiveness of a lateralwedge insole on knee varus torque in patients with knee osteoarthritis. Arch Phys Med Rehabil, 2002;83:889-93. [2] Van Gheluwe, B., & Dananberg, H. J. (2004). Changes in plantar foot pressure with in-shoe varus or valgus wedging. J Am Podiatr Med Assoc, 94(1), 1-11.

Disclosure: No significant relationships.

O26

A COMPARISON OF SHANK SEGMENT PARAMETERS BETWEEN HEMIPLEGIC AND TYPICALLY DEVELOPING INDIVIDUALS

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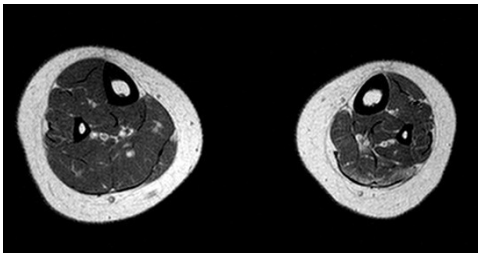
Introduction: Limb segment parameters are important in the calculation of joint moments and forces in gait data. It has been shown that the use of cadaver data in lieu of age correlated data can affect calculated moments in younger populations. [1] However, to date, there have been no studies attempting to quantify such parameters in adolescent children with Cerebral Palsy (CP). It is known that in hemiplegic CP there is often both a discrepancy in limb length and size with the affected limb often being smaller than the healthy one. Quantification of such differences can lead to improved accuracy in calculations of joint forces and moments in gait analysis.



Patients/ Material and methods: After being approved by relevant IRBs, archival MRI data from from 10 hemiplegic and 10 typically developing individuals between the ages of 7 and 25 years were used to calculate the center of mass (COM) location and fractional body mass (FBM) of the shank. These parameters were compared both within and between the CP and TD groups using non-paired, one-tailed t-tests to determine if any differences were significant.

Results: Comparison of the mass of the unaffected leg to that of the affected leg in the CP group showed that the affected leg was lighter than the affected leg being on average 0.87 ± 0.07 of the unaffected leg's mass. In the TD group the average ratio of the mass of the lighter to the heavier legs was 0.97 ± 0.05 indicating much more homogeneity between limbs. The FBM, calculated by dividing the mass of the segment by the body mass of the subject, was significantly lower ($p < 0.01$) for the CP group's affected leg than for either their unaffected leg or for the TD group. Calculation of COM values for the shank indicated that the COM was slightly (but significantly) more proximal in the affected leg of the CP group than for the unaffected leg or for the TD group.

	COM (%prox)	FBM (%)
TD	40.8 ± 0.7*	4.2 ± 0.4
CP Affected	39.3 ± 0.7*	3.7 ± 0.4*
CP Unaffected	40.0 ± 1.2*	4.2 ± 0.4

Discussion & Conclusion: Values for the COM as measured from the proximal joint compare favourably with literature values [2][3] for the TD group and for the CP group's unaffected leg. While the affected leg's COM distance was smaller, this difference was negligible. More important in gait analysis calculations is the FBM which is used to calculate the gravitational force on the segment's COM, and for the calculation of the torque due to the moment of inertia. Since the affected limb segments have both a smaller mass (by nearly 13%) and the mass elements are, on average, closer to the axis of rotation, the moment of inertial in the affected limbs will likely be very much smaller than for the unaffected limb. This suggests that there is a need to quantify segmental inertial parameters in the CP population so as to improve the accuracy of joint moments and forces.

References: [1] Ganley KJ, Powers CM. Clinical Biomechanics 19 (2004) 50-56. [2] Dempster WT. Annals NY Academy of Sciences, 63:559-585, 1956. [3] Clauser CE, McConville JT, Young JW. Technical Report AMRL-TR-69-70 (AD-710 622), 1969.

Disclosure: No significant relationships.

O27

UPMOVE: UNRAVELING PATTERNS OF HUMAN MOVEMENTS

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Introduction: For humans, recognizing running, walking, shuffling or limping appears quite easy [1]. By contrast, an automatic classification of patterns remains a challenge, but is a pre-requisite for objective assessment of gait. Simple measures like step length and frequency have been used for gait classification with limited success. We are developing a classifier system that integrates analyses of multivariate time series and state-of-the-art techniques for pattern recognition. The new system, called UPMOVE, will be useful for fundamental understanding of human locomotion and the diagnosis and evaluation of (pathological) gait.

Patients/ Material and methods: UPMOVE is being developed in Matlab, using object oriented programming. All methods are implemented as separate modules, making the system very flexible and easily extendable. The main workflow consists of a feature extraction phase and a classifier phase. Feature extractors are methods that extract relevant measures from the data, reducing dimensionality and redundancy. From each data set, multiple features are extracted. Features can be simple measures such as step length, step frequency and velocity. We supplement these more conventional approaches by more recent findings from dynamical systems theory, in general, and coordination dynamics, in particular. That is, measures like Lyapunov exponents, scaling exponents, and the eigenvalues of a principal component analysis [2]. These features are then fed into a classifier, which assigns each data set to one of several classes, e.g., male vs. female, young vs. elderly or normal vs. specific pathologies. The classifier will be based on pattern recognition techniques and artificial neural networks, such as self-organizing maps (SOM), learning vector quantization (LVQ) and support vector machines (SVM) (see, e.g., [3]).

Results: Not applicable.

Discussion & Conclusion: Our main objective is to construct a classifier system that can discriminate gait patterns. By changing the input to the classifier, relevant (diagnostic) characteristics can be sought for optimal separation of different gait patterns. In this way, we will also be able to pinpoint information on which differences in gait are judged. UPMOVE is currently in active development, and will be made available open source via www.upmove.org. By choosing for an open source environment, we stimulate collaboration and future development. Initially, UPMOVE will have a text-based interface, making it easy to adapt and improve. Once thoroughly tested, UPMOVE will be extended with a graphical user interface, making it suitable for use in both the lab and the clinic.

References: [1] N. Troje, Decomposing biological motion: A framework for analysis and synthesis of human gait patterns. Journal of Vision, 2(5), 2002.
[2] A. Daffertshofer, C. Lamoth, O. Meijer, and P. J. Beek. PCA in studying coordination and variability: a tutorial. Clinical Biomechanics, 19(4): 415-428, 2004.
[3] D. Janssen, W.I. Schöllhorn, K.M. Newell, J.M. Jäger, F. Rost and K. Vehof, Diagnosing fatigue in gait patterns by support vector machines and self-organizing maps. Human Movement Science, DOI: 10.1016/j.humov.2010.08.010, 2010.

Disclosure: No significant relationships.

O28

EFFECTS OF CHEMODENERVATION OF THE RECTUS FEMORIS MUSCLE IN ADULTS WITH SPASTIC PARESIS AND A STIFF KNEE GAIT: A SYSTEMATIC REVIEW.

IMAGING METHOD, RUNNING, PRESSURE DISTRIBUTION

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Introduction: A Stiff Knee Gait (SKG) is characterised as a diminished knee flexion during swing. Most common cause of SKG is an overactivity of the Rectus Femoris (RF) muscle. The treatment options for SKG such as Functional Electrical Stimulation and RF transfer in adult patients are scarce and not often used in clinical practice. Chemodenervation is thought to have beneficial effects on walking ability, but results reported in literature, are scarce and inconsistent. The primary objective of this systematic review is to determine the effect of chemodenervation (motor branch blocks (MBB) and neuromuscular blocks (NMB)) of the RF on peak knee flexion during swing phase in patients with spastic paresis. Secondary objective is to determine whether this treatment results in an improvement on functional outcome measures in adult patients.

Patients/ Material and methods: A computerized literature search was conducted in Embase, PubMed, CINAHL and the Cochrane library, using MESH terms. Included were studies with adult patients, suffering from a central neurological disorder and a 'stiff knee' gait pattern, treated with MBB and/or NMB. Outcome measures included at least knee flexion during swing phase. Methodological quality was scored following the criteria developed by Downs and Black. Weighted means were calculated and a Best Evidence Synthesis (BES) was used to categorize the evidence.

Results: Literature search yielded 508 articles. The selection procedure led to the inclusion of 6 articles [1-6]. Two articles describe two different studies leading to a total of eight studies. (4 NMB and 4 MBB studies). Knee flexion during swing improved in all eight studies. Knee flexion increased statistically significant in all four NMB studies, varying from 5° [2,6] till 9° [3] with a weighted mean of 6,3°. Knee flexion increased statistically significant in three out of the four MBB varying from 1,9° [4] to 15, 4° [1] with a weighted mean of 10,2. Methodological quality of 3 studies was scored as high (≥17) and five studies were scored as low (<17). BES showed that there are 'indicative findings' for the effect of NMB and 'no evidence' for the effect of MBB on knee flexion during swing. Six (3 NMB and 3 MBB) out of eight studies reported walking speed as a functional outcome measure. Walking speed improved significantly in only 1 NMB study [3] (0.61 to 0,74 m/s). In the 4 MBB studies no significant improvement on functional outcome was recorded. BES showed that there is 'no evidence' for the effect of NMB or MBB on functional outcome.

Discussion & Conclusion: Knee flexion in all eight studies included in this systematic review increased with a weighted mean of 6.3° for NMB and 10.2° for MBB. However, the methodological quality of the selected studies is low and adequate indication setting for intervention is lacking.

References: 1. Sung(2000) 2. Caty(2008) 3. Hutin(2010) 4. Chantraine(2005) 5. Robertson(2009) 6. Stoquart(2008)

Disclosure: No significant relationships.

O29

JOINT KINEMATICS IN RUNNERS WITH PATELLOFEMORAL PAIN SYNDROME

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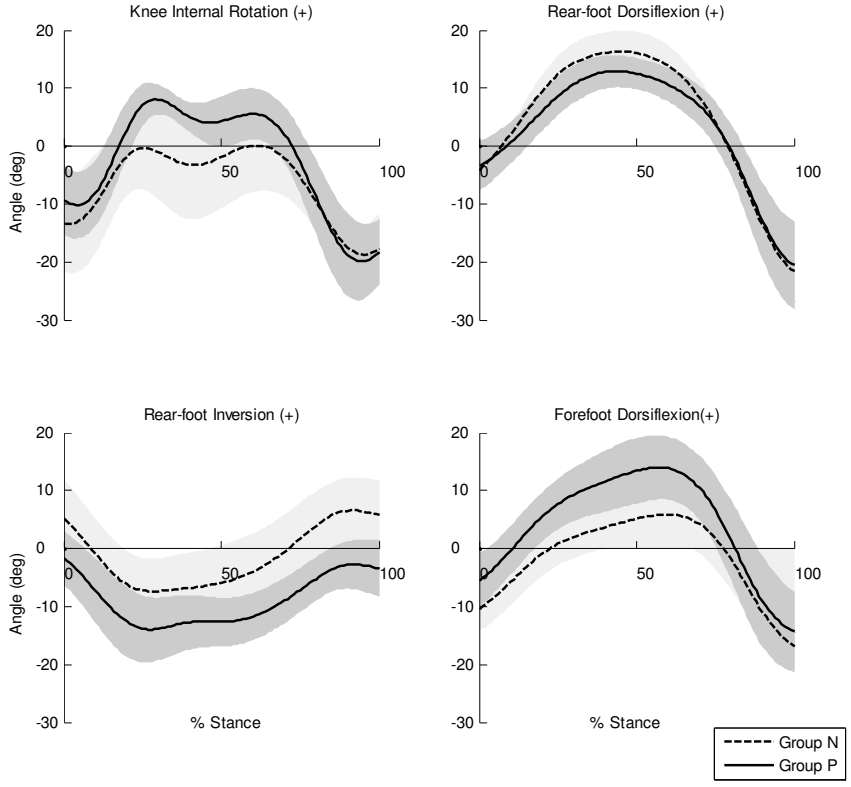
Introduction: Patellofemoral pain syndrome (PFPS) is the most common overuse injury in distance runners. Prolonged rear-foot eversion is believed to cause prolonged tibial internal rotation and excessive femoral internal rotation, and predispose runners to PFPS (1). The aim of this investigation was to compare hip, knee and tibial rotations, and rear-foot and forefoot joint angles between runners predisposed to PFPS and normal controls during barefoot, treadmill running.

Patients/ Material and methods: Six mid-foot-strike (MFS) runners with a history of PFPS and six MFS runners with no history of PFPS participated in the study. Spherical reflective markers (9-mm) were attached to anatomical landmarks of both lower limbs (2). A 12-camera Vicon MX System (Vicon Motion Systems, Oxford, UK) was used to collect 3-D spatial data at 200 Hz as the subject ran barefoot on a treadmill at 3.56 ms^{-1}. The timings of foot-strike and toe-off were identified using kinematic methods (3). Joint angles were calculated using Vicon Plug-in Gait (hip) and the Oxford Foot Model (knee and foot) (2). Five strides of each subject were normalised to the stance period using cubic spline interpolation. Joint angles at foot-strike and toe-off, peak and times to peak angular values, and angular excursions for forefoot and rear-foot plantar/dorsiflexion, rear-foot inversion/eversion, and tibial, knee and hip rotation were identified for each of the five strides of each subject. The variables were compared between runners with and without a history of PFPS using notched box-plots.

Results: Rear-foot eversion (peak and angle at toe-off) were significantly greater in runners with a previous history of PFPS compared to healthy controls (Figure 1). Runners with a history of PFPS exhibited decreased rear-foot dorsiflexion (peak and excursion) compared to healthy controls, although these differences were not significant. Knee internal rotation (peak and excursion) and forefoot dorsiflexion (peak) were higher for runners with a history of PFPS compared to healthy controls, although these differences were not significant.



Discussion & Conclusion: It was proposed that the increased rear-foot eversion that was observed in subjects with a history of PFPS was secondary to the reduced dorsiflexion at the rear-foot that was also observed (4). This mechanism allowed the runners to gain additional dorsiflexion at the forefoot. Rear-foot eversion is coupled with internal rotation of the tibia (5) and so corresponds well with the increased knee internal rotation that was observed in runners with a history of PFPS. The theory that prolonged rear-foot eversion causes prolonged internal rotation of the tibia and excessive internal rotation at the hip, and predisposes runners to PFPS was not supported (1).

References: 1. Tiberio (1987) JOSPT, 9 :160-16 2. Stebbins, et al. (2006) Gait Posture,23:401-410. 3. Leitch, et al. (2011). Gait Posture,33:130-132. 4. Phillips and Phillips. (1983). JAPMA, 73:518-52. 5. Lundberg et al. (1989) Foot Ank 9, 304-309.

Disclosure: No significant relationships.

09:00-10:00 - SIMULATIONS

O30

ULTRASOUND MEASURES OF MUSCLE STRUCTURAL PATHOLOGIES RELATED TO IMPAIRED POWER PRODUCTION DURING GAIT IN CHILDREN WITH CEREBRAL PALSY

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Introduction: The muscle is a highly adaptive tissue; it responds rapidly to mechanical stress and changes in activity [1]. It has been shown in hemiplegic patients that muscle volume was significantly reduced at the involved leg and biarticular muscles were predominantly affected [2]. However it is not known whether structural changes in the muscle tendon unit are directly related to muscle power during gait. The Hypothesis investigated in this study is that asymmetries of muscle structure in children with cerebral palsy correlate to asymmetries in power production during gait?

Patients/ Material and methods: Sixteen children with cerebral palsy were gait analysed using an 8 camera Vicon system. Muscle structure (tendon-aponeuroses and fiber lengths, as well as angle of pennation) of medial gastrocnemius (MG) was determined using ultrasonography. Hereby the patients were seated on a chair and the ankle joint was passively moved by the examiner from maximal plantar to maximal dorsiflexion, while the joint angle and position of the ultrasound probe was monitored with the Vicon camera system. Left – right differences in ankle joint energy (integrated positive power curve) were correlated with differences in the muscle structure at neutral ankle angle.

Results: Significant correlations with the ankle joint energy at push off were shown only for asymmetry in tendon and aponeurosis length ($R=-0.58$, $p=0.027$). The tendon-aponeuroses lengths were 3.7% longer, the fiber lengths were 0.4% shorter and the angle of pennation was 0.9° smaller at the more involved leg with lower power production.

Discussion & Conclusion: Asymmetries in muscle fiber and tendon-aponeurosis lengths show clinically significant correlation to power production during gait, therefore impairment during gait can be directly related to structural changes in the muscle tendon unit. Although power production is reduced, the greater tendon-aponeuroses-length at the weaker leg might be a useful adaptation of the muscle-tendon unit. A longer tendon length has a greater potential for passive energy-storage and release [3], which might be a positive function when fascicle contraction is impaired by the spasticity. These adaptations should therefore be discussed in conventional or surgical interventions of MG that aim to improve its function during gait.

References: [1] Ponten et al. 2008, J. Neurol Sci 266:52-6 [2] Lampe et al. 2008, Brain Dev 28:500-6 [3] Böhm et al. 2006, J Appl Biomech 22: 3-13.

Disclosure: No significant relationships.

O31

HOW PATHOLOGICAL GAIT KINEMATICS, INCREASED FEMORAL ANTEVERSION AND NECK SHAFT ANGLE ADVERSELY AFFECT THE LOADING CONDITIONS OF THE FEMORAL HEAD DURING GAIT IN CHILDREN WITH CEREBRAL PALSY.

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Introduction: Children with cerebral(CP) present an aberrant gait pattern, often characterized by increased hip flexion, adduction and endorotation. With growth, they develop aberrant hip geometry, presenting increased neck-shaft angle (NSA) and increased femoral anteversion (FA). In this study, we used subject-specific musculoskeletal (MS) modeling and inverse dynamic analysis t in control subjects and children with CP. We analysed the effect of altered gait on hip contact forces during gait and compared for the CP subjects the additional effect of proximal femoral geometry on the loading of the proximal femur. palsy (CP) present an crouched gait pattern, characterized by increased hip flexion.

Patients/ Material and methods: For ten control subjects and ten subjects with diplegic CP presenting increased FA (25°- 56°) and NSA (136° - 160°), a generic musculoskeletal model was scaled based on a static Mocap trial. For both groups, subject-specific kinematic and kinetic gait data were imposed on each model. Muscle activation patterns were computed using static optimization, minimizing the sum of muscle activation. 3D hip contact forces were computed using an established workflow[1]. For the CP population, a second analysis was performed where the MS models were individualized by adjusting the FA, NSA and neck length to the femoral geometry extracted from T1 Weighted MR images using the deform tool in Simm (Motion Analysis corp). Maximal contact forces and associated inclination angles of the total contact force were calculated. Differences in loading conditions between control and CP-subjects were analysed using a Man Whitney U test. For the CP subjects, differences between generic and individualized models were analyzed using a Wilcoxon-matched pairtest

Results: Using a generic model, CP gait induces significantly increased resultant and vertical contact forces (respectively 23% and 25% of Body Weight (BW)) compared to control subjects. On the contrary, medio-lateral forces are significantly reduced with 70% of BW. The orientation of the loading configuration is however not significantly altered. In the CP subjects, including subject-specific hip geometry results for identical kinematic and kinetics in a significant reduction of the anterior-posterior and medio-lateral component of the hip contact force with respectively 40% and 20 % of Body Weight. However, the vertical and resultant contact forces still exceed control values. In the deformed models, the contact force is more vertically oriented presenting an average increase of the angle with respectively 20° and 15° in the fontal and sagittal plane. Consequently, excessive anterior and vertical alignment of the contact force is observed.

Discussion & Conclusion: CP gait kinematics and kinetics induce higher loads on the proximal femur compared to control subjects. The reduced medio-lateral component is indicative of compromised hip stability in CP subjects when compared to control subjects. The presence of aberrant femoral geometry reduces the excessive vertical loading of the femur during gait in CP subjects, however still above control values. The observed reduction in the medio-lateral component of the hip contact force in the deformed models indicates that aberrant musculoskeletal hip geometry induces a less favourable orientation of the hip contact force and further compromises hip joint stability.

References: [1] Lenaerts, J Biomech, 2008.

Disclosure: No significant relationships.

O32 CANCELLED

O33

POPLITEAL ANGLE AND STRAIGHT LEG RAISING: CLINICAL AND MUSCULOSKELETAL MODELING ASSESSMENT.

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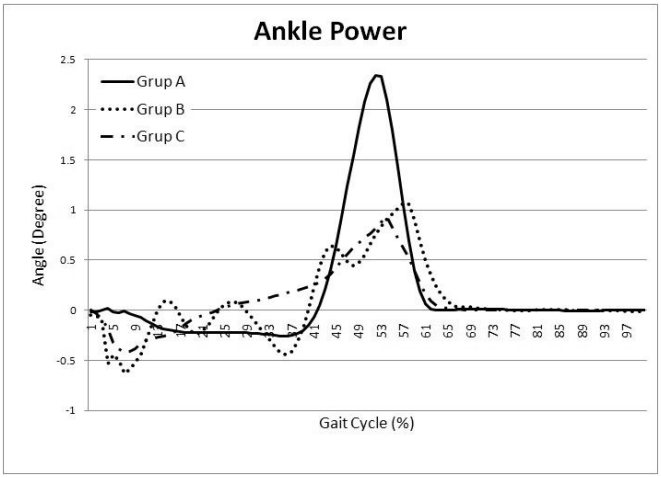
Introduction: Two different clinical tests are used to assess hamstrings contractures: the Popliteal Angle (PA) at V1 (V3 of Tardieu's scale for spasticity) and the straight leg raising (SLR). Why two tests? What do they really measure? PAV1, PAV3 and/or SLR are they able to predict brief hamstrings during gait in spastic cerebral palsy children?

Patients/ Material and methods: 200 lower limbs clinical exams are used to assess the covariance of the two tests. Basic and musculoskeletal simulations are achieved to study the angle-length curves of both tests. Hamstrings length during gait and their maximum length, simulated from goniometric data, are compared for 72 lower limbs of patients who underwent clinical gait analysis associated to musculoskeletal modeling.

Results: PAV1 and SLR are non-covariant (<0.5). SLR angle-length curve is quasi linear while PA one is asymptotic (Figure1). Maximum walking length and muscular length simulated with SLR and PAV1 inputs are statistically different ($p<0.05$). PAV3 simulated length is equivalent to maximum walking hamstrings length ($p=0.8$).



Discussion & Conclusion: SLR and PA are fundamentally different. SLR has ideal angle-length curves in order to quantify the variation of the hamstrings contractures. PAV3 can help to predict the maximum walking hamstrings length in spastic CP children. This one is therefore not only a spasticity assessment tool it can also help in treatment decision of the gait abnormalities caused by short hamstrings.

References: [1] K. Desloovere, et al., Gait & Posture, vol. 24, no. 3, p. 302–313, 2006. [2] S. L. Delp, et al., J. Orthop. Res., vol. 14, no. 1, p. 144-151, 1996. [3] N. S. Thompson, et al., J. Pediatr. Orthop., vol. 21, no. 3, p. 383-387, 2001. [4] A. S. Arnold, M. et al., Gait & posture, vol. 23, no. 3, p. 273–281, 2006. [5] M. Louis et al., OTSR, vol. 94, no. 5, p. 443-448, 2008. [6] E. Desailly, Ph. D. Thesis, Poitiers, 2008.

Disclosure: No significant relationships.

O34

SIMILAR MUSCLES CONTRIBUTE TO HORIZONTAL AND VERTICAL ACCELERATION OF THE CENTER OF MASS IN FORWARD AND BACKWARD WALKING

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Introduction: Backward walking (BW) is often considered a simple reversal of forward walking (FW). Therefore a single neural mechanism such as a central pattern generator is often hypothesized to be responsible for both FW and BW. In this study we want to investigate whether similar muscles remain responsible for accelerations of the center of mass (COM) as gait direction reverses. However, we expect a reversal of muscle function in the horizontal direction (i.e. decelerators become accelerators and vice versa), while muscle function in the vertical direction remains unchanged.

Patients/ Material and methods: Ten subjects (age 26.1± 4.3) walked forward and backward on a treadmill at 4 km/h. Three-dimensional kinematics, ground reaction forces and EMG were collected. A musculoskeletal model (27 DOF, 92 muscles) was scaled to the subject's anthropometry. OpenSim [1] was used to generate subject-specific simulations of walking. A perturbation analysis computed contributions of individual muscles to the horizontal and vertical acceleration of the COM. We identified the muscles that, together with gravity, generated ≥80% of acceleration. The right leg step cycle was taken as reference and will be referred to as the "ipsilateral" side.

Results: Forward walking. During double-limb support, contralateral plantarflexors (cPF, 38.4%) and ipsilateral dorsiflexors (iDF, 14.2%) contributed most to horizontal acceleration, while ipsilateral and contralateral quadriceps (iQUAD, 30.1% and cQUAD, 21.1%) accounted for most of the horizontal deceleration of the COM. Contralateral PF (39.2%) and iDF (8.7%) also provided support, assisted by ipsilateral vastus (10.3%). During single-limb support, ipsilateral gastrocnemius (13.6%), iDF (11.1%) and gravity (13.5%) accelerated the COM forward. Ipsilateral quadriceps (38.6%) continued to decelerate the COM, together with iPF (33.1%). Ipsilateral gluteus medius (iGMED, 19.5%), iPF (35.2%) and iQUAD (14.2%) contributed to upward acceleration.
Backward walking. During double-limb support, cPF (34.4%) contributed most to deceleration of COM. Ipsilateral PF (14.8%) also contributed largely to deceleration, however no substantial contribution was found to forward acceleration. Ipsilateral dorsiflexors (22.1%) were mainly contributing to backward acceleration, while contributions to forward deceleration were much smaller. Bilateral quadriceps (cQUAD, 25.3% and iQUAD, 8.57%) assisted backward acceleration. Similar to FW, iDF (35.3%) and cPF (29.0%) produced most of vertical support. During single-limb support, iDF (20.7%), iGMED (14.4%) and gravity (12.0%) accounted for most of the deceleration. Ipsilateral quadriceps (28.5%) continued to accelerate BW, together with iPF (39.1%). Combined accelerations of ipsilateral GMED (22.8%), gluteus maximus (11.8%), soleus (13.6%), DF (11.5%) and QUAD (18.7%) accounted for most of the upward acceleration.

Discussion & Conclusion: Muscles contributing to progression and support of the COM are similar for FW and BW, although relative amounts of the contributions differ. Our results confirm a reversal of muscle function in horizontal direction; muscles responsible for acceleration in FW decelerate BW and muscles that impede progression in FW, are contributing to acceleration in BW. In the vertical direction the function of muscles remains the same, with similar muscles providing support in FW and BW.
These findings suggest that BW and FW are controlled by identical muscle coordination, therefore making the need for additional neural control mechanisms redundant.

References: [1] Delp et al. IEEE Trans Biomed Eng. 2007;54(11):1940–50.

Disclosure: No significant relationships.

O35

JOINT MOMENTS IN CHILDREN WITH CEREBRAL PALSY BASED ON BIOMECHANICAL MODELS

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Introduction: Cerebral Palsy (CP) is resulting from a static injury to the developing brain. An abnormal motor control with associated delay in onset of walking and an abnormal gait pattern (crouch gait) are commonly characteristics to this type of injury. Subject specified 3-dimensional computational models of the musculoskeletal system will be used for the calculation of the muscle function during gait. To asses the models we will use for further simulations we compared the possible net joint moments in several degrees of freedom.

Patients/ Material and methods: We performed gait experiments of 2 children with cerebral palsy and of a control group of 5 age-matched healthy subjects to get motion capture data and ground reaction forces. Electromyography was only recorded from the healthy subjects. For the lower limbs Magnetic-Resonance-Imaging was taken for all subjects. We created musculoskeletal biomechanical models based on a template-model in OpenSim [1]. After scaling of the template model according to anatomical landmarks [2] the parameters of each muscle in the models were customized according to the individual MRI-based anatomical data. The coordinates of the muscles attachment points, where extracted from a manual segmented MR-data-set. This was done by taking into account biased limb positions during image capture [3]. The parameters for the Hill-type [4] muscle-model in particular maximum isometric force, optimal muscle-fiber-length and tendon-slack-length where set according to calculation algorithms described in [3].

Results: We calculated the net joint moments and all individual muscle contributions in the models over a typical range of motion of all joints in the lower limbs with OpenSim. The results were compared to data from a scaled generic model [5].
Even if the net joint moment in CP-children is lower due to weaker muscles the results indicate no significant differences in net joint moment due to biased bone geometry or shifted muscle attachment points in CP-children.

Discussion & Conclusion: We might have to change this calculation and take into account the special physiological conditions in CP muscles. The derived net joint moments only represent the maximum possible joint moment without taking into account passive forces and spasticisms of antagonists.

References: [1] Delp 2007, OpenSim: Open-Source Software to Create and Analyze Dynamic Simulations of Movement. IEEE Transactions on Biomedical Engineering. 54(11) [2] Hainisch et. al, Scaling of biomechanical models: A comparison of motion tracking markers and anatomical landmarks, 9th International Symposium on computer Methods in Biomechanics and Biomedical Engineering, Valencia 2010.
[3] Hainisch et al, METHOD for Determination of Musculotendon Parameters in A Subject-Specific Musculoskeletal Model of a child based on MRI Data, Proceedings of Euromech Colloquium511, 3/2011 [4] Hill, The heat of shortening and the dynamic constants of muscle. Proceedings of the Royal Society of London Series
[5] Anderson, A dynamic optimisation solution for a complete cycle of normal gait, Dissertation, University of Texas 12/1999

Disclosure: No significant relationships.

O88

QUANTIFYING GAIT DEVIATIONS IN PATIENTS WITH RHEUMATOID ARTHRITIS USING THE GAIT DEVIATION INDEX

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Introduction: Patients with Rheumatoid Arthritis (RA) and involvement of the lower limbs may demonstrate gait deviations (1). Despite deviations in kinematic and kinetic parameters gait deviations in these patients are commonly evaluated using stride parameters, such as walking speed, stride and step length, functional tests or questionnaires. In 2008 the Gait Deviation Index (GDI) was published (2).The GDI demonstrates good face and concurrent validity for patients with CP but its suitability for patients with RA has not been evaluated. We aimed to quantify gait deviations, as GDI scores, in patients with RA in relation to healthy persons without gait deviations and to examine the relationship between the GDI, stride parameters and functional disability.

Patients/ Material and methods: Sixty-three patients with RA (mean age (SD) 57(13) yrs) and 59 age matched adults (mean age (SD) 54 (15) were selected from our database. All patients were diagnosed with RA and had a history of lower limb involvement. None of the patients had undergone any major lower limb treatment and all ambulated without walking aids. No attempts were made to select patients based on medical treatment. Three-dimensional lower extremity joint kinematics and stride parameters of independent barefoot walking were collected. Mean GDI of the left and right side of three representative strides were used in the calculations. Walking speed, stride and step lengths were normalized to body height. Functional disability was evaluated using the Health Assessment Questionnaire (HAQ). Descriptive statistics characterized the sample and correlational analyses were used to examine relationships between variables.

Results: Patients with RA had significantly lower GDI compared to the healthy controls (mean (SD) RA GDI; 85,1(12) controls 99,1(9) p=0,000). GDI values for both patients with RA and healthy controls were normally distributed. GDI values from patients with RA showed statistically significant correlations with walking speed (r=0,54, p=0,000), cadence (r=0,25 p=0,046) , stride (r=0,60 p=0,000) and step length (r=0,60 p=0,000) double limb support (r=-0,64 p=0,000) and HAQ (r= 0,33 p=0,008).

Discussion & Conclusion: The GDI was able to differentiate the joint kinematics, described as GDI-values, between patients with RA and control subjects suggesting that the GDI is a promising outcome measure of gait deviations in studies including these patients. The GDI demonstrated correlations with stride parameters indicating that greater kinematic gait deviations relate to slower walking speed and shorter stride and step length and longer double limb support. These correlations also indicate that the GDI may provide information on differing aspects of gait compared to stride parameters. The lower correlation demonstrated between GDI and HAQ may be due to the inclusion of upper extremity activities in the scale and the subjective nature of the questionnaire. While kinematic changes can result from reduced walking speed, it is likely that the reduced GDI in this patient group may be related to changes in pathology, such as joint destruction, swollen and tender joints and stiffness, however, these relationships require further investigations (3).

References: [1] Weiss R. Gait & Posture 2008;28:229-234. [2] Schwartz M, Rozumalski A. Gait &Posture 2008;28:351-357. [3] Dubbeldam R. Gait & Posture 2011; 33:390-395.

Disclosure: No significant relationships.

09:00-10:00 - GAIT DISORDERS II

O36

POTENTIAL EFFECTS OF AN INCREASED AEROBIC CAPACITY ON WALKING EFFORT AND WALKING SPEED IN LOWER LIMB AMPUTEES.

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Introduction: Walking with a lower limb prosthesis requires a higher aerobic load than walking with two intact limbs.[1] When this higher aerobic load coincides with a reduced available aerobic capacity, walking becomes strenuous and may even become impossible. When aerobic capacity is increased subjects can either choose to walk at a higher speed with the same relative aerobic load, or reduce the relative aerobic load while maintain the same walking speed. In this study we determined at which relative aerobic load subjects choose to walk, and estimated the effect of a 10% increased in aerobic capacity on either walking speed or relative aerobic load.

Patients/ Material and methods: A total of 36 people walking with a prosthesis were included and grouped according to cause of amputation (i.e. trauma, n=26 or vascular deficiency, n=10). An additional 21 healthy age-matched subjects were included as the control group (overall age was 61.6 ± 6.3, n=57). Peak aerobic capacity was determined during a graded one-legged peak exercise test. The relative aerobic load was calculated as the ratio of aerobic load and peak aerobic capacity while walking at the preferred walking speed (PWS) and at speeds 15 and 30% higher and lower than PWS. The relative aerobic load was determined as a function of walking speed (Figure 1).

Results: When walking at PWS, the traumatic amputee subjects walked at a relative aerobic load of 50.1%, this was similar to that of able bodied controls (48.7%, p=1.0). They accomplished this by reducing their walking speed with 22.8% compared to controls (p<.001, Figure 1). Interestingly, this resulted in a PWS that was lower than their most economic walking speed. Even though the vascular amputee subjects reduced their walking speed even more, they were unable to reduce the relative aerobic load (70.9%) to the level of the able bodied control subjects (p<.001). Based on the regression equations, we estimated that a 10% increase in aerobic capacity will potentially result in a 9.1% decrease in relative aerobic load when walking at the same PWS. Alternatively, when maintaining the same relative aerobic load, traumatic and vascular amputee subjects could potentially increase their walking speed by 13.9% and 17.2%, respectively.

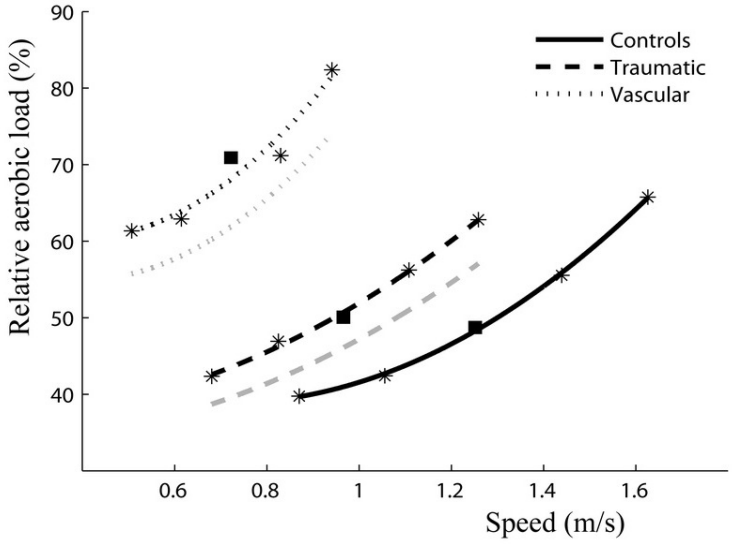

Figure 1. Relative aerobic load as a function of walking speed. The lighter curves represent the relative aerobic load for that specific group when aerobic capacity is increased with 10%. The squares represent PWS.

Discussion & Conclusion: Traumatic amputees might benefit by increasing their peak aerobic capacity as this would enable them to walk at a higher, and more economic, walking speed while maintaining the same relative aerobic load. People with a vascular amputation use a much larger proportion of their available capacity, and therefore, experience walking as more strenuous. These subjects might primarily benefit from an increased aerobic capacity by reducing the relative effort for walking. To sum, improving the aerobic capacity seems to allow traumatic amputees to walk at a more energy efficient walking speed and allows vascular amputees to decrease the relative aerobic load.

References: [1] Waters RL, Perry J, Antonelli D, Hislop H. Energy cost of walking of amputees: the influence of level of amputation. J Bone Joint Surg Am. Jan 1976;58(1):42-46.

Disclosure: No significant relationships.

O37

ADAPTATION STRATEGIES OF PATIENTS WITH A TRANSTIBIAL OR TRANSFEMORAL AMPUTATION DURING LEVEL WALKING: A SYSTEMATIC REVIEW.

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Introduction: Walking is highly dependent on dynamic interactions between sensory afferents and the central motor program for locomotion. [1] An amputation leads to a loss of sensorimotor function of the amputated body part, thereby affecting gait. During the period of rehabilitation, a person with an amputation learns to compensate for this loss, by adaptation strategies in both the intact leg and the remaining stump. This systematic review aims to describe the adapation strategies of patients with a transtibial (TT) or transfemoral (TF) amputation in both the intact and amputated leg. Comparisons, in terms of joint power or work, are made with able-bodied or normative data.

Patients/ Material and methods: The following databases were searched: Medline, Embase, Cinahl, PEDro, and Cochrane register of controlled trials. Studies were selected when a comparison between (1) intact and amputated leg, (2) intact and a referent leg, or (3) amputated and a referent leg was made. Outcome measures should include joint power or joint work obtained during normal level walking. Eligibility of identified studies was independently assessed by two reviewers. Methodological quality was assessed using the Downs and Black instrument. [2] When results of multiple studies could be pooled, heterogeneity was statistically tested. In case of heterogeneity, random effect models were used instead of fixed effect models. When data could not be pooled, results of individual studies are presented.

Results: A total of 13 studies were identified based on the applied inclusion criteria. Trials studied patients with a TT amputation (n=11), TF amputation (n=1), and both TT and TF amputation (n=1). Results of trials studying TT amputation showed a reduced amount of performed work on knee level of the amputated leg during stance. On hip level, the concentric work of the hip extensor during early stance is increased in the amputated and intact legs when compared to a referent leg. Results of trials studying TF amputation show remarkable similar results on hip level when compared to the trials studying TT amputation. In addition, push-off of the intact ankle is increased when compared to a referent leg.

Discussion & Conclusion: In both TT and TF amputation, adaptations were seen in the amputated and intact leg. The majority of the adaptation can be attributed to a reduced involvement of the amputated leg in weight acceptance, and the loss of ankle plantar flexors. Based on these adaptations it can be concluded that the amputated and intact leg are asymmetrical in function. Striving towards gait symmetry based on the idea that symmetry is more functional, seems therefore inappropriate. Finally, muscle groups were identified, primarily the hip extensor of both the amputated and intact leg, that compensate for the loss of sensorimotor function of the amputated body part. Rehabilitation programs could emphasize on training these muscle groups, thereby enabling maximal adaptability.

References: [1] Rossignol S, Dubuc R, Gossard JP. Dynamic sensorimotor interactions in locomotion. Physiol Rev 2006;86:89-154. [2] Downs SH, Black N. The feasibility of a checklist for the assessment of the methodological quality both of randomized and nonrandomized studies of health care interventions. J Epidiomiol Community Health 1998;52:377-84.

Disclosure: No significant relationships.

O38

SELF-ESTEEM AND SENSE OF COHERENCE IN RELATION TO UPPER- AND LOWER EXTREMITY MOVEMENT DEVIATION DURING WALKING IN TEENAGERS AND YOUNG ADULTS WITH MILD UNILATERAL CEREBRAL PALSY

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Introduction: Individuals with unilateral cerebral palsy are often high functioning although their movement pattern deviates from normal both in gait and arm posturing during walking. Possible influence of movement deviations on self-esteem, sense of coherence and quality of life could be important to consider when counselling teenagers and young adults and making treatment recommendations. A few studies have examined quality of life in relation to severity of involvement in cerebral palsy defined according to the GMFCS. Most report decreased quality of life with increased severity, increased GMFCS, but some report an impact on the quality of life of patients with mild involvement. The aim was to correlate movement deviations with self-esteem, sense of coherence and quality of life.

Patients/ Material and methods: Forty-four patients mean age 17.6 years (range 13.0-24.0 years), 22 female and 22 male participated. Sixteen had left side and 28 had right side involvement. Two were classified as GMFCS II and the rest as GMFCS I. Fifteen matched controls were included. Three dimensional gait analysis was performed with an 8-camera capture system. Movement deviations of lower and upper extremities were calculated as the root mean square. Gait Profile Score (GPS) describes movement deviation from normal in the lower extremity and the Arm Posturing Score (APS) in the upper extremity. Self reported questionnaires “I think I am” (ITIA) measuring self-esteem, Sense of coherence (SOC) and EQ-5D were used.

Results: The patient group rated lower self-esteem (ITIA) than controls (mean 63.4 versus 84.7; $p=0.025$). The sense of coherence (SOC) assessment revealed no difference between the patient and control group, mean 62.8 and 64.6 respectively ($p=0.595$). Nor did the Quality of life (EQ-5D) assessment with a mean of 78.3 and 81.1 respectively ($p=0.573$). Leg movement deviation GPS was significantly greater among patients than controls (6.9 versus 4.1; $p<0.001$). Arm movement deviation in the APS was also more pronounced among patients (mean 10.5 versus 5.7; $p<0.001$). APS correlated with both SOC (coefficient -0.375; $p=0.05$) and ITIA (coefficient -0.397; $p=0.001$). No significant correlations were found between GPS and SOC or ITIA.

Discussion & Conclusion: Our findings suggest that there is an impact on self-esteem in teenagers and young adults with mild unilateral CP. We draw the same conclusion as Russo et al, namely that self-esteem and self-concept can be affected by physical impairment in highly functioning patients with unilateral CP, which was clearly reflected in the subscales “physical appearance” and “skills”. When evaluating teenagers and young adults with unilateral cerebral palsy one should be aware of their possible low self-esteem. Greater deviation in arm movement seems to be correlated with lower self-esteem and sense of coherence.

References: 1. Antonovsky, A., Unraveling the Mystery of Health. 1987 2. Ouvinen-Birgerstam, P. I think I am, Manual. 1999 3. EuroQol--a new facility for the measurement of health-related quality of life.1990 4. Pirpiris, M., et al., Function and well-being in ambulatory children with cerebral palsy. 2006 5. Russo, R.N., et al., Self-esteem, self-concept, and quality of life in children with hemiplegic cerebral palsy. 2008

Disclosure: No significant relationships.

O39

THE INFLUENCE OF AUDITORY CUEING ON SAGITTAL KINEMATICS IN HEALTHY ADULTS

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Introduction: 'Every feature of walking changes when speed changes'[1]. Research demonstrates that several gait parameters are altered by a change in velocity[2, 3]. Pathological gait is often characterised by a reduction in self selected (SS) velocity, it is often difficult to differentiate between the effects of pathology and the effects of velocity on gait. The aim of this study was to investigate the influence of controlling velocity with an auditory cue (AC) on sagittal kinematics.

Patients/ Material and methods: Participants were recruited from the staff and student body of the Faculty of Health Sciences. Those with a leg length discrepancy of greater than two inches, a history of musculoskeletal disease or, lower limb injury in the last six months were excluded from participation. Participants attended the gait laboratory and were fitted with 22 light emitting diodes (LED). They then traversed a 10m walkway which ran between two CODA CX1 cameras. Participants first walked at their SS velocity. Their SS cadence was then calculated and participants then walked to an audible cue set to their SS cadence. Left side sagittal plane hip, knee and ankle range were selected for analysis. Correlations, paired t-tests and limits of agreement were utilised to assess the relationship between parameters with and without an AC[4].

Results: Thirty participants (15 male; 15 female) completed the test session (age 25.8 ± 8.6; height 173.0 ± 9.4 cm; weight 72.9 ± 11.7 kg). Results of statistical analysis are presented in table 1.

	SS mean ± s	AC mean ± s	Pearson's correlation coefficient	t-test p value	Bias	Limits of agreement
Hip range	40.7° ± 4.6°	41.1° ± 4.6°	0.7	0.5	0.4	-6.4 → 7.2
Knee range	64.8° ± 4.0°	65.0° ± 4.0°	0.8	0.8	0.2	-5.4 → 5.7
Ankle range	35.1° ± 7.3°	34.6° ± 8.9°	0.5	0.7	-0.5	-16.4 → 15.3

Table 1: s = standard deviation

Discussion & Conclusion: A strong linear relationship was present for hip and knee range and, a moderate relationship for ankle range with and without an AC. Utilising an AC to control velocity had no significant effect on sagittal plane hip, knee and ankle range of movement. Negligible bias was calculated for hip, knee and ankle range. The limits of agreement for the hip, knee and ankle were 17.7%, 8.7% and 47.0% of the overall mean respectively. The use of an AC to control velocity during gait analysis in healthy adults appears to have a small affect at the knee, a larger effect at the hip and a major affect at the ankle.

References: [1] Inman VT, Ralston, H.J. and Todd, J. Human Walking. Baltimore: Williams and Wilkins; 1981. [2] Hanlon M, Anderson R. Prediction methods to account for the effect of gait speed on lower limb angular kinematics. Gait & Posture. 2006;24(3):280-7. [3] Schwartz MH, Rozumalski A, Trost JP. The effect of walking speed on the gait of typically developing children. J Biomech. 2008;41(8):1639-50. [4] Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. 1986 Feb 8;1(8476):307-10.

Disclosure: No significant relationships.

O40

MECHANISMS UNDERLYING SPEED CHANGES AFTER CHEMODENERVATION INTERVENTION IN LIMITED AND FULL COMMUNITY AMBULATORS WITH STROKE

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Introduction: Post-stroke spasticity can interfere with function, cause disturbances in gait and can be a source of significant disability. Clinical interventions often prioritize diminishing spasticity through the utility of chemodenervation with botulinum toxin in suitably targeted muscles. Although previous research has shown that intramuscular injections of botulinum toxin decrease spasticity and improve ankle range of motion, there is a paucity of information demonstrating how these improvements translate into functional improvements in gait [1,2]. Identifying the functional improvements in gait after chemodenervention is important to evaluate the response to treatment and to quantify important treatment effects that would otherwise go undetected by more global outcomes such as gait speed. The purpose of this investigation was to quantify the mechanisms underlying speed changes after chemodenervation intervention in individuals with stroke to more objectively evaluate functional improvements in mobility.

Patients/ Material and methods: Eight male participants diagnosed spasticity and equinovarus (57.5±15.4 years, 1.8±0.1m, 91.2±19.8kg), secondary to stroke. All participants were at least 19 months post stroke and currently being treated clinically with botulinum toxin, a chemoneurolytic intervention for spasticity. Wireless pedobarography data was collected bilaterally using the Pedar-x Expert System while subjects performed a 2 minute walk pre and 6 weeks post clinical intervention. Data were analyzed for the first ~30 seconds of the walking test using custom Matlab programming. Average gait speed was calculated during the 2 minute walk pre and post intervention and subjects were grouped according to their pre intervention gait speed (<0.08 m/s limited community ambulation; >0.08 m/s full community ambulation.) Primary outcome variables included impulse (Ns) in the wholefoot, hindfoot, forefoot, heel and toes during initial double support (IDS) and terminal double support (TDS).

Results: Changes in impulse during IDS and TDS on the affected limb, and gait speed post intervention in the limited community ambulators and full community ambulators can be found in Table 1. Timing parameters throughout the stance phase of gait revealed no trends towards significance pre versus post intervention regardless of gait speed.

	Affected Limb IDS Impulse			Affected Limb TDS Impulse			Speed
	Wholefoot	Hindfoot	Heel	Wholefoot	Forefoot	Toes	
Limited	16.1%	13.6%	13.9%	12.2%	15.0%	9.5%	16.0%
Full	-12.2%	-14.7%	19.0%	-10.7%	-10.1%	-10.8%	5.2%

Discussion & Conclusion: This preliminary investigation shows that the effects of chemodenervation in individuals with stroke vary depending on pre treatment ambulation category. Limited community ambulators received a greater benefit from chemodenervation. The increased gait speed in limited community ambulators was attributed to an increased propulsive force (forefoot impulse) during TDS on the affected limb while increased speed in the full community ambulators can be attributed to decreased braking forces (hindfoot impulse) and better weight acceptance on the affected limb. Further research is needed to understand the relationship of chemodenervation intervention on functional and mechanical characteristics of gait for individuals stratified by ambulation category.

References: [1] Cardoso, E., Pedreira, G., Prazeres, A., Ribeiro, N. & Melo, A.2007. Does botulinum toxin improve the function of the patient with spasticity after stroke? Arq Neuropsiquiatr, 65, 592-5. [2] Bleyenheuft, C., Cockx, S., Caty, G., Stoquart, G., Lejeune, T. & Detrembleur, C.2009. The effect of botulinum toxin injections on gait control in spastic stroke patients presenting with a stiff-knee gait. Gait Posture, 30, 168-72.

Disclosure: No significant relationships.

O41

CARDIORESPIRATORY LOAD OF WALKING IN A GAIT ORTHOSIS COMPARED TO ASSISTED OVERGROUND WALKING IN NON-INDEPENDENTLY WALKING STROKE PATIENTS

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Introduction: In the last decade, automated walking therapy (as with the Lokomat) has become commercially available to people with gait impairments. During therapy, settings of the Lokomat are adjusted to the needs of a patient to walk comfortably in a kinematically normal gait pattern for the duration of therapy. The advantage of the Lokomat may be the longer and more intense training sessions compared to regular therapy. Higher cardiorespiratory loads than resting levels have already been reported in both hemiplegic patients and healthy subjects (Krewer et al. 2007). However, a comparison between the cardiorespiratory load during walking in the Lokomat and overground walking in severely impaired patients has not been made. The objective of this study was to determine the heart rate and oxygen consumption (VO_2) responses of Lokomat therapy compared to assisted overground walking.

Patients/ Material and methods: Eight non-ambulatory stroke patients (5 men, 57±5 yrs) participated in the study. Heart rate and VO_2 were measured during Lokomat walking and assisted overground walking. During Lokomat therapy (30 minutes), patients walked at speeds ranging from 1.9-2.2 km/hr whereas during at least 3 minutes of assisted overground walking they walked at 0.69±0.20 km/hr (self selected). Furthermore, to check for possible changes over time, 5 patients performed both tests again after 4 weeks.

Results: Both VO_2 and heart rate were significantly lower ($p<0.05$) during Lokomat walking compared to assisted overground walking (9.2 ± 2.4 vs. 11.0 ± 1.6 ml/min/kg, and 94 ± 12 vs. 109 ± 13 bpm, respectively). Data of the tests performed 4 weeks later provided similar results.

Discussion & Conclusion: It can be concluded that the HR and VO_2 responses during Lokomat walking was lower than during assisted overground walking. Most likely, the (weight) support by the gait orthosis has contributed to this difference. Although training sessions can be tolerated much longer using the Lokomat, the lower cardiorespiratory intensity suggests that training effects on this system, if any, may be smal.

References: Krewer et al. Gait and Posture. 2007 sep:26(3) 372-7.

Disclosure: No significant relationships.

11:00-12:00 - CEREBRAL PALSY II

O42

IS INTERLIMB COORDINATION DURING WALKING PRESERVED IN CHILDREN WITH CEREBRAL PALSY?

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Introduction: SUMMARY Objective of the study was to investigate whether the interlimb coordination patterns in children with Cerebral Palsy (CP) are preserved during walking. CONCLUSIONS On average, coordination patterns of arms and legs during walking were found to be quite similar between typically developing children (TD) and CP, except for the coordination between the arms. However, coordination patterns were more variable in CP compared to TD. INTRODUCTION In typical subjects the arm swing plays an important role in the energy expenditure of walking [1]. Arm swing in children with Cerebral Palsy (CP) is altered compared to typically developing children (TD) [2]. In hemiparetic CP the increased arm swing on the non-hemiplegic side was suggested to be a compensatory strategy to increase the angular momentum on that side, so that the total body angular momentum could remain low [3]. Such compensatory behaviour suggests that the altered arm movements cannot be the sole result of passive dynamics (as has been suggested for typical subjects). Thus, interlimb coordination might be altered during walking in CP. Yet, it is still unknown if, and to what extent interlimb coordination during walking is altered in CP gait. To address this issue in the current study, we investigated the interlimb coordination in CP for two walking speeds and compared this to TD.

Patients/ Material and methods: 26 spastic CP (4-12 yr) and 24 TD (5-12 yr) were included. CP included 11 children with hemiplegia (HE) and 15 with diplegia (DI). Total body kinematics were recorded using an 8 camera Vicon system. Three trials were assessed for each condition (preferred speed & fast speed). We calculated mean absolute relative phase (MARP) between upper arm and upper leg segments for trials where participants maintained a 1:1 arm to leg swing ratio. The within subject variability was expressed by the standard deviation of the MARP (SDMARP). To compare the three groups, we used a general linear model with group as a factor, two repeated measures factors (walking condition and limb pair combination) and walking speed as a covariate.

Results: In TD, the percentage of 1:1 coordination trials was 95.6%, while this was 78.1% for DI and 75.5% for HE (table 1). Further analysis of the 1:1 data revealed that HE had significantly lower MARP scores for the coordination between the arms compared to DI and TD. No other group differences were found for other limb pair combinations. Overall, CP had a more variable coordination pattern compared to TD. Specifically, SDMARP between the arms was higher for the CP compared to TD. For HE, SDMARP between the legs was lower compared to the DI, while that between the most affected arm and least affected leg was higher compared to TD.

Discussion & Conclusion: Despite the differences in kinematics between CP and TD, interlimb coordination is preserved in CP except for the coordination between the arms, which might be linked to spasticity and/or compensatory arm swings.

References: [1]Collins et al. (2009) Proc Biol Sci, 276(1673):3679-88. [2]Meyns et al. (2011) Res Dev Disabil, In Press. [3]Bruijn et al. (2011) Res Dev Disabil, Submitted.

Disclosure: No significant relationships.

O43

3D THORAX KINEMATICS DURING GAIT IN CHILDREN WITH CEREBRAL PALSY (CP)

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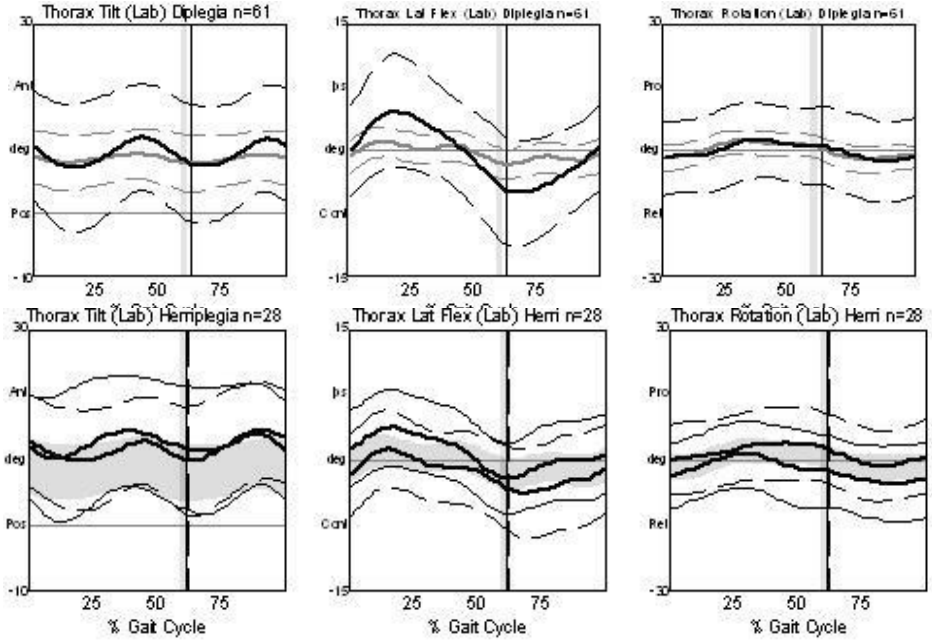
Introduction: 3D thorax data from cohorts of children with spastic diplegia and hemiplegia are presented. The aim of these evaluations was to aid understanding and interpretation of thorax data in children with cerebral palsy (CP). The trunk contributes considerably to both achieving and controlling locomotion (Leardini et al. 2011). As such, a number of clinical gait analysis laboratories routinely record its motion during gait with 3D motion capture. However, limited information is available regarding typical 3D patterns in children with cerebral palsy (CP) and their clinical interpretation (Romkes et al. 2007). This study is part of a service evaluation at Sheffield Children's Hospital Gait Laboratory (SCH) and presents 3D thorax kinematics collected from children attending the laboratory for routine clinical gait analysis.

Patients/ Material and methods: 3D thorax data collected from children with spastic diplegia and hemiplegia, attending SCH gait lab between November 2009 and February 2011 were analysed. This included 61 children with diplegia (GMFCS level I=29 II=32; male=37 female=24; mean ±1sd age= 12.3 ±4.4 years) and 28 children with hemiplegia (GMFCS level I=22 II=6; male=17 female=11; mean ±1sd age= 12.6 ±3.4 years). Data were collected using 8 Vicon (Oxford, UK) MXF40 cameras at 100Hz and processed using the model described by Baker (2006), with markers placed on T2, T10 and the manubrium. An in-house model written in Vicon Bodybuilder was used to calculate the angles between the thorax and lab axis systems.



Results: In children with CP increased thorax excursion is seen particularly in the coronal plane, with a tendency for increased ipsilateral thorax lateral flexion in stance (affected>unaffected side in hemiplegia).

Discussion & Conclusion: At SCH, dependent upon the results of the clinical examination, increased coronal plane thorax excursion is commonly attributed to: compensation for hip abductor weakness to facilitate coronal plane pelvic stability; facilitation of unloading of contralateral limb in pre-swing secondary to plantarflexor weakness (diplegia only); and/or impaired abdominal control/weakness.

References: Leardini A et al. (Mar 16, 2011) Clinical Biomechanics [Epub ahead of print]. Romkes J et al. (2007). Journal of Pediatric Orthopaedics, Part B, 16 (3) 175-80. Baker R (Sept 2006). Seminar: Modelling concepts in Motion Analysis. JEGM, Amsterdam.

Disclosure: No significant relationships.

O44

DISCOVERING OPTIMAL PATIENT SELECTION CRITERIA USING THE RANDOM FOREST ALGORITHM: APPLICATION TO INTRAMUSCULAR PSOAS LENGTHENING

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Introduction: Treatment of hip flexion contractures in children with cerebral palsy has been controversial, and there is a wide variation in reported outcomes and patient selection criteria [1-3]. Advocates of intramuscular psoas lengthening claim the surgery improves pelvis and hip kinematics and kinetics, with little or no associated weakness or surgical complications. Recently, Truong proposed that a good candidate for intramuscular psoas lengthening meets two-out-of-three criteria related to pelvis and hip kinematics [4]. Using a retrospective case-control design, Truong found only weak evidence to support the criteria. There is still a need for explicit, data-based criteria that can identify candidates likely to benefit from psoas lengthening surgery. The Random Forest (RF) algorithm is a new and powerful classifier that is widely used in many fields, but relatively novel to clinical gait analysis [5]. The RF algorithm employs an ensemble of classification trees. Each tree uses a different subset of predictor variables to classify a unique bootstrap sample of the available cases. The overall class assignment for a given case is determined by the votes of the ensemble of trees. The RF algorithm is comparable in accuracy to the best existing classifiers, generates an internal unbiased estimate of the error, and ranks the importance of individual variables to the classification. The goal of this study was to derive patient selection criteria for intramuscular psoas lengthening using the RF algorithm, and to assess the criteria in a retrospective case-control design experiment.

Patients/ Material and methods:

Classes: The goal of the classification problem is to find a set of preoperative variables (predictors) and a set of calculations using those variables (criteria) that can predict whether a subject would have a good or bad outcome from intramuscular psoas lengthening. Outcome was based on sagittal plane pelvic and hip kinematic deviations. A method analogous to that used in the derivation of the gait deviation index (GDI) was applied to the pelvic tilt and hip flexion/extension data to derive a pelvis-hip deviation index (PHiDI). The PHiDI has a normal value of >= 100, and a standard deviation of 10. Good outcomes were defined as PHiDI improvements >5 or a postoperative PHiDI >90. All other outcomes were classified as Poor. **Subjects:** The database at our center was queried for subject sides meeting the following criteria: Diagnosis of cerebral palsy, underwent single event multi-level surgery (SEMLS) defined as more than one major orthopaedic procedures on a given limb, underwent gait analysis 18 months before and 9-24 months after surgery. **Variables:** Predictor variables included 286 parameters related to birth history and diagnosis, prior treatment, function, anthropometrics, physical examination, stride parameters, and gait kinematics. **Building the Classifier:** Subjects were divided into two sets based on whether or not the SEMLS included psoas lengthening surgery (+Psoas, -Psoas). The +Psoas set was used to build a full (286 variable) RF classifier. Variable importance was assessed by examining the impact of individual predictors on misclassification error. A reduced RF classifier was derived using the 24 most important variables. **Evaluating the Classifier:** For the +Psoas group, a confusion matrix was generated to evaluate the accuracy of the classification. For the retrospective case-control experiment, subjects who met criteria and received treatment were labeled as ”cases”, while subjects who met criteria but did not receive treatment were labeled as ”controls”. Pre- and postoperative PHiDI were assessed for cases and controls.

Results: The RF method correctly classified 79% of the +Psoas subjects, with sensitivity = 0.88, specificity = 0.68, positive predictive value = 0.80, negative predictive value = 0.79 [Table 1]. The PHiDI improved by 7.3 for cases and 3.1 for controls ($p < 0.05$, unpaired samples t-test). The predictor variables included birth weight and prematurity, age and mass, stride time and speed, as well as elements of hip flexion, pelvic rotation, knee flexion, and foot progression.

Discussion & Conclusion: Criteria based on the RF algorithm appear useful for selecting patients who are likely to improve their pelvis and hip function following psoas lengthening surgery. Classifier performance was outstanding, based on accuracy and other standard metrics. The case vs. control results demonstrate that the criteria are ”psoas-specific”. That is, the criteria identified patients who benefitted from psoas lengthening beyond what would be expected from a SEMLS that did not include psoas lengthening. Ongoing work involves implementing these criteria in the form of a clinical decision-making support tool, as well as applying this methodology to other surgeries.

References: [1] Sutherland et al. (1997) J Pediatr Orthop, 17:563-570 [2] Novacheck T. et al. (2002) J Pediatr Orthop, 22:158-164 [3] Morais M. et al. (2006) J Pediatr Orthop, 26:260-264 [4] Truong W. et al. (2011) J Pediatr Orthop, in press. [5] Breiman L. (2001) Machine Learning 45:15-32.

Disclosure: No significant relationships.

O45

QUANTIFIED SPASTICITY MEASUREMENT FOR GASTROCNEMIUS AND HAMSTRINGS BY INTEGRATION OF MULTI-DIMENSIONAL SIGNALS, IN CHILDREN WITH CEREBRAL PALSY

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Introduction: An integrated muscle tone procedure was developed for measuring spasticity in children with cerebral palsy (CP). The aim was to integrate three groups of signals during passive movements in different joints, which are (1) stretch characteristics (joint angle parameters), (2) reactive resistance and (3) muscle activity, to provide objective spasticity parameters for lower limb muscles. The current study focused on gastrocnemius(GAS) and hamstrings(HAM).

Patients/ Material and methods: 29 children (5-16years) with CP (10 hemi, 22 di, 1quadri) and 12 age-related typically developing (TD) children were evaluated. The CP group had mild to moderate spasticity (Modified Ashworth 1-3). The GAS and HAM were evaluated by passively moving the ankle and knee through the full range of motion at slow (V0) and medium (V1) velocity and as fast as possible (V2). Stretch characteristics (joint angles, angular velocity, acceleration) were measured using inertial measurement units. Reactive resistance (torque) was estimated using a 6 DoF force transducer and muscle activity of the agonistic and antagonistic muscle groups were recorded using surface EMG (sEMG). sEMG signals were normalized to maximum voluntary contraction (MVC). The measures were collected and analysed using custom made software (Labview®& Matlab®). The average amount of sEMG (= area under the rms EMG-time curve divided by time), and torque at specific joint angles were calculated during a period around the time of maximum velocity. This period of interest was defined as starting 200ms prior to the time of maximum velocity and ending when 90% of the range of motion had been reached. EMG and torque parameters calculated at V0, V1, and V2, as well as their change at V2 with respect to V0, were compared between groups and between muscles. CP patients were also subdivided by Modified Ashworth scores (AS) to allow comparison of lower scores (AS:0-1+) with higher (AS:2-3). Inter groups differences were studied by Mann-Whitney U test ($p_{sign}<0.05$).

Results: Increase in averaged amount of sEMG due to increased stretch velocity was significantly higher in CP compared to TD, for both muscles ($p<0.0001$). Change in torque due to increased velocity at ankle angle of 0° was comparable between both groups, while change in torque at knee angle of 70° was significantly higher for the CP group versus TD ($p<0.0001$). Increase in averaged amount of sEMG and in torque due to increased velocity was significantly higher in high AS versus low AS, only for HAM ($p<0.01$). HAM was characterized by lower spastic threshold velocity (=velocity at EMG-onset) than GAS.

Change parameters for GAS and MEH comparing CP with TD

Change parameters (V2-V0)	GAS		MEH	
Change between low and high	**CP**	**TD**	**CP**	**TD**
average normalized EMG	**7,53**	**0,04**	**9,49**	**0,54**
SD	10,62	0,28	8,86	0,65
p-value	< 0,0001		< 0,0001	
torque at ankle/knee angle(Nm)	**4,20**	**3,45**	**5,96**	**1,73**
SD	2,51	1,67	3,65	1,07
p-value	0,45		0,0007	

Discussion & Conclusion: The results clearly indicated that electrophysiological and biomechanical parameters were able to quantify spasticity. Characteristics of sEMG also allowed to classify patients, by decomposing neurogenic and non-neurogenic spasticity components. It can be concluded that different integrated spasticity parameters, studied for an individual patient or a group of patients, provide quantitative levels of spasticity, which seems to be more sensitive than current subjective clinical spasticity scales.

References: No_references

Disclosure: No significant relationships.

O46

DISCRIMINATION BETWEEN THE NEURAL AND NON-NEURAL ORIGIN OF INCREASED JOINT STIFFNESS OF THE ANKLE IN CEREBRAL PALSY

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Introduction: Cerebral Palsy (CP) is characterized by increased joint stiffness, i.e. resistance to movement which can be of neural or non-neural origin[1] by respectively improper muscle activation and changes in viscoelastic properties of connective tissues. Current manual tests cannot discriminate between underlying contributors to joint stiffness, i.e. elastic 'muscle stiffness', 'viscosity' and 'reflex activity'. Specific therapy aimed at stiffness reduction can therefore not be selected beforehand. De Vlugt et al.[2] developed an assessment method to quantify neural and non-neural contributions to ankle joint stiffness in stroke patients. Stroke patients were distinguished from controls by increased tissue stiffness, viscosity and reflexive torque. We applied aforementioned approach to CP patients.

Patients/ Material and methods: Twenty CP patients (GMFCS level I-III) and fifteen healthy subjects matched for age and sex were seated with their foot fixated onto an electrically powered single axis footplate (MOOG FCS Inc., Nieuw Vennep, The Netherlands). During passive ankle rotations, foot reaction torque and angular displacement were measured. Muscle activation of the tibialis anterior (TA) and triceps surae muscles (TS) was recorded by surface EMG. The motor was driven in either torque mode to assess ankle Range of Motion (RoM) and position mode to impose Ramp and Hold (RaH) perturbations at four different angular velocities (15, 30, 60, 120 degrees/sec) over the full, individually assessed RoM, starting in maximal plantar flexion and ending at the maximal dorsal flexion angle. Subjects were asked to remain maximally relaxed during the entire experiment. A nonlinear neuromuscular model[2] was subsequently fitted onto the total measured ankle torque. Model inputs were recorded ankle angle and EMG signals. Output parameters were elastic tissue stiffness (connective tissue and muscle), viscosity, TA and TS reflex torques. Tissue stiffness and viscosity were determined at the smallest maximal dorsiflexion angle among subjects.

Results: In CP, RoM was smaller and tissue stiffness and viscosity were larger compared to controls, although the difference in tissue viscosity was small. Reflexive torque of TS was substantially increased in CP patients. In contrast to stroke patients, joint stiffness in CP was generally dictated by reflexive torque more than tissue stiffness.

Discussion & Conclusion: Ankle joint stiffness in CP was successfully disentangled in its neural and non-neural components using a nonlinear neuromuscular model. CP patients were distinguished from healthy controls by RoM, TS reflex torque and tissue stiffness. Within the RoM, tissue stiffness was smaller and reflexive torque larger compared to stroke patients. Reduced RoM in CP patients can be explained by the relative short structural length of the muscle tendon complex of triceps surae. The used approach may be successfully applied to select patient and component specific therapy to tune improper joint stiffness in CP. Next steps are to relate outcome parameters to clinical phenotype in a larger cohort of patients, to assess the influence of interventions like casting and botulinum toxin treatment and to relate the currently applied single joint approach to walking ability.

References: [1] Dietz & Sinkjaer, Lancet Neurol 2007;6:725
[2] de Vlugt et al. J Neuroeng Rehabil 2010;7:35

Disclosure: No significant relationships.

O47

CHANGES IN INTER-SEGMENTAL COORDINATION AND GAIT PERFORMANCE AFTER THE RECTUS FEMORIS TRANSFER PROCEDURE IN CHILDREN WITH CEREBRAL PALSY

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Introduction: While the rectus femoris transfer procedure (RFT) has often been shown to improve overall gait performance in children with cerebral palsy (CP) exhibiting stiff knee gait (SKG), few previous studies have investigated inter-segmental coordination (ISC) after surgery using the tools common to dynamic systems theory [1]. ISC is quantified by analytical procedures including phase plane portraits and continuous relative phase (CRP) plots, which describe the elegant interaction between lower body segments as they oscillate in a manner similar to compound pendulums in normal gait [2]. The CRP plot quantifies the uncoupling of lower extremity segment oscillations, a requirement for rapid thigh acceleration in pre-swing, and a precursor to swing period knee flexion. CRP measures of ISC are particularly useful in addressing the impaired knee flexion dynamics characteristic of SKG because kinematic achievements in knee flexion require complex coordination of the thigh and shank segments. A previous analysis demonstrated that changes in thigh/shank (T/S) ISC explained much of the variance in gait performance change after RFT [3]. This retrospective study expands prior knowledge by describing how pelvis-thigh (P/T) and shank-foot (S/F) ISC changes complement T/S change in these patients, leading to a more complete understanding of how lower limb coordination is modified after a successful RFT.

Patients/ Material and methods: The study included 54 subjects (94 legs) with symmetric or asymmetric spastic CP, GMFCS level I-III, and ages between 5–20 years (: 9.8; SD: 3.9). Each subject had pre/post-operative instrumented gait analyses, with post analysis an average of 1.42 years (SD: 1.09) after RFT (with/without concomitant surgery). A group of 35 typically developing children of the same age were used as a reference. Motion data were collected with a 13-camera Vicon MX system with a Bertec force platform array, using a conventional gait model. Gait performance was measured by knee flexion range (RnKF), and knee flexion rate (RtKF) in swing, and Gait Deviation Index (GDI). Custom MatLab programs converted instantaneous joint centers into global segment orientations used to generate CRP plots of the P/T, T/S, and S/F segments. These depicted relative oscillations in distal vs. proximal segments in 1% gait cycle increments. Pre-post differences in extrema and slopes from these curves were tested using paired t-tests (=0.05). R Square statistics estimated variance in RnKF and RtKF change accounted for by T/S ISC change. Pearson r statistics identified relationships between T/S and P/T and F/S ISC change.

Results: Table 1: Overall Gait Performance and ISC Metrics - Group Means, Stdev, and Paired t-test Results

n=94	Overall Gait Perf.			CRP: Pelvis/Thigh			ISC: Thigh/Shank			ISC: Shank/Foot		
	RnKF	RtKF	GDI	Min	Max	Slope	Min	Max	Slope	Min	Max	Slope
Pre-op Mean (SD)	38.0° (11.1)	1.0 (0.4)	68.78 (9.39)	-30.7° (13.7)	45.1° (11.9)	2.6 (1.4)	-69.7° (25.1)	46.5° (13.5)	3.4 (1.3)	-13.0° (27.3)	17.4° (20.9)	3.6 (3.7)
Post-op Mean (SD)	46.1° (12.8)	1.4 (0.5)	75.53 (10.3)	-26.8° (14.0)	40.9° (11.8)	2.5 (1.9)	-83.7° (26.4)	56.5° (13.2)	5.0 (1.3)	1.9° (13.3)	31.3° (19.3)	3.8 (4.0)
p-value	<0.001	<0.001	<0.001	0.0069	0.0011	n/s	<0.001	<0.001	<0.001	<0.001	<0.001	n/s

There were significant changes in gait performance measures and ISC measures including extrema on all three CRPs (Table 1). The change in T/S minimum, reflecting the maximum uncoupling of the thigh before initial swing, accounted for 38% and 41% of RnKF and RtKF change variance respectively. Pearson r statistics revealed moderate correlations of T/S change with P/T and T/S CRP change.

Discussion & Conclusion: This investigation confirms overall gait performance changes after RFT and expands on our previous work to suggest that removing the obstruction to normal knee motion not only restores the typical decoupling of the T/S segments during pre-swing and initial swing, but also promotes reorganization of coordination at adjacent segments. We propose that the biomechanical advantage produced after RFT affords motor control changes that 1) attenuate the strong extension synergy typical of CP that promotes coupling of all lower extremity segments and compromises limb advancement, and 2) reduce compensatory patterns at the P/T and F/S segment pairs. These motor control changes interact with effects of concomitant procedures, which are now under review.

References: [1] Desloovere K et al: “Intra-Limb …” Gait & Posture: v24 (S2), S261-2, JEGM 2006 Amsterdam, Sept 2006. [2] Hurmuzlu Y et al: “Presenting Joint Kinematics of Human …” J. of Biomech, 27(12):1495-1499, 1994. [3] Valvano J et al: “Relationship between Inter-Segmental Coordination …” JEGM 2010 Miami, May 2010.

Disclosure: No significant relationships.

11:00-12:00 - SIT/STAND

O48

SAGITTAL BALANCE: REPEATABILTY OF AN INTERVERTEBRAL NET LOAD EVALUATION PROTOCOL FOR POSTURE ASSESSMENT

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Introduction: Sagittal balance is commonly evaluated on sagittal X-ray of the spine. To do so, geometrical descriptors (such as lordosis, sacral slope) are calculated from anatomical landmarks on these X-rays. A novel approach of the sagittal balance evaluation is proposed, based on the computation of the net loads at the C7-T1, T12-L1 and L5-S1 intervertebral joints. The model is briefly described and an evaluation of the repeatability of the protocol is proposed.

Patients/ Material and methods: Model construction: A set of 34 anatomical markers is defined for the tracking of the lower limbs, the trunk (abdomen and thorax) and the head [2]. Segments lengths, articular centers and anatomical frames are computed from the markers [2] at each time sample. Then, weigth, center of mass and segment inertial parameters are determined for each segment [2]. Finaly, joint net loads are computed in an ascending maneer from two force plateform (one under each foot), except for the loads at the C7-T1 joint obtained from the weigth of the head and neck. Preliminary model evaluation: 2 asymptomatic volunteers were included (1 boy, 1 girl) in the repeatability protocol. The study design was adapted from Schwartz et al. [1], where each volunteer attended 3 sessions for each of the 3 therapists participating to the study. Five standing are recorded for each session, where the volunteer are positionned with one force plateform under each foot and asked to adopt their most natural free standing position. Net joint loads are calculated for each standing. Statistical evaluation of the intra-session, inter-session and inter-therapist variability of the joint net loads are obtained as described in the Schwartz et al. paper, but for one instant of the standing instead of an entire gait cycle.

Results: A total of 84 standing trials are evaluated in this repeatability study (6 were not exploitable). Variability results for the net moments calculated at the spinal joints are reported in table 1. The sagittal plane is the less repeatable one, then in the frontal plane. Intra-session is low compared to inter-session and inter-therapist variability.

		Net moments (Nm/kg)		
Variability	**Joint**	Sagittal	Frontal	Transversal
Intra-session	C7-T1	0.004	0.0013	0
	T12-L1	0.0249	0.0117	0.0056
	L5-S1	0.0192	0.0112	0.0056
Inter-session	C7-T1	0.0067	0.0021	0
	T12-L1	0.0739	0.0395	0.0234
	L5-S1	0.0766	0.0301	0.0234
Inter-therapist	C7-T1	0.0077	0.0025	0
	T12-L1	0.0962	0.0481	0.0241
	L5-S1	0.0953	0.033	0.024

Discussion & Conclusion: These results suggest two things: Either the net load protocol is poorly reproductible, or the natural free standing position is quite variable over time for a same subject. Some geometrical descriptors are currently evaluated from the data, and further data acquisition are planned to answer this question. These results may also imply that postural parameters used to described the sagittal balance, obtained from X-ray, could be weakly reproductible over time for a subject. In conclusion, an evaluation of a protocol aimed to describe sagittal balance for sagittal balance evaluation is proposed and evaluated. This protocol yields to joint net load evaluation as postural descriptors, instead of geometrical descriptors. An advantage of this approach is that postural evaluation could be obtained without radiation exposure.

References: [1] Schwartz M et al.: Measurement and management of errors in quantitative gait data. Gait & Posture, 2004(20): 196-203.
[2] Dumas R et al.: Adjustments to McConville et al. and Young et al. body segment inertial parameters. Journal of Biomechanics. 2007 (40): 543-53.

Disclosure: No significant relationships.

O49

STRIDE AND BALANCE CHARACTERISTICS OF CHILDREN LEARNING TO WALK

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Introduction: It is only recently that motion capture techniques have been employed to measure the evolution of locomotion from the initiation of walking to the emergence of a mature walking pattern. This has proved a useful adjunct to neuro-developmental theory; however the association between motion and development is still poorly understood. The aim of this pilot study was to determine the association between stride characteristics and balance control during the development of walking.

Patients/Materials and Methods: Level walking data were collected from children aged between 9 and 59 months. This included data from 15 children, some of whom attended on more than one occasion, for a total of 24 sessions of data collection. Six children (aged 9 -13 months) were measured during hand-held walking, the remainder during independent walking. Data were collected using a 12 camera, Vicon MX system, using a conventional full body model (PlugInGait, Vicon). A minimum of three trials was collected in each session (each trial containing multiple strides). Lateral and vertical range of motion of the head and calculated centre of mass (CoM) were recorded, along with maximum foot clearance. Walking velocity, step length, step width, and double support time were also recorded. Finally, a symmetry index for foot clearance, step length and step width was calculated. Regression analysis was performed to determine the relationship of each of these variables with age. Intra-subject variation was assessed using inter-quartile ranges and compared across different age brackets.

Results: Stride characteristics were found to vary with age. In particular, significant step length and foot clearance asymmetry existed in early walkers. This became more symmetrical by around 20 months of age (Figure 1). A similar trend was observed in step length and foot clearance variability within subjects, which was greater in early walkers and then reduced by around 20 months. In agreement with the literature, height of foot clearance reduced with age, associated with an increase in walking velocity. Range of lateral motion of the head and CoM also reduced with age (Figure 1), while vertical motion of the head and CoM tended to increase with age. The intra-subject variation in lateral motion of the head and CoM reduced with age, while there was no discernible difference in the vertical range variation across different ages.

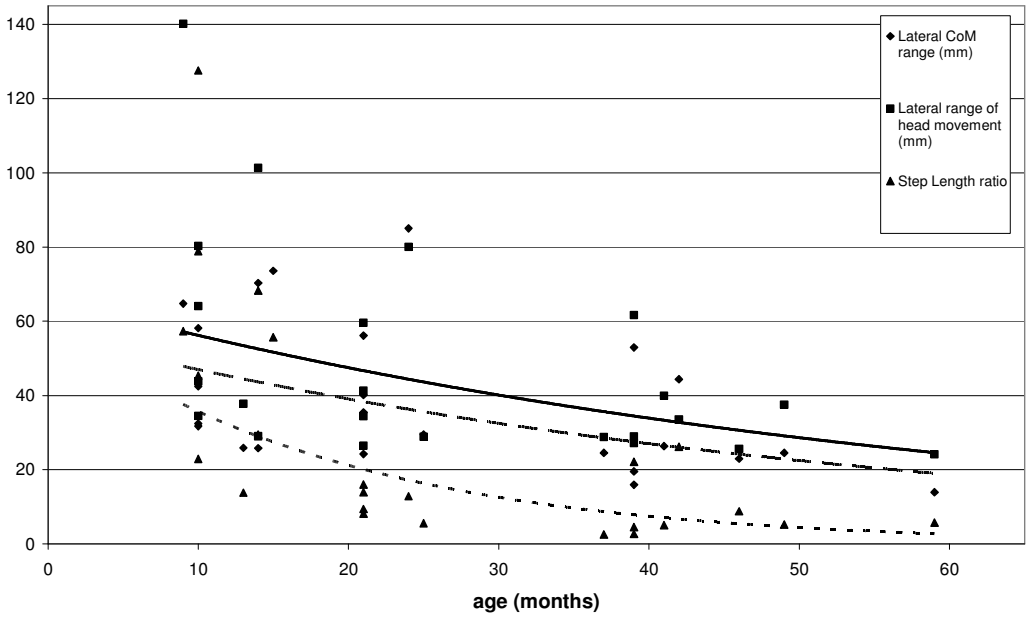

Figure 1: Association between lateral head movement, lateral CoM movement, and step length asymmetry with age.

Discussion & Conclusions: In addition to confirming findings from previous studies, for example increasing foot clearance and velocity with increasing age, along with reduction in lateral motion of the trunk, we report interesting new results in particular regarding gait asymmetry in early walkers. Interestingly, the reduction in asymmetry with increasing age appeared to follow a similar pattern to the reduction in both head and CoM lateral movement. We suggest that this may be because early walkers have immature central control, which causes asymmetrical stepping (both vertically and anteriorly), which necessitates lateral movement at the head and trunk to maintain upright posture. Alternatively, poor balance control in early walkers could lead to the increased lateral sway, which in turn causes asymmetrical stepping patterns to compensate. Further investigation into this relationship is warranted.

O50

THE INFLUENCE OF GAZE BEHAVIOUR ON POSTURAL CONTROL FROM EARLY CHILDHOOD INTO ADULTHOOD

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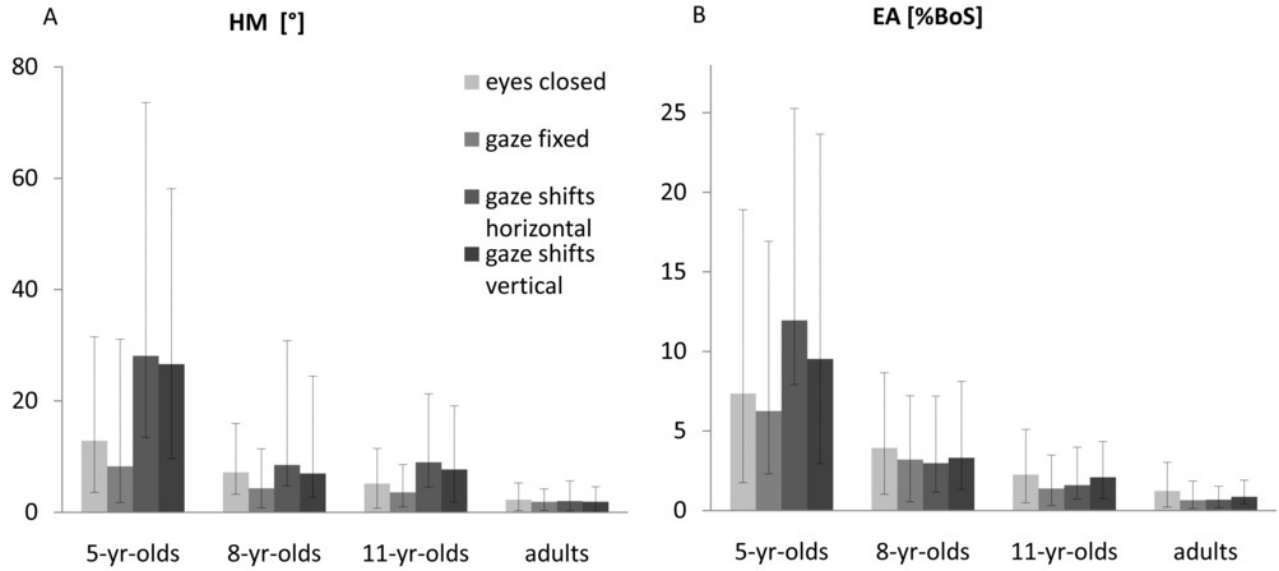
Introduction: The influence of gaze behaviour on postural control in children has not been studied. In adults, results of this influence are highly contradictory: Eye movement has been reported to cause increasing body sway [1], decreasing body sway [2], and unaltered body sway [3]. Primary aim of the present study was to track the development of the influence of natural gaze behaviour on postural control from early childhood into adulthood.

Patients/ Material and methods: Time series of centre of pressure (COP) data and three-dimensional head movement was measured in three children groups aged around five (n=16), eight (n=15), and eleven (n=14), and in one group of young adults (n=15). Four experimental conditions were analysed: quiet stance with eyes closed, with gaze fixed on a dot and with gaze shifts between two dots horizontally and vertically. In order to characterise postural control, magnitude, average speed, and irregularity of COP displacements were calculated from force plate data. In order to characterise gaze behaviour, head movement was determined from the mean range of motion of head yaw, roll and pitch.

Results: Across all conditions, head movement and magnitude of COP displacements (Figure 1) as well as average speed and irregularity of COP displacements significantly decreased with increasing age. Only the 5-year-olds showed a prominent deterioration of postural stability and excessive head movement with gaze shifts.



Discussion & Conclusion: A decrease of magnitude and average speed of COP displacements with increasing age suggests a steady improvement of postural control from five to beyond eleven years of age. The stability decrease in 5-year-olds during gaze shifts might largely be due to excessive head movement. This suggestion is consistent with Assaiante et al. [4], who found that only children aged 7 and up adopted a head stabilisation in space strategy like adults. It would be interesting to investigate whether a lack of head stabilisation also plays a critical role in the decreased postural stability of children with neurological disorders.

References: [1] Glasauer S et al. Neurology 2005; 65:1291-1293 [2] Stoffregen TA et al. Motor Control 2007; 11: 86-102 [3] Rey F et al. Auris Nasus Larynx 2008; 35: 185-191 [4] Assaiante C et al. Neural Plast 2005; 12: 109-118

Disclosure: No significant relationships.

O51

SIMMULATING MUSCLE WEAKNESS BY INCREASING BODYWEIGHT: THE EFFECT OF EXTRA LOAD ON THE SIT-TO-STAND MOVEMENT

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Introduction: Muscle weakness, especially in the knee extensors, is a common problem in the elderly [1]. Changing the load/capacity ratio could be an appropriate method to simulate weakness in young healthy subjects [2]. In order to confirm this assumption, the effect of an additional load on joint kinematics and kinetics should be investigated.

Patients/ Material and methods: Eleven healthy subjects took part in this study (5f, 6m age 28.9 ± 8.2; height 1.78m ± 0.09m; mass 74.1kg ± 14.3kg). They were asked to perform a sit to stand movements (STS) from a bench without back and armrests. Seat height was adjusted to 90°knee flexion; the initial posture for each STS was self selected. Arm position was standardized with both hands in front of the chest. Velocity was self selected "normal velocity". Two different conditions were captured. Condition 1 was normal STS (normal STS). For the second condition (loaded STS) subjects wore a weight vest adjusted to 30% of their bodyweight. Motion was recorded with a 12 camera Vicon system. 3 Kistler force plates measured the force exerted by each foot, and the seat loading. Joint angles, moments, and power of the tree joints of the lower limbs were computed using Vicons Plugin Gait. Peak joint torque and power from each trial was taken into account. Values were normalized to bodyweight or bodyweight plus 30% for condition 2(extra load). A ratio was calculated between the maximum joint torque for loaded STS and normal STS in every joint. This, to see how subjects deal with the increase of additional trunk-weight in their joint kinematics.

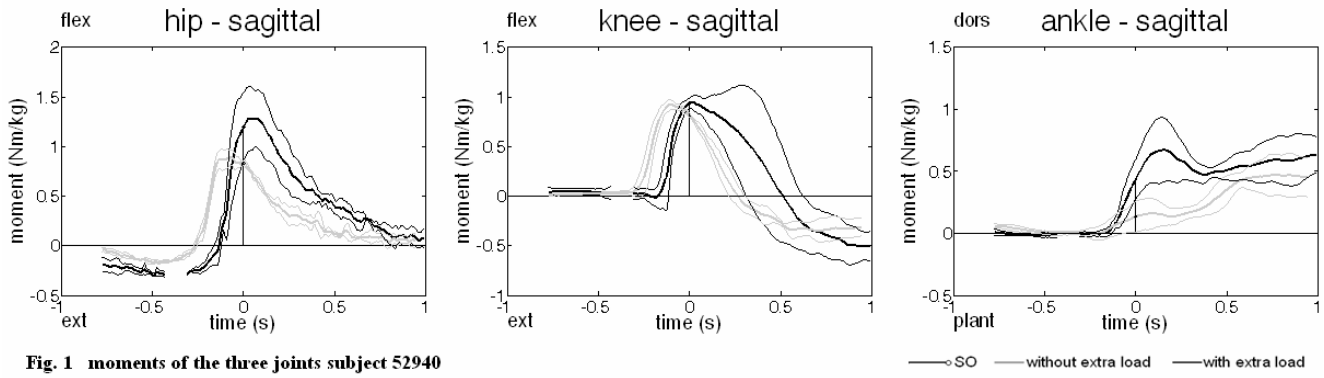

Fig. 1 moments of the three joints subject 52940

Results: The increase in torque is not evenly distributed between the joints. For the knee, the peak moments in loaded STS are lower than those in normal STS. The ratio shows a slight increase in peak torque for the hip joint. In seven of the eight subjects, the peak ankle torque for the extra load condition was increased. The same effect could be seen in the peak joint power. (power-ratio mean ± SD: hip 1,06 ± 0,17; knee 0,83 ± 0,14; ankle 1.30 ± 0,39) Also the kinetics shows an influence through the additional load. Maximal hip flexion in loaded STS is lower than in normal STS. The variability in the curves (angle, moment, power) increased, with respect to normal STS, visible in a greater standard deviation for all 3joints. Subject 52704 shows a different distribution pattern. Here the knee had the highest ratio, while the ratio in ankle and hip joint were lower.

subject	$\frac{\text{peak moment cond. 2}}{\text{peak moment cond. 1}}$		
	hip	knee	ankle
52704	0,77	0,95	0,90
52570	0,84	0,92	1,44
52564	0,91	0,83	1,43
52942	1,12	0,84	0,93
52381	1,03	0,83	1,26
51319	1,04	0,90	1,12
52941	1,09	0,84	1,31
52940	1,24	0,84	1,12
mean ± SD	1,01 ± 0,15	0,87 ± 0,04	1,19 ± 0,19
Tab.1	**moment-ratio**		

Discussion & Conclusion: The results suggest that subjects avoid increasing torque at the knee joint, preferring to distribute the additionally required torques on the hip and ankle joint instead. This pattern has also been found in gait analysis of obese subjects [3]. The inverted distribution-pattern observed in one subject may be due to a different strategy in dealing with increased load. This should be considered for further investigation.

References: [1] Hughes et al.(1996)Journal of Rehabilitation Research and Development33(4) page409-12 [2] Savelbreg H.H.C.M et al.(2007)Clinical Biomechanics22 page805-812 [3] DeVita P. et al.(2003)Journal of Biomechanics36 page1355-1362

Disclosure: No significant relationships.

O52

CORRESPONDENCE BETWEEN KNEE JOINT ANGLE AND MOMENT AFTER SEAT UNLOADING IN SIT-TO-STAND

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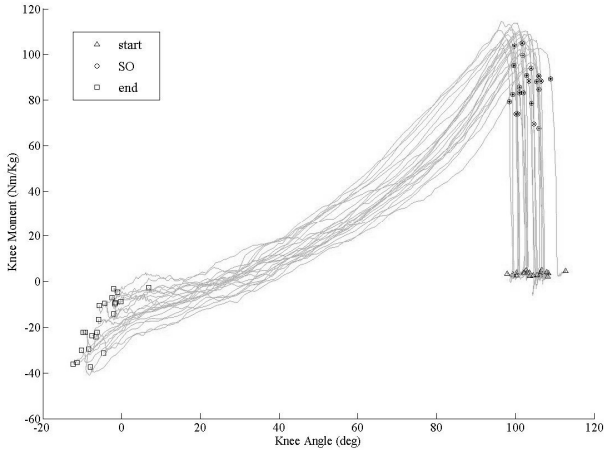
Introduction: The Sit-To-Stand movement (STS) is a key task in daily activities, and can be challenging for the elderly or people with disabilities [1]. Our research group is developing an orthosis for the lower limbs, with a motorized knee joint, to facilitate the task. The design of the device requires deep knowledge of STS kinematics. This paper investigates the relationship between the knee angle and moment in a particular phase of the movement, starting with the unloading of the seat (seat-off, SO) and terminating with the maximum of the knee moment. It is a phase requiring high moments to be exerted in a short time window, hence crucial for the development of an active orthosis/exoskeleton.

Patients/ Material and methods: A group of 11 (5 females, 6 males, aged 28.9(±8.2), height 1.78(±0.09)m, mass 74.1(±14.3)kg) volunteers performed 10 STS movements from a bench without backrest, adjusted in height so that the knees were at 90° of flexion while sitting. Subjects maintained their arms close to the body, and were free to choose their initial sitting posture. Each foot was in contact with a force plate (Kistler), to measure ground reaction forces. A third platform measured bench loading. Movement was recorded with a Vicon system, using marker positions specified by Vicon's "Plug-in Gait" (PIG). Markers were sampled at 120Hz; forces at 1080 Hz. Joint angles and moments were obtained using PIG. The SO event was defined as the time frame in which the force plate under the bench was completely unloaded. Two other events were defined for each STS: start (time frame of the maximal backward leaning of the trunk before SO), and end (full knee extension).

Results: Figure 1 shows the knee moment as a function of the angle for one subject, between start and end. Little angle variation is present while the moment is increased to its maximum just after SO. Considering the group of 11 subject, the maximal joint moment was reached after a delay of 0.07(±0.03)s from SO. In the time window between SO and the instant in which the maximal moment is reached, an increase of 2(±1)° in knee flexion was measured. The average increase in knee moment in the same time window was found to be 6.38(±6.14)Nm, corresponding to a 9.25% increase.



Discussion & Conclusion: The peak moment at the knee during STS is reached very shortly after SO, with little variation of the knee angle. Hence, it may be sufficient to increase knee stiffness maintaining a fixed join angle in order to facilitate the manoeuvre. In the context of a motorized orthosis, this could be achieved with passive element (e.g. a spring-clutch), blocking the knee for a short time following SO. Hence, a less powerful actuator could be used, dimensioned considering the moments (typically lower) required in the other phases of STS and daily activities. The clutch would also serve as a safety feature to avoid joint collapse, a potential cause of STS failure [2].

References: [1] Hanke et al. PhysTher 75(2) pp105-112,1995. [2] Mak et al. PhysTher 91(3) pp1-9,2011.

Disclosure: No significant relationships.

O53

DIFFERENCE OF THE MOTOR STRATEGY BETWEEN SIT-TO-WALK AND GAIT-INITIATION OF PATIENTS AFTER STROKE

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Introduction: The first step of walking begins from various postures in daily living. Most stroke patients spend a lot of time in sitting on chairs or lying down in bed because of their disability. In many occasions, they have difficulty in sit-to-walk (STW) task although they can start walking from standing (GI: gait initiation). The purpose of this study is to examine the difference of the motor strategy between STW and GI tasks of patients after stroke focusing on the first step.

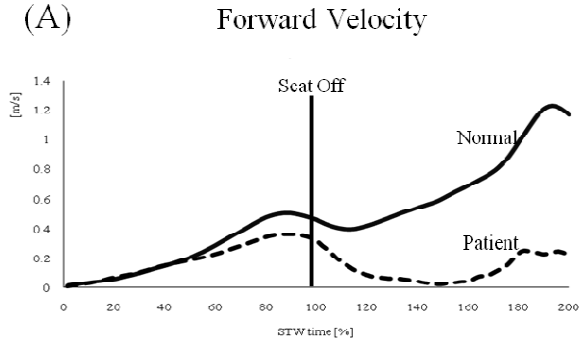
Patients/ Material and methods: Twelve subjects who had sustained stroke and 12 healthy subjects performed the STW and GI. The STW, 5-m walk starting from sitting position and GI from standing position were measured by the motion analysis system (VICON). In both tasks, the affected leg was used for the initial step. The significance of kinematic data between patients and normal subjects, and between the two tasks (STW and GI) were compared using nonparametric Mann-Whitney U test. The probability level was set at $p<0.05$.

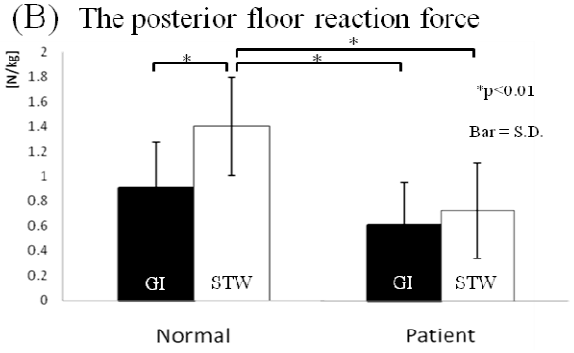
Results: In STW, the decrease of forward velocity at the center of gravity during the first step was significantly larger in patients than in normal subjects ($p<0.01$). Comparing the first step of STW to that of GI, the increase of the step length and the posterior component of the floor reaction force were larger in normal subjects than those in patients ($p<0.01$). The large posterior floor reaction force was found just after seat-off in patients.

Discussion & Conclusion: These results indicate the fact that the normal subjects merged two tasks during movement and showed larger posterior floor reaction force to control residual forward velocity at the first step. On the other hand, the largest posterior floor reaction force was found just after seat-off in patients. This difference showed the difficulty to take large burden of the first step by the affected limb for patients. This might be one of the reasons why patients can not start walking smoothly from sitting position.

References: [1] Francine Malouin. A fluidity scale for evaluating the motor strategy of the rise-to-walk task after stroke. Clin Rehabil 17.: 674-684. 2003 [2] Andy Kerr. Defining phases for the sit-to-walk movement. Clinical Biomechanics. 19(4).: 385-390. 2004

Disclosure: No significant relationships.





14:30-15:30 - UPPER EXTREMITY II

O54

UPPER LIMB MOVEMENT PATHOLOGY IN CHILDREN WITH UNILATERAL CP: THE ARM PROFILE SCORE

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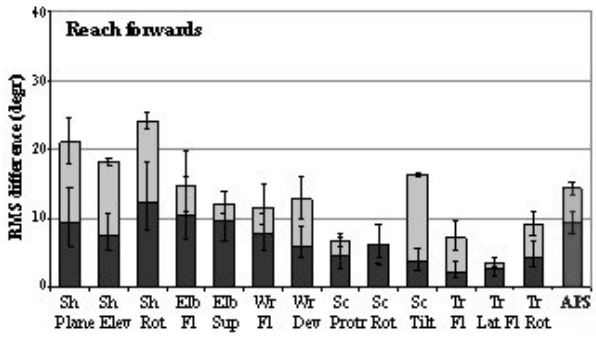
Introduction: Three-dimensional movement analysis (3DMA) is being increasingly used to evaluate upper limb movements, though the interpretation of the multiplicity of data remains complex. We introduced a new summary index, the “Arm Profile Score” (APS), to quantify upper limb movement pathology in children with unilateral cerebral palsy (CP).

Patients/ Material and methods: Twenty children with unilateral CP (10.9ys ± 2.9ys) and 20 individually age-matched typically developing children (TDC) with no history of musculoskeletal or neurological problems (10.9ys ± 3.0ys) were included in the current study. All children were assessed by one trained physiotherapist using a standardized and reliable protocol for the upper limb 3DMA[1,2]. Marker tracking was done with the Vicon MX-system (Oxford Metrics Group, UK) and kinematics were calculated following the ISB-recommendations[3]. In children with unilateral CP, the House-score and clinical measures of muscle tone, manual muscle strength and grip strength were also assessed. The APS was calculated similar to the "Gait Profile Score"[4]. The index is the RMS difference between kinematic data of the individual child with movement deficits and the average data from TDC. The APS can be decomposed into 13 Arm Variable Scores (AVS), representing individual joint angles. The APS, together with the AVS form the “Arm Movement Analysis Profile” (A-MAP; Fig. 1). Intra-session variability was calculated as the median IQR of the APS for each child. Spearman-rank correlation coefficients were calculated between the APS/AVSs and the House-scores and clinical measures of motor impairments[5] for each task.

Results: Intra-session variability was low for the different tasks, with median inter-quartile ranges below 2°. Correlation analysis showed significant good to high negative correlations between the House-scores and the APS, indicating that children with lower House-scores had more deviating joint kinematics. Correlation analysis also showed that increased wrist tone, decreased forearm strength and lower grip strength were highly correlated with higher APS-scores, especially for the reach and reach-to-grasp tasks.



Discussion & Conclusion: This study provided a sound base to use the APS to evaluate upper limb movement pathology in children with unilateral CP. The low inter-quartile ranges indicated that the APS can be used as a reliable measure within a single session for the different tasks. Current results confirmed the role of distal muscle tone and strength in the emergence of upper limb kinematic deficits. This suggests that treatment aimed at distal tone reduction, e.g. BTX-injections, or strength training, might influence the AVS-scores. Further study will need to confirm the value of the APS as an outcome measurement.

References: [1] Jaspers et al. Gait Posture 2011;33:279-285. [2] Jaspers et al. Gait Posture 2011;33:568-275. [3] Wu et al. J Biomech 2005;38:981-992. [4] Baker et al. Gait Posture 2009;30:265-269. [5] Klingels et al. Disabil Rehabil 2010;32:409-416.

Disclosure: No significant relationships.

O55

INTER-GIRDLE COORDINATION WHILE LOCOMOTION UNDER CONSTRAINTS

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Introduction: Human locomotion is characterized by an anti-phase coordination between the pelvic and scapular girdles. Lamoth [1] and Huang [2] reported that humans spontaneously adopt an in-phase intergirdle coordination at low walking velocities, while they adopt an anti-phase pattern at higher velocities. The coordination between girdles pertains also to the specific motion of the arms and the legs. Particularly, the inertial effects of the arm swing contribute to a stable walking pattern [3]. However, an individual may be confronted to situations in which a mobilization of the upper limb may be forbidden. Dynamic Pattern Theory offers tools to identify how limbs are coordinated without reference to underlying mechanisms and how coordinative modes spontaneously arise by some quantities, called order parameters [4-5]. Using concepts and tools of from a dynamical approach to coordination, this study aimed to determine the persistence and the strength of the coordination patterns between the pelvic and scapular girdles when no arm swing was allowed during walking and running.

Patients/ Material and methods: Eight participants were asked to walk or run barefoot on a treadmill under 4 randomized conditions manipulating two factors: Arm ("free swing" vs. "no arm swing") and Velocity (walking and running). The relative phase value Φ, proved to truthfully measure synchronization [5], was assessed by a Continuous Relative Phase algorithm, using a Hilbert transform [6]. The frequency distribution of Φ was computed for every participant in each condition. The analysis of these distributions allowed one to determine the coordination patterns adopted most frequently. Data were analyzed using a (2 Arm × 2 Velocity) ANOVA with repeated measures on both factors with significance level set at $p < 0.05$.

Results: Results showed that an absence of arm swing led to a change from an anti-phase to in-phase pattern and that an increase in velocity in both arm conditions strengthened the adopted pattern more canonical. Moreover, the frequency distribution of Φ with arm swing proved for some participants to be bimodal.

Discussion & Conclusion: Bimodality indicates that the prevailing anti-phase pattern was mixed with a noticeable proportion of in-phase pattern. The presence of the in-phase pattern in the natural locomotion with arm swing manifests its persistence and its stability. It perhaps pertains to its prevalence in earlier times in ontogeny as founded in early acquisition of walking [7] or to its presence in atypical locomotion[8]. Although during unrestrained locomotion the anti-phase intergirdle pattern is naturally adopted, it is the fundamentally more stable in-phase pattern that is used under a higher constraint level. Finally, to characterize the adaptive properties of the locomotor system in the face of varying constraints, intergirdle relative timing could be a pertinent descriptor.

References: [1] Lamoth, C. J. C., et al. (2002). SPINE. [2] Huang, Y., et al. (2010). Gait & Posture. [3] Pontzer, H., et al. (2009). Journal of Experimental Biology. [4] Haken, H., et al. (1985). Biological Cybernetics. [5] Kelso, J. A. S., et al. (1992). Journal of Experimental Psychology: Human Perception and Performance. [6] Pikovsky, A., et al. (2001). Cambridge, Cambridge University Press. [7] Ledebt, A. (2000). Infant Behavior and Development. [8] Wagenaar, R. C., et al. (1992). Journal of Biomechanics.

Disclosure: No significant relationships.

O56

REVERSE SHOULDER PROSTHESIS - MARKERBASED MEASUREMENT OF THE CENTER OF ROTATION LOCALISATION

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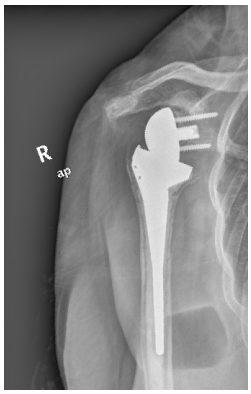

Introduction: A Reverse shoulder prosthesis is a surgical option for patients with irreparable cuff tear arthropathy. It allows restoration of active anterior elevation. This improvement of range of motion is attributed to a medialisation and distalisation (with resprect to the humerus) of the center of rotation to increase the lever arm of the deltoid muscle. It results in a stronger abduction movement. The purpose of this study is to check the medialisation with markerbased motion analysis techniques.

Patients/ Material and methods: Nine patients were enrolled who underwent reversed arthroplasty (Aequalis Reversed; Tournier, Lyon, France) for massive and irreparable cuff tear arthropathy.

All patients were examined before the operation and six months after surgery in a motion analysis study using the Heidelberg Upper Extremity Model (HUX) [1].

This model is based on functional methods to estimate the shoulders centers of rotation. In this study its localisation is determined in medio-lateral direction in a thorax based coordinate system. To make pre- and postoperative measurements comparable a static relaxed posture is choosen with arms in a hanging position and the hands laying on the ipsilateral knees.

Results: Six patients show a medialisation of shoulders center of rotation about 8,3±2,8mm (mean/std) postoperative. For the nonaffected contralateral side the difference between the two measurements is -0,3±2,7mm.

Three patients have to be excluded due to a too small preoperative range of shoulder motion (smaller then 30°).

Discussion & Conclusion: The expected effect of the medialisation of the center of rotation cauld be checked by markerbased motion analysis techniques. The high reproducibility of the method is reached by functional rotation center estimation and the measurement in a relaxed and well repeatable static pose. Unfortunately not all of the patients are able to execute the functional movements for shoulder joint center estimation with sufficient range of motion. The algorithm for center of rotation estimation described in [2] allows a proper estimation based on a smaller range of shoulder motion. The drawback of this algorithm is that it needs three instead of only one marker placed on the humerus [1].
Based on the encouraging results the medialisation is analysed in the ongoing project for more patients. These are measured before and 3/6/12 months after surgery. One interesting question is if the medialisation stays stable or vanishes in a while.

References: [1] Rettig, et al. Gait & Posture 2009; 30(4):469-476
[2] Ehrig, et al. J BIOMECH 2006; 39;2798-2809

Disclosure: No significant relationships.

O57 CANCELLED

O58

UPPER LIMB MOVEMENT CHARACTERISTICS IN CHILDREN WITH UNILATERAL CEREBRAL PALSY

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Introduction: Children with unilateral cerebral palsy (UCP) have an impaired ability to reach, grasp, release and manipulate objects, which impacts on many daily activities. Adequate treatment planning is crucial to improve these children's function and independence in daily life. Three-dimensional movement analysis (3DMA) allows the objective quantification of upper limb (UL) motor performance by means of spatiotemporal and kinematic parameters. The aim of this study was to identify distinct UL movement characteristics in children with UCP compared to typically developing children (TDC) using 3DMA.

Patients/ Material and methods: Twenty children with congenital UCP (10.9±2.9ys) and 20 individually age-matched TDC (10.9±3.0ys) with no history of musculoskeletal or neurological problems were recruited. Children with UCP had to be able to actively grasp and hold an object weakly and were excluded in case of UL surgery or recent BTX-injections. They were sampled across the first 3 levels of the MACS (level I: n=4; level II: n=15; level III: n=1). UL limb task performance was assessed during reach forward (RF), reach to grasp a vertically oriented cylinder (RGV) and hand to mouth (HTM). During testing, children were seated in a custom-made chair with individually adjustable sitting position and reaching distance/height. All tasks were executed with the non-preferred (affected or non-dominant) arm at self-selected speed. Seventeen retro-reflective markers were placed over the trunk, scapula, humerus, forearm and hand in clusters of 3-4 markers[1,2]. Anatomical landmarks were palpated and digitized during static trials[3]. Marker tracking was done with the Vicon MX-system (Oxford Metrics, UK), data was further processed with Matlab® (www.bodymech.be). Kinematics were calculated following the ISB-guidelines[4]. Spatiotemporal (task duration, maximum hand velocity) and kinematic (endpoint joint angles) parameters were compared between both groups using an unpaired t-test. Statistical analysis was done with SAS E-Guide (SAS Institute, Inc., Cary, NC), significance was set at 0.05.

Results: Children with UCP had significantly longer task durations for the 3 tasks and lower maximum velocities during RGV and HTM (Fig. 1). Children with UCP used more trunk flexion (±5°, $p<0.05$) and less elbow extension (>20°, $p<0.0001$) during RF and RGV. RGV also resulted in less shoulder elevation (± 7°, $p<0.001$) and elbow supination (>30°, $p<0.0001$). During HTM, children with UCP used more scapula protraction (±5°, $p<0.05$), shoulder external rotation (±10°, $p<0.001$) and less elbow supination (±18°, $p<0.0001$). While TDC had a neutral wrist position at endpoint, children with UCP used 15° to 35° more wrist flexion to complete all tasks ($p<0.0001$).

Discussion & Conclusion: Significant differences between TDC and children with UCP were found for task duration and maximum velocity. Task-dependent significant differences were also found for endpoint angles of the trunk, scapula, shoulder, elbow and wrist. This study is a first step to gain further insights in UL movement pathology. However, the conversion of 3DMA results into useful information at the level of contributing muscles, bones and joints will be a necessary next step to improve our understanding of UL movement pathology.

References: [1]Jaspers et al. Gait Posture 2011;33:279-285
[2]Jaspers et al. Gait Posture 2011;33:568-275
[3]Cappozzo et al. Clin Biomech 1995;10:171-178
[4]Wu et al. J Biomech 2005;38:981-992

Disclosure: No significant relationships.

O59

A PROTOCOL TO ANALYZE 3D SCAPULO-HUMERAL MOTION IN CHILDREN

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[1]Latim Inserm U650, LaTIM INSERM U650, Brest/France, [2]Chru De Brest, CHRU de Brest, Brest/France

Introduction: Upper-limb motion analysis using external markers in children is a recently growing field. Most studies have evaluated shoulder motion as the thoraco-humeral joint [1] and not as the thoraco-scapulo-humeral complex. However, an accurate 3D analysis of the gleno-humeral motion would be relevant for many situations in neurology or orthopaedic diseases. In order to obtain a detailed analysis of the shoulder, we developed a protocol based on an acromion marker cluster [2], the determination of the gleno-humeral rotation center using functional method and different Euler sequences.

Patients/ Material and methods: 10 typically developing (TD) and 10 hemiplegic cerebral palsied (HCP) children were included. The HCP children had mild to moderate hemiplegia. The kinematics was recorded using the optoelectronic tracking system Vicon. Humeral and thoracic markers were placed as recommended by the International Society of Biomechanics [3]. A cluster of four markers was fixed on the upper arm. An acromion marker cluster was added on the acromion flat surface. Each child performed 3 trials of 6 tasks: full flexion, full abduction, horizontal abduction, hand to head, hand to controlateral shoulder and hand to ipsilateral back pocket. Moreover, 3 flexions/extensions, 3 abductions/adductions and 3 circumductions were performed to calculate the gleno-humeral rotation center [4]. The scapular orientations relative to the thorax (ST) were described using the YXZ Euler sequence. Humeral motions relative to the thorax (TH) and relative to the scapula (GH) were computed with the XZY Euler sequence. Inter-trial reliability was assessed using the coefficient of multiple correlations (CMC). The comparison between the mean data of the TD and HCP children at 0%, 100% and the range of motion were carried out using a paired Wilcoxon rank test.

Results: The overall CMC was good to excellent for the TH joint (0.90 in TD, 0.87 in HCP), moderate for the ST joint (0.79 in TD and HCP) and good for the GH joint (0.82 in TD and HCP). Significant differences were found for the TH, ST and GH joint kinematics in the 3 planes of motion depending on the tasks. At TH joint, the resting position of the HCP showed more humeral elevation for all the tasks and more humeral internal rotation for 4 tasks (flexion, abduction, hand to shoulder and pocket). The scapula of the HCP was about 10° more internally rotated for all the tasks and throughout the movements. For most tasks, the scapula was slightly more lateral in HCP than TD children and showed a trend to less posterior tilt at 100% of the flexion, abduction and hand to head tasks.

Discussion & Conclusion: This study showed an excellent feasibility, a moderate to good inter-trial repeatability and the clinical relevance of such a protocol. To our knowledge, this is the first time that coupled TH, ST and GH joint kinematics have been reported in children.

References: [1] Jaspers et al. (2009) Gait Posture, 30(4): 395-404. [2] Brochard et al. (2010) Proc IME H J Eng Med, 225(1): 100-105. [3] Wu et al. (2005) J Biomech, 38(5): 981-992. [4] Gamage and Lasenby (2002) J Biomech, 35(1): 87-93.

Disclosure: No significant relationships.

14:30-15:30 - FOOT KINEMATICS

O60

CORRELATION BETWEEN THE OXFORD FOOT MODEL KINEMATICS AND THE OXFORD ANKLE FOOT QUESTIONNAIRE

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Introduction: It is well accepted that outcomes of treatment should be assessed and recorded in order to provide an evidence base for each treatment option. Recently, there has been growing interest in "patient reported outcomes", in recognition of the fact that patient perceptions of outcomes may be just as critical as physical improvement. However, there is often discrepancy between the physical outcome measure, and the patient's perception of the treatment outcome. In order to provide optimal treatment, it would be helpful to understand what physical factors are important to patients, and if this differs in between pathologies. The aim of this study is to determine the association between physical foot deformity and perceived impact on children's lives in two different patient groups, by correlating the Oxford Foot Model (OFM) [1] and the parent-reported version of the Oxford Ankle Foot Questionnaire (OxAFQ) [2].

Patients/ Material and methods: OFM and OxAFQ data were collected from 12 children with clubfeet (CF) and 8 children with cerebral palsy (CP). Three-dimensional foot motion was collected using a 12 camera Vicon MX system during level walking at self-selected speed. A score representing the degree of dynamic physical foot deformity during gait of either their affected (unilateral involvement) or worst (bilateral involvement) foot was calculated from the OFM data, following the protocol suggested by Baker et al [3], and termed the Foot Deviation Score (FDS). This was correlated (Pearsons correlation) with the three domain scores calculated from the OxAFQ.

Results: The average FDS was comparable between the two groups (9.3± 3.9 CP group, 9.7 ± 2.8 CF group). OxAFQ scores ranged between 45% to 69% for the CP group, and 64% to 88% for the CF group. For the CF group, there were no significant correlations between their FDS and OxAFQ physical and functional (School & Play) domains. In the CP group, the correlations were much higher in the physical and functional domains. The correlation between the FDS and the Emotional domain was small but similar across both diagnostic groups.

	Physical	School/Play	Emotional
CP	-0.46	-0.63	-0.31
CF	-0.09	-0.07	-0.35

Table 1: Pearsons correlation between OxAFQ domain scores and FDS. Correlation is negative since a high FDS score indicates increasing deformity, while a high OxAFQ score indicates better functioning

Discussion & Conclusion: These results suggest that the degree of foot dynamic deformity has higher association with impact on quality of life in children with CP compared to those with CF, regardless of the actual degree of physical deformity, during gait. Whether the children had one or two feet affected did not appear to influence parent's perception of impact. Clinicians should evaluate and take account of the impact of foot dynamic deformity on children's lives. This should influence treatment decisions and also the assessment of a broad range of outcomes.

References: [1] Stebbins J, et al. Gait & Posture, 23(4), 401-10, 2006. [2] Morris, C et al Journal of Bone and Joint Surgery 90-B:1451-1456 [3] Baker, R. et al. Gait & Posture, 28 (S2), S7, 2008

Disclosure: No significant relationships.

O61

CONTRIBUTION OF MULTISEGMENT 3D FOOT KINEMATICS, KINETICS AND EMG DATA TO THE ASSESSMENT OF DIABETES SUBJECTS' LOWER LIMB IMPAIRMENTS

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Introduction: Diabetic neuropathy is the most invalidating complication of diabetes mellitus strongly associated to the risk of developing plantar ulcers [1]. The literature [2-3] suggests that diabetic foot gait alterations may not be detectable by assessing only kinematics or kinetics or muscle activation. We therefore propose an approach which combines multisegment 3D foot kinematics and kinetics together with lower limb muscle surface electromyography (SEMG).

Patients/ Material and methods: Gait analysis was assessed on 40 subjects: 10 diabetic non neuropathic subjects (NoDN, mean age and BMI ± SD respectively of 53.6±14.4 years and 27.3±1.4 kg/m^2), 10 diabetic neuropathic subjects (DN, mean age and BMI ± SD respectively of 62.6±9.6 years and 9.5±2.0 kg/m^2), 20 controls (mean age and BMI ± SD respectively of 60.5±4.7 years and 24.2±2.8 kg/m^2). A 6 cameras stereophotogrammetric system (60/120 Hz BTS, Padova), 2 force plates (Bertec Corporation, USA), 2 plantar pressure systems (Imago s.n.c. Piacenza) and a 16 channels SEMG system (BTS pocket EMG) were adopted. 3D foot multisegments kinematics and kinetics [1-2], SEMG of lower limb muscles were evaluated (Matlab R2008b) [3]. Correlation analysis was performed together with One Way ANOVA, after evidence of normality (Levene's Test for Equality of Variances) or Kruskal Wallis Test (SPSS v13).

Results: In DN and NoDN, altered foot kinematics was observed on each subsegments ($p< 0.01$). Both DN and NoDN showed a COP pattern more medially directed, together with excessive forefoot and midfoot plantar pressure and ground reaction forces ($p< 0.001$). DN's EMG analysis demonstrated in rectus femoris earlier activation at initial contact ($p< 0.0007$) and reduced activation during pre swing phase of gait. NoDN showed altered muscle activation on rectus femoris, gluteus medius and gastrocnemius lateralis ($p<0.04$). Pathologic subjects displayed a nice correlation between the peak of envelope of lower limb muscles and the peak of each foot subsegments' tangential forces and angles ($0.6<R<0.9$, $p<0.01$). Meanwhile an inverse correlation was found between the peak of envelope of tibialis anterior and the peak of each foot subsegments' tangential forces and plantar pressure ($R<0.5$, $p<0.001$).

Discussion & Conclusion: Results showed this method has a good ability of describing diabetes subjects' biomechanics alterations. Such a characterization of diabetic foot could be useful in order to understand its aetiology and to plan prevention programs aiming at reducing plantar ulcer formation.

References: [1] Sawacha Z. et al., 2009. Clinical Biomechanics 24 (9), 722-728. [2]Sawacha Z. et al., 2009. J. NeuroEng Rehab. 6:37. [3] Sawacha Z. et al., 2011. Gait & Posture, Accepted.

Disclosure: No significant relationships.

O62

RELATIONSHIP BETWEEN MOTION OF THE HALLUX AND THE FOOT IN CEREBRAL PALSY

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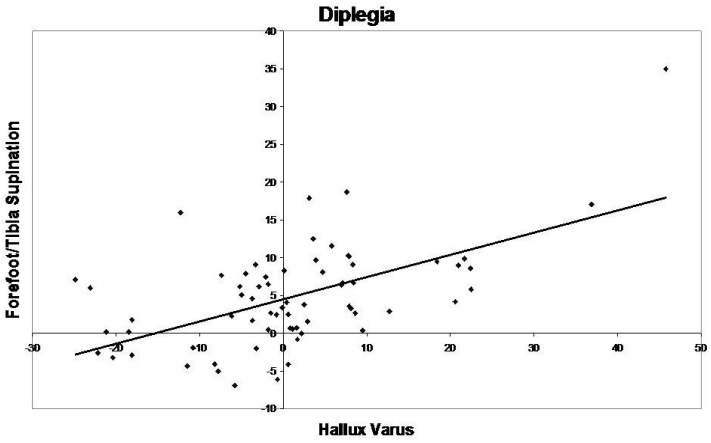
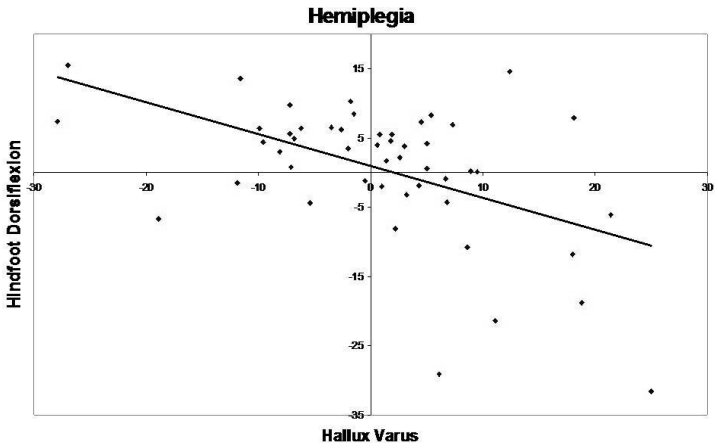
Introduction: Foot deformity is a common occurrence in cerebral palsy (CP), affecting around 90% of the population [1]. The hallux is often implicated, with valgus or adduction deformity occurring most frequently. In addition, dynamic function of the hallux during gait is often compromised. However, the relationship between motion of the hallux and the rest of the foot is unknown. The aim of this study is to investigate this relationship, and thereby improve understanding of the role of the hallux during gait in children with CP.

Patients/ Material and methods: Subjects included 67 children with diplegic CP (mean 11.8yrs), 49 children with hemiplegic CP (mean 10.6yrs), and 73 typically developing chidren (mean 10.2yrs). Barefoot, level walking data were collected at self-selected speed using 12 Vicon MX cameras. Multi-segment foot motion was obtained using the Oxford Foot Model (OFM) [2]. Discrete, kinematic variables were extracted from the data, including average data during stance and swing, as well as range of motion across the whole gait cycle, for the hindfoot, forefoot and hallux. Averages between groups were compared using ANOVA, and Pearsonâ€™s moment correlation was used to assess relationships between variables within each group. Correlations were deemed significant at p

Results: The hallux data varied across subjects within each group, with the CP groups exhibiting greater inter-subject variation than the typically developing children. As a result, there were no significant differences between the groups in any kinematic variable. However, correlations between hallux variables and other foot variables differed between groups. In the typically developing group, the only significant correlations found were between different hallux variables (for example, between hallux dorsiflexion and hallux valgus during stance). However, in the diplegic group significant correlations were discovered between forefoot supination and hallux valgus (Figure 1), along with forefoot adduction and hallux valgus. In the hemiplegic group, a significant inverse correlation was found between hallux varus and hindfoot (ankle) dorsiflexion in particular (Figure 2).





Discussion & Conclusion: While hallux motion appears to be independent of motion of the rest of the foot in typically developing children, this is not the case in CP. In particular, hallux valgus is directly related to pronation of the forefoot (with respect to both the hindfoot and the tibia) in diplegia. This alteration in loading of the hallux and the change in the balance of forces probably drives the dynamic deviation towards abduction/valgus. In contrast, movement of the hallux appears more closely associated with sagittal plane motion of the hindfoot in hemiplegia. It would appear that in hemiplegia it is the spasticity of the plantaflexors and toe flexors, and not the loading pattern, that drives the dynamic deviation of the foot and the hallux in these children. It would seem reasonable to assume that motion at the ankle and midfoot during walking influences hallux movement to some extent in both diplegic and hemiplegic CP. This has implications for treating dynamic foot deformity in this population. In some cases, dynamic hallux dysfunction may resolve spontaneously if other foot deformities are treated, where there is a relationship between foot and hallux motion. In addition, this information could be used to help prevent the development of hallux deformity by addressing the primary foot deformities.

References: [1] Connell et al (1998), Journal Paed Orthop, 18, 743-7 [2] Stebbins et al (2006), Gait Posture, 23, 401-10

Disclosure: No significant relationships.

O63

THE COMPARISON OF PATELLOFEMORAL JOINT FORCES BETWEEN FLAT FOOTED AND NORMAL SUBJECTS DURING STANCE PHASE OF GAIT

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Introduction: Foot hyper pronation may cause malalignment of the lower extremity, frequently leading to structural and functional deficits both in standing and walking [1]. Based on coupling between rear foot frontal plane motion and rotation of tibia, it is speculated that excessive pronation results in abnormal tibial rotation which increases stress on the joints of the lower extremity during weight bearing [2]. It has been postulated that abnormal subtalar joint motion is linked to knee joint problems like patellofemoral pain syndrome as it may affect knee mechanics. The purpose of this study was therefore to measure patellofemoral joint forces during stance phase of walking in subjects with hyper pronated foot and to compare them to the healthy subjects.

Patients/ Material and methods: 10 subjects with neutrally aligned feet and 10 with hyperpronated feet aged 23 ± 2.5 years were selected via clinical examination. Kinetic and kinematic data were collected by using a force platform (Kistler©, Switzerland) and six camera motion capture system (Qualisys©, Ltd., Sweden) while subjects walked at their preferred speed. Mean and peak knee extensor mechanism forces were quantified using Newtonian inverse dynamics during stance phase of walking. Then, mean and peak patellar mechanism angles and patellofemoral joint forces were calculated in both groups.

Results: Significant higher amount of mean patellar mechanism angle and also mean and peak forces across the knee extensor mechanism were found in flat footed group compared to normal group [$P<0.05$]. But there were no significant differences between groups when the peak patellar mechanism angle was taken into account [$P>0.05$]. Moreover, statistical analysis revealed a significant difference in mean patellofemoral joint force between normal (178.3±93.27 N) and hyper pronated foot groups (478.1±191.5 N) [$P=0.001$]. Peak patellofemoral joint force was also significantly higher in flat footed group (561.8±279.6 N) compared to normal group (269.8±193.8) [$P= 0.019$].

Discussion & Conclusion: Increased patellofemoral joint force cause the patellofemoral joint pathologies like arthritisIt can be concluded that changes of the medial longitudinal arch height would alter the net external flexion moment, force applied to the extensor mechanism, patellar mechanism angle and consequently the patellofemoral joint forces during stance phase of walking, through which developing a tendency towards musculoskeletal injuries.

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Disclosure: No significant relationships.

O64

CHARACTERISATION OF PES PLANOVALGUS BY PATIENTS WITH JUVENILE IDIOPATHIC ARTHRITIS WITH THE OXFORD FOOT MODEL

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Introduction: Patients with Juvenile Idiopathic Arthritis (JIA-P) often have affected ankle joints (Truckenbrodt et al. 2006). This could lead to pain which may result in deformities (von Altenbockum et al. 1998) like pes planovalgus. Until now, only static characteristics of the pes planovalgus were measureable. Descriptions of the behavior in dynamics, like walking, are lacking. The Oxford Foot Model (Stebbins et al. 2006), compared to conventional lower body models, divides the foot into three rigid segments (hindfoot, forefoot, hallux), which enables measurements of relative motion between the different foot segments. Thus the characteristics of foot deformities like pes planovalgus during gait can be measured. The aim of this pilot study was to assess functional impairment of pes planovalgus by JIA-P during the stance phase of gait.

Patients/ Material and methods: The kinematic data of maximum hindfoot eversion and minimum longitudinal arch height were obtained by reflective markers during barefoot walking at self-selected speed. An 8-camera 3d-motion analysis system (200Hz) (Vicon) was used. The patient group included five individuals (sex: f=3, m=2; age: 12±1 yr; height: 1.5±0.1 m; weight: 40±8.2 kg) with at least one affected ankle joint and fixed pes planovalgus (≥5° and also heel valgus while toe-standing). In addition five voluntary, healthy peers (sex: f=4, m=1; age: 12±2 yr; height: 1.5±0.1 m; weight: 40.1±8.4 kg) neither with rheumatic nor orthopedic or neurological disease served as control group (cg). Children with lower limb surgeries or orthopedic insoles in history were also excluded. For statistical analysis the Mann-Whitney U test (p=.05) was used to compare the kinematic data between these two groups.

Results: At comparable speed (1.2 m/s) JIA-P showed a significant increased maximum eversion in loading response (Mdn 7.3° eversion; cg Mdn 0.4° inversion; p=.05) and a significant decrease in minimum longitudinal arch height during stance phase (Mdn 17.9 mm; cg Mdn 19.5 mm; p=.05).

Discussion & Conclusion: With the application of this special 3d gait model, characteristics of the JIA induced pes planovalgus can be measured. JIA-P still have a longitudinal arch height serving as shock absorption during walking. The results provide important quantitative information for medical care and physiotherapy of patients with JIA induced pes planovalgus. Further research with 15 patients is planned. In addition the Oxford Foot Model can be applied for the control of the longitudinal development of pes planovalgus. Finally in adulthood when longitudinal arch height is possibly lost the method can be additionally used for surgical planning.

References: Truckenbrodt, H., Häfner, R., Spamer, M. & Beisken, C. (2006). Der Fuß in der Kinderrheumatologie. Frühzeitige und funktionell ausgerichtete Behandlung gelenkspezifischer Fehlstellungen. Arthritis & Rheuma 26 (3), 145-155.
von Altenbockum, C., Hibler, M., Spamer, M. & Truckenbrodt, H. (1998). Juvenile chronische Arthritis. Entwicklung von Achsenfehlstellungen an Hand, Knie und Fuß und ihre krankengymnastische Behandlung (2., unveränderte Auflage). München: Hans Marseille Verlag.
Stebbins, J., Harrington, M., Thompson, N., Zavatsky, A. & Theologis, T. (2006). Repeatability of a model for measuring multi-segment foot kinematics in children. Gait & Posture 23, 401–410.

Disclosure: No significant relationships.

O65

A COMPARATIVE EVALUATION OF THE EFFECT OF THREE DIFFERENT IN-SHOE ORTHOTIC APPLIANCES ON THE FORCE APPLIED TO THE KNEE EXTENSOR MECHANISM IN FLAT FOOTED SUBJECTS DURING STANCE PHASE OF GAIT

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Introduction: Flat foot is a relatively common anatomical abnormality, which in turn can cause foot and lower extremity dysfunction [1]. It has been stated that excessive hyper pronation can delay the external rotation of the tibia and alter the desirable timing between knee extension and rear foot supination [2], probably leading to increase strain on soft tissue. Different types of orthoses have been introduced to reduce the flat foot complications on the other joints due to the proposed kinematic interaction between foot and other lower extremity segments during walking. The aim of this study was therefore to compare the force applied to the knee extensor mechanism while applying three different in-shoe orthotics.

Patients/ Material and methods: 10 female subjects (aged 19-25 years) with pes planus (rear foot angle≥4) were studied in this investigation. Kinetic and kinematic data were collected by employing a force platform (Kistler^{O}, Switzerland) and six camera motion capture system (Qualisys^{O}, Ltd., Sweden) while walking at a preferred speed in four different test situations: simple insole (no correction), insole with medial arch support, insole with medial arch support and medial heel wedge, and insole with medial arch support and lateral fore foot wedge.

Results: Statistical analysis revealed that applying a medial arch support with lateral wedge significantly reduces the amount of mean knee flexion angle, extensor mechanism moment arm, net external flexion moment and mean force applied to the knee extensor mechanism in comparison to applying other insoles [$P<0.05$]. No significant differences were found in measured parameters between medial arch support, medial arch support with medial heel wedge and simple insole [$P>0.05$].

Discussion & Conclusion: Medial arch support with lateral forefoot wedge could decline the force applied to the knee extensor mechanism in flat footed subjects, due to its capability in reducing the functional foot malalignment somewhat, by unloading the medial longitudinal arch and also by decreasing the hind foot pronatin and forefoot supination, which are the main characteristics of flat foot. But the other in shoe orthotics couldn't significantly decrease the force since they couldn't alter the alignment of foot sufficiently.

References: [1] Khamis S et al (2007). Gait and posture 25:127-134 [2] Hunt A et al (2004). Clinical Biomechanics 19: 391-397

Disclosure: No significant relationships.

16:00-17:00 - TECHNICAL DEVELOPMENT

O66

TRANSFORMING GAIT CURVES RECORDED AT ONE WALKING SPEED TO SIMULATE GAIT CURVES AT DIFFERENT WALKING SPEEDS USING FUNCTIONAL PRINCIPAL COMPONENT ANALYSIS

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Introduction: Adjusting gait curves for walking speed is of prime interest in both research and clinical practice. As walking speed affects different parts of a gait curve differently, various modes of change in kinematic curves related to walking speed must be identified. Knowing how walking speed affects the kinematic curves makes it possible not only to adjust the curves for walking speed, but to transform individual curves to simulate kinematic curves recorded at other walking speeds. Creating such a transformation was the aim of this study.

Patients/ Material and methods: Two healthy female volunteers, aged 24 years, 58 kg, 166 cm, and 27 years, 71 kg, 168 cm, without diseases or disabilities affecting gait gave written informed consent to take part in the study. A total of 179 and 250 trials, respectively, with self-selected walking speeds ranging from "very slow" through "very fast", had satisfactory data quality. The first right cycle in each trial was used in the statistical analysis of the sagittal pelvis, hip, knee and ankle kinematics. In order to isolate the effect of walking speed the two individuals were analyzed separately. General features of the kinematic curves that held most of the variation between individual curves were extracted using functional principal component analysis (FPCA) [1]. This gives a set of functional principal components (FPC), i.e. curves spanning the full gait cycle, and accompanying individual scores on each FPC, expressing how much of each such mode of variation is contained in a given kinematic curve. The relationship between the FPC scores and walking speed was assessed by fitting univariate generalized additive regression models (GAM) [2]. GAM allows for possible non-linearity in the relationship between the independent and the depent variable by fitting an optimal spline. Finally, five kinematic curves were selected at random, and on the background of the above calculations, transformed to simulate corresponding kinematic curves at various other walking speeds.

Results: For both subjects, the first FPC explained 50-85% of the observed variation between the kinematic curves, while the first four FPCs explained 90-95% of the observed variation for all segments. Walking speed was strongly associated with the first FPC for all segments, though not generally linearly. By visual inspection the transformed kinematic curves, using the proposed methodology, did not differ from the kinematic curves recorded at the actual target walking speeds, indicating face validity of the method.

Discussion & Conclusion: We have presented a method that allows for the transformation of kinematic curves recorded at one walking speed to simulate gait curves recorded at other walking speeds. Larger studies are needed, for both healthy and pathological gait, in order to explore whether general transformation rules applicable for most individuals can be constructed, as well as the size and shape of the possible individual component of such transformations.

References: [1] Ramsay JO and Silverman BS. Functional Data Analysis. Springer; 1995.
[2] Wood SN. Generalized additive models: and introduction with R. Chapman & Hall /CRC; 2006.

Disclosure: No significant relationships.

O67

PERSISTENT AND ANTI-PERSISTENT PATTERN IN STRIDE-TO-STRIDE VARIABILITY OF TREADMILL WALKING: INFLUENCE OF RHYTHMIC AUDITORY CUEING

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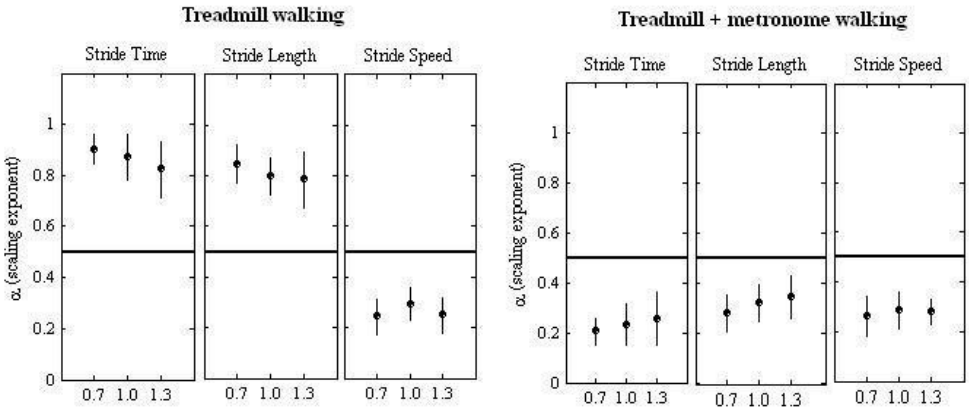
Introduction: Detrended Fluctuation Analysis (DFA) provides a valid indicator of statistical persistence in walking time series. "Persistence" means that deviations in a time series are more likely followed by subsequent deviations in the same direction: in this case, DFA scaling exponent α lies between 0.5 and 1.0. On the contrary, "anti-persistence" indicates that a deviation is more likely to be followed by deviations in opposite direction: in this case, α stands below 0.5 [1]. It has been observed that long time series of Stride Time (ST), Stride Length (SL) and Stride Speed (SS=SL/ST) exhibited persistent patterns (α ~ 0.8) under free-walking conditions [2]. On the other hand, rhythmic auditory cueing (metronome walking) induced anti-persistent pattern in ST series [2]. Conversely, it has been recently shown that SS became strongly anti-persistent in treadmill walking (α<0.5) [1]. The aim of this pilot study was to analyze the effect of the combination of treadmill walking (imposed SS) and auditory cueing (imposed ST) on persistent pattern of stride-to-stride variability.

Patients/ Material and methods: Ten subjects (7 males, 3 females) took part in the study (age: 43±10yr). They performed 6 x 5min walking trials on an instrumented treadmill, which measured foot pressure at 100Hz (1.4 sensors per cm^2). Imposed speeds were 0.7, 1.0 and 1.3 times PWS (Preferred Walking Speed). Freely-chosen walking cadences were measured during the first three trials, and then imposed accordingly in the last three trials by using a metronome. Position and time of each heel strike was detected; ST, SL and SS (=SL/ST) time series were computed accordingly. Standard DFA was performed on the times series, providing scaling exponent α.



Results: As show in the figure above, the results confirm that treadmill induces strong anti-persistence in the time series of SS, but preserves the anti-persistence of ST and SL. On the contrary, with the additional rhythmic auditory cueing, all the parameters became anti-persistent.

Discussion & Conclusion: Dingwell and Cusumano [1] suggest that individuals control jointly ST and SL (cross-correlation) to adapt SS to the speed imposed by a motorized treadmill: deviations in either ST or SL are "cancelled out" by concomitant changes in the other, and hence both variables are allowed to persist (α ~0.8). Anti-persistent dynamics of SS (α ~0.3) is related to tight control required to the task, i.e. deviations being constantly over-corrected. In light of the present results, we hypothesize that an additional rhythmic cuing induces individuals to control ST more tightly to match the imposed cadence, as already shown under free-walking conditions [2]. In addition, individuals have tol control their speed to stay on the treadmill. They achieve this task by controlling SL, which became also anti-persistent.

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Disclosure: No significant relationships.

O68 CANCELLED

O69

TECHNICAL VALIDATION OF A NEW MOVEMENT THERAPY SYSTEM FOR TREATMENT OF LOW BACK PAIN.

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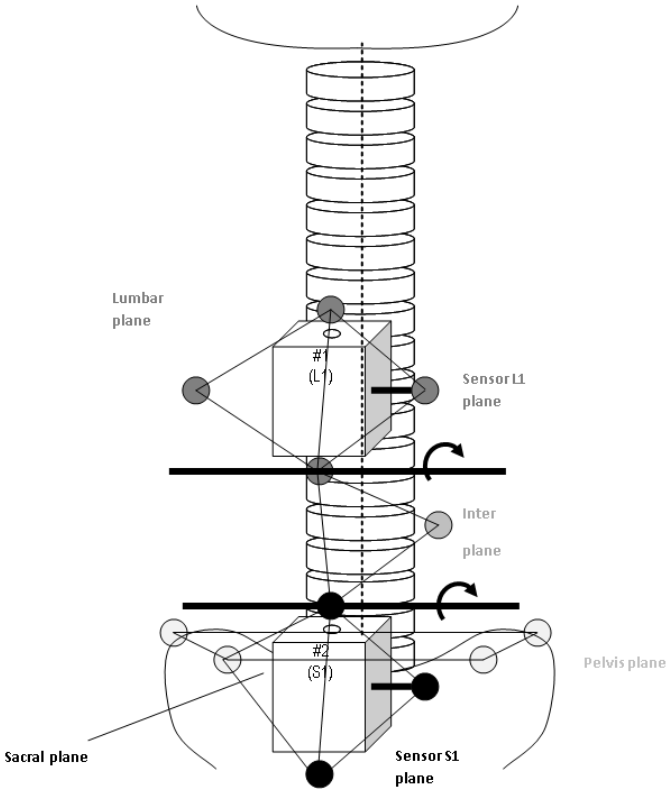
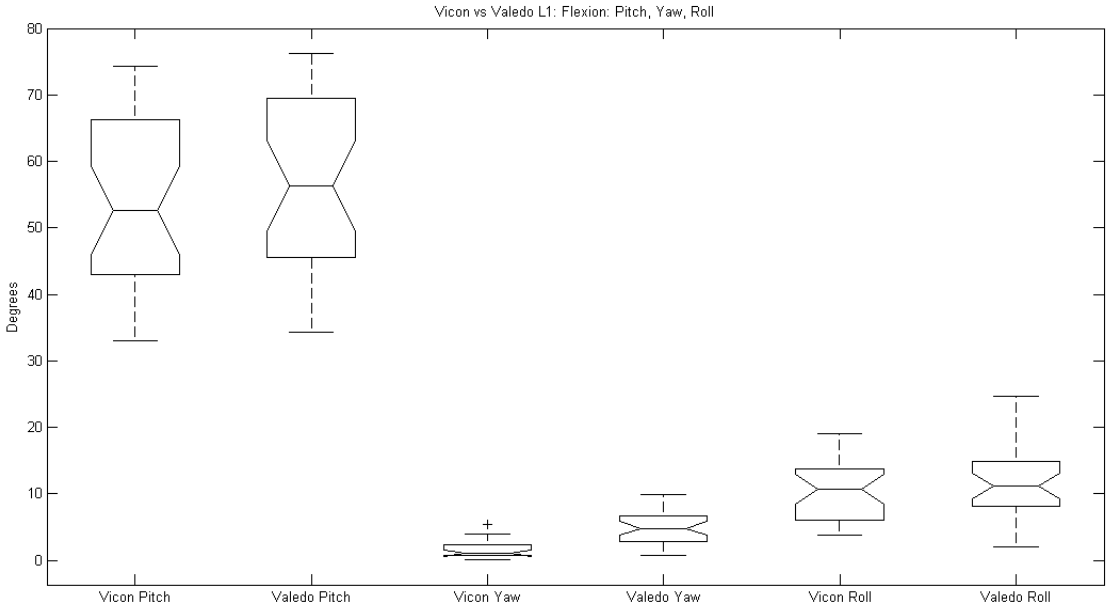
Introduction: Movement analysis laboratories provide important insights into movement disorders related to low back pain (LBP), but are not applicable for use in daily physiotherapy practice. Alternatives include use of inertial sensors [1]. A research prototype [1] demonstrated that wired inertial sensors placed above C7, S1 and L1 could be used to record limited trunk movements. However they did not investigate the full range of movement assessments undertaken in low back pain therapy [2]. The Valedo Motion (Hocoma, Switzerland) has recently been developed as a low cost system to provide augmented feedback and movement therapy to patients with LBP. The system uses advanced wireless inertial sensors to record movements from S1 and L1 positions. Our aim was to investigate how accurate the Valedo Motion system is compared to traditional 3D movement analysis for a set of lumbar and pelvic movements.

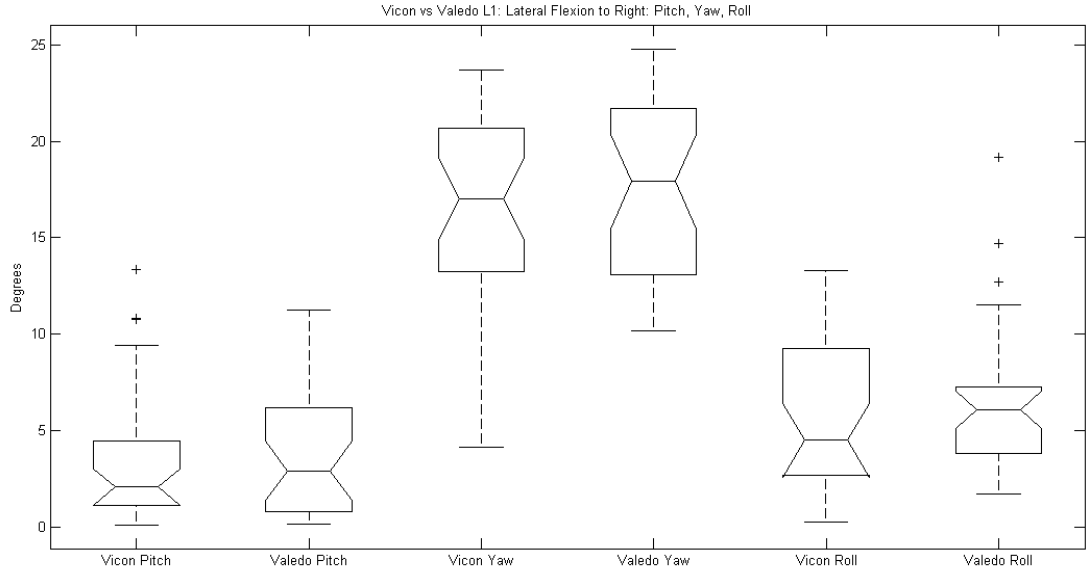


Patients/ Material and methods: Lumbar spine and pelvic movements were recorded in 10 healthy adults using both Valedo Motion sensors and Vicon 3D movement analysis. The Valedo sensors were placed above the S1 and L1 positions, and Vicon markers placed to record the movement planes (Fig.1). The test conditions applied were: 1) trunk flexion and extension, 2) trunk lateral flexion, 3) pelvic flexion and extension, 4) pelvic left and right.

The angular differences between the world origin and S1 or L1 planes were calculated from the Vicon marker set, and compared to measurements from the Valedo sensors. Flexion and extension corresponded to sensor pitch; left and right movements to sensor yaw, and rotation to sensor roll. R-squared statistics were calculated to estimate the fit between the two data sets at the maximum movement range. Boxplots were used to compare the median and inter quartile differences between the data sets.

Results: The regression coefficients (r^2) for the primary axis of each movement (flexion/extension and pitch, left/right and yaw) demonstrate high correlation between the Valedo-Motion sensors and Vicon systems (r^2>.97). For the secondary and tertiary movement axes the coefficients of regression varied between 0.31 and 0.56. Outliers were recorded as sensor roll during movement 4 (r^2=0.95), and sensor pitch during movement 3 (r^2=.91). Fig.2 rsp 3. show boxplots for sensor L1 during pelvis flexion 1 and L1 trunk lateral-flexion to the right.





Discussion & Conclusion: The measurement of lumbar and pelvic movements recorded by Valedo Motion sensors is comparable to Vicon 3D movement analysis, for the principle movement plane, but is a significantly lower cost device which can be used in regular clinical practice. The results are comparable in accuracy to other studies [2, 3] using inertial sensors for back movements.

References: 1. Wong, W.Y et al., Ieee Transactions on Instrumentation and Measurement, 2009. 58:p. 2737-2742. 2. Luomajoki, H., et al., BMC Musculoskeletal Disorders, 2008. 9(: p. 170. 3. Lou, E., et al., Ieee Transactions on Instrumentation and Measurement, 2000. 49: p. 108-113.

Disclosure: The principle authors thank Hocoma for providing Valedo Motion sensors for the purpose of this study. Authors LB and ML work in the research and development department of Hocoma, and assisted with the data processing. The analysis was done by ZHAW.

O70

A COMPARISON OF REGRESSION TECHNIQUES TO CONTROL FOR GAIT SPEED

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Introduction: Speed affects lower-limb gait parameters and can be controlled for using regression analysis [1]. However, regression based predictions are often derived using overall group data and might therefore not reflect individual variations with speed. Thus, the purpose of this study was to compare a novel approach using regression equations based on individual subject data (IR) to the standard overall regression (OR) protocol.

Patients/ Material and methods: 17 healthy adult volunteers fitted with reflective markers according to a modified Plug-in-Gait data set [2] performed slow, comfortable, and fast walking trials over two sessions. Video and force plate data were acquired to compute stance phase joint angles and external torques. Kinematic data comprised of peak hip flexion (HA_{FL}), hip extension (HA_{EX}), knee flexion (KA_{FL}), ankle plantarflexion near foot strike (AA_{PF}), and ankle dorsiflexion (AA_{DF}). Computed moments were peak hip flexion (HM_{FL}), hip extension (HM_{EX}), knee flexion (KM_{FL}), ankle plantarflexion (AM_{PF}), and ankle dorsiflexion (AM_{DF}). For the IR method, regression was applied to all the fast and comfortable walking trials (to predict slow) and to all slow and comfortable trials (to predict fast) for each parameter and individual subject. For the OR, the same procedure was followed except data were grouped for all subjects before applying the regressions. Between-session reliability was assessed using intra-class correlation (ICC, 1,1) [3] and the measurement error with respect to the true slow and fast recorded values for the pre-test data of both methods was compared.

Results: The IR and OR methods revealed moderate to excellent between-session reliability (ICC ≥ 0.4) for nearly all parameters for slow and fast predictions. Measurement error comparison between methods showed that IR had a decreased or equal error for 5 of 9 parameters for slow and 6 of 9 for fast predictions (Table 1). Table 1: Comparison of IR and OR method regressions

	Joint angles (°)					Joint Torques (N×mm/kg)			
	HA_{FL}	KA_{FL}	AA_{DF}	HA_{EX}	AA_{PF}	HM_{FL}	KM_{FL}	AM_{DF}	HM_{EX}
IR Fast	32.0 (3.6)	18.7 (4.1)	11.4 (3.4)	12.9 (2.2)	8.6 (3.5)	1077.4 (225.9)	311.1 (137.6)	1565.2 (251.4)*	377.2 (234.5)*
IR slow	22.6 (3.7)	10.3 (3.0)	10.5 (2.8)	8.9 (2.1)	6.7 (2.4)	481.9 (313.3)	426.0 (223.1)	427.5 (170.9)*	206.8 (166.8)
OR Fast	30.3 (4.4)	16.3 (5.2)	10.4 (2.9)*	12.9 (2.6)	9.5 (3.6)	930.0 (388.2)	296.2 (228.4)	1425.5 (156.8)	341.8 (90.1)
OR Slow	25.5 (3.7)	15.6 (6.4)	12.3 (2.5)	10.0 (2.7)	5.9 (3.6)	698.4 (239.9)	401.9 (183.5)	437.2 (273.6)	198.7 (67.0)

Means (measurement error). * indicates parameters with poor reliability (ICC < 0.4). Bold shows decreased or equal error for the IR method.

Discussion & Conclusion: Ideally, trials should be captured at similar speeds between sessions. However, when an intervention precludes this approach both methods have the potential to provide reasonable prediction of gait parameters. Importantly, the IR method does not rely on a matched set of group data and provides decreased error compared to the OR method. Therefore, we believe the IR approach should be favored for both clinical and research based applications.

References: [1] Hanlon, M., Anderson, R., 2006. Gait Posture, 24(3), 280- 287. [2] Stief, F., Schwirtz, A., et al. 2009. Gait & Posture, 30 Supplement 2), 138. [3] Shrout, P. E., Fleiss, J. L., 1979. Psychol Bull, 86(2), 420-428.

Disclosure: No significant relationships.

O71

ROBOT-ASSISTED REACHING AGAINST GRAVITY: EMG ACTIVITY, MOVEMENT PERCEPTION AND BIOMECHANICS

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Introduction: Stroke patients generally present muscle weakness and pathological co-contractions. Robotic treatment is a possible solution despite the debate is still open. The objective of this work is to study the biomechanics, the EMG patterns and the subject's movement perception associated to various reaching movements trajectories, velocities and robot/subject interaction modalities.

Patients/ Material and methods: Participants. Six healthy subjects (29±5 years, 1 female).
Equipment. An end-effector based robot (Mitsubishi Pa10-7), a 4 TVC 3D-motion tracking system coupled with wireless EMG (BTS Smart D with FreeEMG) and a safety inertial device assembled on the robot (developed by authors).
Study Design. Subjects were requested to perform consecutive reaching movements (RchMov) [1] assisted by the robot. Four types of movements are derived from 2x2 combinations of path pairs (rectilinear/natural) and velocities pairs (constant/RchMov). Natural trajectories were tracked during free reaching movements, then averaged and scaled to the same starting and ending positions and movement duration. The resulting 4 trajectories were implemented on the robot in order to provide the subjects with assisted movements. Subjects, unaware of both the purpose of the study and the ongoing movement characteristics, were asked to perform the described 4 types of movements holding the end-effector handle in two ways: first, following the robot (without touching or barely holding the end-effector handle); second, anticipating the robot movement by slightly pushing/pulling the handle.
Two further tests were performed implementing a force control strategy through sampling the forces/torques exerted at the end-effector. Subjects were asked to purposefully push/pull the handle along constrained 3D paths given by the rectilinear/natural pair of paths used in previous tests. This control mode is directly derived from an Admittance Control strategy [2]. Dynamical parameters of the robot interaction behavior were kept constant for all the subjects.
Each subject was therefore asked to perform a total of 11 series (12 repetitions) of movements: 1 free movement for tracking the natural RchMov, twice the 4 combinations of trajectories, 2 force controlled movements.
Dependent measures. A visual analog scale (VAS) about how natural the movement was felt, EMG, limb and robot kinematics.
Statistics. Wilcoxon test.

Results: Both the natural path and the natural RchMov velocity profile are preferred (higher VAS scores, $p<0.05$) by subjects and allow a reduction of the maximum shoulder torque ($p<0.05$) due to an optimal conversion of kinetic energy into potential one. The slowest RchMov performed without touching the handle (just following alongside) displayed the highest co-contraction values ($p<0.05$). Co-contractions decreased in the robot-assisted exercises with respect to the free movements, especially when subjects actively provided energy in moving the robot along constrained paths.

Discussion & Conclusion: Trajectories (path and velocities) and robot control modes should be accurately tuned during the customization of robotic treatments. Hybrid force-position robot control strategies seem to show a good effect on co-contraction limitation. These results may be useful also in the process of designing rehabilitation robots.

References: [1] Caimmi M. et al., Neurorehabil Neural Repair 2008 (22):31-39. [2] Hogan N., Impedance control - Parts I – III, ASME Trans. J. Dyn. Sys. Meas. Control, 1985 (107): 1-24

Disclosure: No significant relationships.

O71A

GAIT PARAMETER SET FOR GILLETTE GAIT INDEX DEPENDS ON DISORDER - OPTIMIZATION OF DATA SET CHOICE WITH DATA MINING ALGORITHMS

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Introduction: The Gillette Gait Index (GGI) evaluates deviation of the patient's gait from the normal control group [1]. It is based on 16 gait parameters extracted from the results of the instrumented gait analysis. The choice was based on parameters with relevance for cerebral palsy (CP) [1]. Our aim was to see if other sets of gait parameters used for construction of „modified GGI" could better describe gait deviation of patients with other disorders than CP.

Patients/ Material and methods: Patients: Gait data from 3 groups of patients: 30 CP patients, 24 scoliotic patients, 30 stroke patients. From the gait reports 16 original gait parameters were extracted, together with additional 7 parameters: pelvic obliquity, knee flexion (stance phase), pass retract, pelvic range in transversal plane, foot rotation, step length as % of the reference value, single stance phase as % of the gait cycle: together 23 gait parameters. Methods: The original number of parameters (16) was kept, the selection of subsets of gait parameters was done using several data mining methods: correlation based filters, 4 correlations, and randomForest method. The choice was based on the results given by all methods. Each method attributed a score to each gait parameter, scores were summed up, and 16 parameters with the highest sums were chosen.

Results: In scoliotic patients 4 original gait parameters (stance phase, cadence, mean pelvic tilt, range of pelvic tilt) were substituted for 4 added parameters (knee flexion in stance, pass retract, pelvic range, and step length). In CP and stoke patients more than one subset of gait parameters could be chosen. In CP patients results indicated 9 gait parameters from original set and 4 from added set as the parameters (13 together) which should be included into the GGI algorithm, and 3 from original one and 2 from added as equivalent ones from which remaining 3 could be chosen. In stroke patients results indicated 10 gait parameters from original set and 4 from added set as the parameters (14 together) which should be included into the GGI algorithm, and 4 from original one from which the remaining 2 should be chosen.

Discussion & Conclusion: GGI gains popularity, and is used to assess children with CP [1, 2], idiopatic toe-walkers [2], patients after brain and spinal cord injury [3], oncological patients [4], and to assess the surgery procedures [5]. The set of original 16 gait parameters was chosen based on the most typical problems in CP patients. The changes in gait patters occurring in other diseases are different. Creating GGIs dedicated to defined diseases could be beneficial, as the sensitivity of the GGI to detect changes appearing due to treatment could be increased. Data mining methods seems to be a good tool to select subsets of gait parameters for creation a disease tailor-made GGI.

References: [1] L.M.Schutte et al., G&P 2000; 11: 25 - 31 [2] M.Romei et al., G&P 2004; 19: 85 – 90 [3] A.Cretual et al., G&P 2010; 32: 307 – 310 [4] M.Syczewska et al., G&P 2010; 32: 358 – 362 [5] N.Postans et al., G&P 2006; 24S: S143

Disclosure: No significant relationships.

16:00-17:00 - DEVIATION INDEXES/ RELIABILITY

O72

THE RELIABILITY OF THREE-DIMENSIONAL GAIT KINEMATICS IN HEALTHY CHILDREN

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Introduction: Three-dimensional gait analysis (3DGA) has become an important tool in planning the treatment of gait deficiencies in patients. A recurring question is whether the results are sufficiently reliable to justify their significance. Variability within some clinically acceptable limits of 2-5º has been found in most kinematic variables (1). Such data analysis is however commonly based on selections of points or summary statistics, not the complete gait curve. The aim of this study was to investigate reliability in 3DGA measurements by estimating the consistency of kinematic gait data throughout the gait cycle in healthy children.

Patients/ Material and methods: Gait data from 10 healthy children aged 8-14 years was collected using a 6 camera MXF40 Vicon system and two AMTI force platforms. Two tester teams placed markers according to the Pug-in Gait protocol on two consecutive days, two weeks apart, allowing for the assessment of both inter- and intra-tester reliability. The second left gait cycle from one trial of each of 40 sessions was used in the statistical analysis of 11 kinematic variables. A functional generalization of the Bland & Altman plot (2) and corresponding limits of agreement was used to investigate variability through the gait cycle. 95% limits of agreement (LoA) of ±10° were considered clinically acceptable.

Results: The mean difference was close to zero across the gait cycle for all variables, implying no systematic difference between tester teams. The greatest differences were found in transverse plane knee and thigh rotation with LoA ranging from ±10-20°. Pelvic motion, foot progression, hip sagittal and coronal plane motion resulted in variations not exceeding the clinically acceptable values. Variability stayed mainly within ±5° for ankle and knee sagittal plane but increased to ±20° during pre-swing (ankle) and terminal swing (knee) respectively. Knee coronal plane kinematics had peak variability during mid-swing of ±10-20°.

Discussion & Conclusion: Even though testers were experienced and working team-wise the high differences found in some variables confirm marker placement variability between and within testers. This is in line with previous research that found high variability relating to thigh rotation offset. Some sagittal plane variables had a substantial variation of LoA through the gait cycle that has not been described in previous studies. The variations occurred during periods known to be more sensitive to factors such as changes in walking speed and thus possibly caused by natural variability within subjects. As a reliability assessment tool the statistical approach proved useful in revealing the range within which measurements could be expected to differ through the gait cycle. Favourably, calculation of LoA is not sensitive to between subject variability. Through rather wide confidence intervals the methodology indicates a need for larger samples than is often common in 3DGA. Further investigation concerning individual inter-cycle and –trial variation without marker replacement is important to achieve an improved estimate of clinically acceptable values.

References: [1] McGinley et al. Gait Posture 2009; 29:360-69 [2] Bland & Altman. Lancet 1986; 1:307-10

Disclosure: No significant relationships.

O73

INTER-LABORATORY CONSISTENCY OF GAIT ANALYSIS MEASUREMENTS

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Introduction: Sharing data among motion analysis laboratories is a top priority in gait analysis research [1]. Repeatability of the typical gait analysis measurements has been rarely assessed over laboratories [2]. Our purpose is to explore the consistency of routine gait analysis on a single healthy subject once it is performed in differentclinical laboratories.

Patients/ Material and methods: A single healthy subject, 26-year-old, male, 177 cm height, 70 kg weight, was examined within a 1-month period in seven gait analysis laboratories. These had their own motion analysis systems, and established protocols: 4 'conventional', 2 Total3DGait, 1 CAST. A full kinematics and kinetics assessment was performed at each site by a local examiner. Each lab provided six gait trials data, along with other characteristics (pathway length, force-plate positions, details on hardware, software releases, kinematics and analog data sampling rate, etc). The consistency of all the measurements was assessed by the coefficient of variation (CV) and the maximum spread, i.e. the worst-case difference. These were used for the anthropometric measurements, spatio-temporal parameters, local peaks, braking and propulsive areas from the GRF, and all joint rotation values in up-right posture ('offset'). The similarity between two curves was assessed by the coefficient of determination r^2, along with the scaling factor (SF) and the bias term (B), obtained by a robust linear regression, thus separating the effect of the vertical shifts from that of shape variation. For any given gait analysis curve, all possible 21 two-labs comparisons were performed and the obtained coefficients averaged. This procedure was applied to left and right lower limb joint rotations, moments and powers in the sagittal plane.

Results: Differences as large as 2-3 cm were found in the anthropometric measurements at the pelvis. CV of the spatio-temporal parameters was in general lower than 6%. GRF were similar, with differences in the order of a few percentage of the body weight. The similarity amongst joint kinematic curves was high, with, on average, $r^2>0.90$ in both the sagittal and the frontal planes and $r^2>0.60$ in the transverse plane (knee excluded) with the worst performance at the hip ($r^2=0.30$). Pattern similarity was excellent for joint moments at the ankle ($r^2=0.90$) and good at knee ($r^2=0.70$) and hip ($r^2=0.66$) joints. For the latter, comparisons between labs with the same protocols resulted in better similarities ($r^2>0.80$). Patterns similarity was very good also for joint power at the ankle ($r^2=0.80$) but not satisfactory at the knee and the hip joints ($r^2=0.30$ and $r^2=0.40$ respectively).

Discussion & Conclusion: Large consistency was found in joint kinematic and kinetic curves, despite of the large spectrum of differences in the techniques utilized in the laboratories. Different protocols can result in similar curves, except for those measurements where knee axes and hip centre are implied [3]. Relevant variability was observed to be accounted for differences in markers positioning on the thigh, anthropometric measures, and event detection, all dependent on the examiner.

References: [1] Engsberg et al. 2009. Gait & Posture 29;169–171. [2] Gorton et al. 2009. Gait & Posture 29; 398–402. [3] Ferrari et al., 2008. Gait & Posture 28(2):207-16

Disclosure: No significant relationships.

O74

EFFECTS OF AGE AND WALKING SPEED ON LONG-RANGE AUTOCORRELATIONS AND ON FLUCTUATION MAGNITUDE OF STRIDE DURATION

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Introduction: Stride duration variability is often considered as a marker of gait balance and can be investigated on two different ways[1,2]. Classical mathematical methods (standard deviations, coefficients of variation) assess fluctuation magnitude, whereas fluctuation dynamics (long-range autocorrelations) is evaluated through complex mathematical methods. Both variables were reported as different in children and in older adults in comparison with young adults. However, the effects of age on stride duration variability are on one hand mostly assessed at spontaneous speed, which is always different between groups. On the other hand, gait speed is described as a possible confounder in the assessment of stride duration variability, but its precise influence remains controversial. The first objective of this study was to assess the effect of gait speed on stride duration variability of young healthy subjects. The second aim was to investigate the influence of age on the same parameters.

Patients/ Material and methods: Stride duration was measured with a high sampling rate thanks to footswitches[3]. We first compared data obtained from 6 young healthy subjects (19-24 years old) walking during several minutes (512 consecutive gait cycles) at 6 different speeds (20–40–70–100–130–160% of spontaneous speed) on a treadmill (One Way RM ANOVA). Second, we compared the results of 18 subjects from 3 different age groups (~5-25-75 years old) walking at three equivalent speeds (slow – medium – fast) (One Way ANOVA). Fluctuation magnitude was assessed by coefficients of variation (CV), while fluctuation dynamics was evaluated thanks to gold-standard methods (rescaled range analysis, power spectral analysis, relation d)[4], to reach a high level of evidence.

Results: Values of CV were inversely related to speed and age: they were significantly greater at slowest speeds in young subjects ($p<0.001$), and were also significantly larger for children in comparison with young and old adults, whatever the speed of walking ($p=0.011$ at slow speed; $p=0.002$ at medium speed; and $p<0.001$ at fast speed). Conversely, long-range autocorrelations were found in all subjects at all speeds. Moreover, gait speed and age of subjects did not influence their characteristics, that remained similar in the different testing conditions.

Discussion & Conclusion: These results confirm with a high level of evidence that long-range autocorrelations are quite robust and intrinsic to the locomotor system. Fluctuation magnitude and dynamics are differently influenced by speed and age, which indicates that they probably have different neurophysiological origins. The precise clinical implications of those results need further investigation, in particular regarding fall risk, but CV and long-range autocorrelations could be complementary tools in the assessment of gait balance.

References: [1]Hausdorff JM et al. Is walking a random walk? Evidence for long-range correlations in stride interval of human gait. J Appl Physiol 1995. [2]Jordan K et al. Walking speed influences on gait cycle variability. Gait Posture 2007. [3]Bollens B et al. Does human gait exhibit comparable and reproducible long-range autocorrelations on level ground and on treadmill? Gait Posture 2010. [4]Crevecoeur F et al. Towards a « gold-standard » approach to address the presence of long-range auto-correlation in physiological time series. J Neurosci Methods 2010.

Disclosure: No significant relationships.

O75

ARE STABILITY ISSUES A POTENTIAL CAUSE FOR ADAPTATIONS IN SPLIT BELT WALKING?

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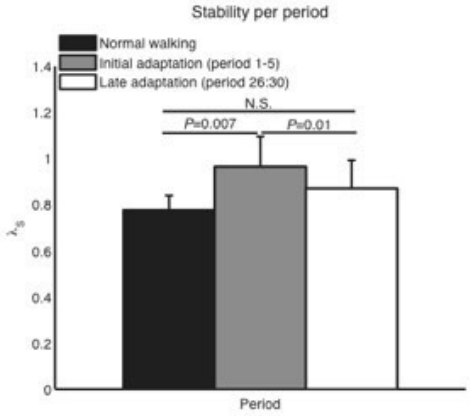
Introduction: Although the split belt paradigm has been used extensively to assess the capability of subjects to adapt the gait pattern [1], reasons as to why this adaptation occurs remain obscure. For stride length, which quickly adapts, this is clear; if no adaptation would take place, subjects would not be able to keep walking on the treadmill. For step length however, this is not the case; in principle, subjects are capable of a pattern that is not adapted; they show such a pattern in the immediate phase after the transition from tied to split belts. Still, they adapt their gait pattern, and, store this adapted gait pattern, so that after-effects are visible. This leads one to believe that the adapted gait pattern is in some way "more optimal" than the unadapted gait pattern.
Potential ways in which the adapted gait pattern may be "more optimal" could be symmetry, energy consumption and stability. In the current study, we tested the latter of these, to see if gait adaptations during split belt walking are aimed at stabilizing the gait pattern. We hypothesized that (1) unadapted split belt walking (as seen in the initial phases of the adaptation period), would be less stable than normal walking and (2) that stability would improve as the gait pattern got more adapted to the split belt.

Patients/ Material and methods: 8 healthy subjects participated in a split belt adaptation protocol. In short, they walked on a treadmill for 5 minutes with belts tied (running at 1.0 m/s), then 10 minutes with belts split (1.0 and 0.5 m/s). Kinematics of a pelvis cluster marker were recorded using a optoelectronic measurement system at 100 samples/s. Time series of the 3d velocity and angular displacement of the pelvis marker were cut into episodes of 15 strides, and of each episode, stability was estimated using the maximum Lyapunov exponent (λ_s) [2]. Differences in stability between normal walking (designated as the average over all episodes during the tied condition), initial adaptation (average value over the first 5 episodes of split belt walking) and late adaptation (average value over episodes 26-30 of split belt walking) were tested using a repeated measures ANOVA.

Results: are shown in figure 1. In line with our hypotheses, split belt walking initially decreased stability (i.e. led to higher values of λ_s), but stability improved as the gait pattern adapted to split belt walking, so that during the late adaptation period, stability was not significantly different from normal walking.



Discussion & Conclusion: The present study suggest that stability issues may be responsible for the adaptations in split belt walking. Other factors may also improve because of these adaptations. One likely candidate is energy consumption [3]. We plan on further exploring the potential reasons why humans adapt their gait pattern when walking on a split belt.

References: [1] Reisman, D.S., et al. (2005) J Neurophysiol. 94(4): p. 2403-15. [2] Bruijn, S.M., et al. (2009) J Neurosci Methods. 178(2): p. 327-33. [3] Zarrugh, M.Y., et al. (1974) Eur J Appl Physiol Occup Physiol. 33(4): p. 293-306.

Disclosure: No significant relationships.

O76

ASYMMETRY VS. DEVIATION PLOT: A NEW GAIT ANALYSIS DATA REDUCTION TOOL.

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Introduction: Clinical practice in gait analysis, accepts a range of deviation and asymmetry that is considered as normal. This range is defined by one Normal SD around the normal mean values. In order to summarize the gait condition of a patient, various attempts have been made, using either the deviation from normal by calculating a deviation index, or for evaluating asymmetry, Asymmetry / Symmetry indexes. Most often asymmetry is not being considered and the evaluation focuses on deviations from normal. During the application of the indexes in the clinical practice, for assessing the condition of a subject's gait, it occurred that the evaluation of deviations from normal and the inherent asymmetry should be studied together for a more comprehensive description of subject's gait normalcy. The outcome of our research was a combined plot of these two parameters which presents a new comprehensive tool to visualize gait condition.

Patients/ Material and methods: Gait Graph Deviation Indexes (GGDI) and Gait Graph Asymmetry Indexes (GGAI) are being obtained using the methodology described by Darras et al.[1,2] These two indexes are measuring the gait graph deviations, for the right and left side from the normal values as well as asymmetry between right and left side graphs as proportions of the normal standard deviation of the gait graphs. So these two gait graph indexes have a common denominator (Normal Standard Deviation). Plot format: Horizontal axis shows Asymmetry values, Vertical axis shows Deviation values. Finally a box that defines the normal range is drawn at (0.0)- (1.5, 1.5). This box is defining "the aim of the treatment" to brink the deviations inside the normal range. Each point on the plot has an id caption (P.L) the first number (P) is showing the plane of the graph and the second (L) the level of the graph. Thus, for p (1=sagital, 2=coronal, 3=transverse) and for L (1=Ankle/foot, 2=knee, 3=hip and 4=pelvis). Blue plots are showing right side values and red plots are showing left side values.

Results: From the analysis of a sample of 1000 (GGDI) & (GGAI) indexes, it was found that both indexes are following normal distribution, so parametric statistics can be applied. It was also documented that Normal Subjects are exhibiting GGDI & GGAI values ~ 1.0 + 0.5 SD. Various plot combinations were used depending on the underlying clinical & research question. For example a single graph that contains all the indexes of the gait report can be used to identify the total gait condition, or graphs that contain indexes of a subject (figure 1) or a group of measurements, pre-treatment compared to post – treatment.

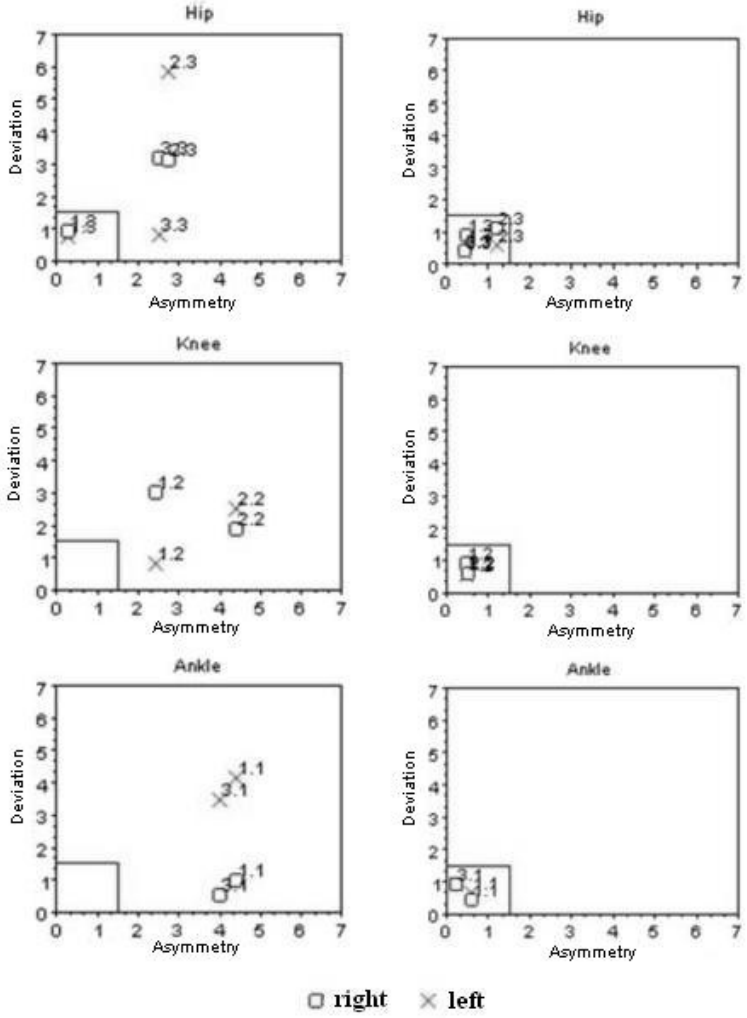

Figure 1. Assymetry vs Deviation Plot example.

Discussion & Conclusion: A new tool for the visualization of the overall gait condition has been established. The new tool which is actually the plot of Deviation vs. Asymmetry, gave impressive results in visualizing and discriminating the gait condition of subjects.

References: [1] Darras, N, Pasparakis, D, Tziomaki M, Papavasiliou, A,. Dimitriadis, D , Nestoridis, C, Pentarakis M. Deviation graphs and deviation indexes for clinical gait evaluation. Gait and Posture, 26S (2007) **[2]** Darras, N, Pasparakis, D, Tziomaki M, Papavasiliou, A,. Dimitriadis, D , Nestoridis, C, Pentarakis M. Gait asymmetry graphs and indexes. Gait and Posture, ISSN: 0966-6362, Vol: 30, Issue: 2, (2009)

Disclosure:

O77

ADJUSTMENT OF THE THIGH ROTATION OFFSET RESULTS IN REDUCED VARIABILITY IN THE HIP ROTATION CURVE

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Introduction: Inter- and intra-observer variability may be a problem in gait analysis and marker placement is still a matter of discussion. In this study, we have investigated the kinematic consequences of changing the thigh rotation offset when abnormalities of the knee curves were observed in the frontal plane.

Patients/ Material and methods: The aim of the study was to study the kinematic consequences of adjusting the thigh rotation offset, post testing, when abnormalities were observed in the knee varus/valgus curves in the frontal plane. One healthy adult male was used as a subject for all trials. Four different investigators put reflective markers on the same subject 5 separate times. The investigators consisted of three physiotherapists and one ortopeadic engineer. Two members of the staff did the marker placement every second time. The investigators were blinded to previous measurements. Furthermore, the thigh rotation offset was corrected when the knee curves in the frontal plane showed increased valgus/varus in swing phase. The thigh rotation offset was adjusted until the varus graphs were within the normal band in mid swing. These data were compared with the original data and the differences in means and standard deviations for ten specific positions in the gait cycle, were estimated.

Results: When adjusting the thigh rotation offset, we observed as expected a significant reduction of mean and standard deviations for the knee varus/valgus curves. The results also showed significant changes in mean and standard deviations of the hip rotation at toe off in the transversal plane. Furthermore, we found a decrease in the mean hyperextention of the knee in stand phase in the sagittal plane. There were minor or no changes in the other positions in the gait cycle.

Discussion & Conclusion: Adjustment of the thigh rotation offset by monitoring knee varus-valgus angle, results in decreased variability in the hip rotation curve. Only minor changes in the other curves were observed. These results justify the implementation of adjusting the thigh rotation offset, when abnormalities are present during the swing phase (and normal curves are present during the stand phase) in the varus/valgus curves in the frontal plane.

References: 1.McGinley JL, Baker R, Wolfe R, Morris ME. The reliability of three-dimensional gait measurements: A systematic review. Gait and Posture 2009:29:360-369.

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Disclosure: No significant relationships.

09:00-10:20 - CLINICAL OUTCOME II

O78

EFFECT OF CLIMBING THERAPY ON GAIT PERFORMANCE IN CHILDREN WITH CEREBRAL PALSY

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Introduction: Physical therapy is one of the most important aspects of cerebral palsy therapy; the treatment aims to improve posture and movement to enable more realistic functioning in daily life. Sport therapy helps to increase and maintain the motivation of therapy. In particular, climbing combines challenging aspects of height with therapeutical aspects of strength, flexibility and coordination for all levels of gait impairment (GMFCS I-III). Strength training of the lower leg muscles improves knee flexion and stride length during gait [1]. The effect of climbing therapy on gait performance was not investigated before.The hypothesis of this study is that climbing therapy has a positive effect on gait performance.

Patients/ Material and methods: Nine children and adolescents with cerebral palsy (GMFCS I-III) underwent an 8 week climbing therapy program with two session of 1.5 h per week. Within a crossover study design the children were gait analyzed using an 8 camera Vicon system before and after climbing as well as before and after their conventional therapy program. Gait analysis was followed by clinical assessment of strength and flexibility. MANOVA for repeated measures on two factors testing (pre-post) and therapy (climbing, conventional) was performed on selected gait parameters (velocity, step time, step length, asymmetry of stance time as well as the Gait Profile Score). Additionally clinical parameters, peak dorsiflexion, popliteal angle, hip flexion, knee extension and ankle plantarflexion strength were assessed.

Results: Significant differences between pre and posttest with significant interactions with the climbing therapy were found for an increase of symmetry of stance duration ($p=0.015$) and an increase in step length ($p=0.044$) of the more involved leg.

Discussion & Conclusion: These findings suggest that climbing therapy is an effective treatment strategy to improve gait symmetry and performance and as such should be considered as a component in rehabilitation of children with cerebral palsy.

References: [1] Damiano, Phys. Therapy 1995, 76:658-67.

Disclosure: No significant relationships.

O79

GAIT DEVIATIONS IN PATIENTS WITH LONGTERM FOLLOW-UP AFTER LEGG-CALVé-PERTHES DISEASE

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Introduction: Legg-Calvé-Perthes disease (LCPD) is a self-limiting, iuvenile osteonecrosis of the femoral head among children 4 to 10 years of age. Depending on the final result the deformity will lead to early osteoarthritis. Until now follow-up-evaluations are analyzing only subjective results, clinical parameters like ROM-measurements and radiological changes. The objective was to analyze the gait pattern in the longterm follow-up after LCPD and to correlate the results with the clinical and radiological outcome.

Patients/ Material and methods: 30 adults (mean age 31 $\pm$ 11ys) treated for unilateral LCPD in childhood conservatively (n= 16) or operatively (n= 14) were investigated clinically and radiographically. The clinical results were classified according to the Harris Hip Score (HHS). According to the radiological Stulberg-rating system the patients were devided in 3 subgroups: group 1 = good congruency (Stulberg type 1 and 2, n = 16), group 2 = moderate congruency (Stulberg type 3, n = 3) and group 3 = poor congruency (Stulberg type 4 and 5, n = 11). 3D-gait-analysis was performed with a VICON 512 system. Patients walked at a self-selected speed – barefoot. Spatiotemporal, kinematic and kinetic parameters were evaluated and compared to a group of normal adults (n = 40, average age 28.0 ys.). Statistical analysis was performed by the Mann-Whitney-U-test for independent samples; the correlation within the patients group was performed using an ANOVA-analysis and the Kruskal-Wallis-test for non-parametric samples; a p-value of less than 0,05 was considered to indicate statistical significance.

Results: In comparison to the controls the LCPD-group showed the following significant differences: reduced cadence ($p = 0,007$), increased step duration on the involved side ($p = 0,002$), increased step width ($p = 0,001$), increased ROM of the pelvis in sagittal plane ($p < 0,001$), on the involved side reduced hip extension ($p = 0,002$), reduced maximum knee flexion in swing ($p < 0,001$), reduced maximum ankle dorsiflexion ($p < 0,001$), reduced power generation at the hip ($p < 0,001$). The analysis in dependence of the radiological outcome showed a significant influence of the hip deformity on the duration of stance phase ($p = 0,024$), especially single stance ($p = 0,024$) and the motion pattern of the pelvis in frontal plane ($p = 0,026$); a radiographically increased hip deformity correlated with a significantly decreased HHS ($p=0,019$).

Discussion & Conclusion: Gait analysis after LCPD showed significant deviations of the gait pattern in comparison to the controls with loss of symmetry. These are part of an unloading mechanism. The deviations are correlating poorly with the radiological outcome according to the Stulberg classification. Further studies are necessary to determine functional predictors for the development of secondary osteoarthritis which may than be influenced by conservative or surgical treatment options.

References: Westhoff et al. Gait Posture 2006

Disclosure: No significant relationships.

O80

THREE-DIMENSIONAL GAIT ANALYSIS IN CERVICAL SPONDYLOTIC MYELOPATHY: COMPARISON WITH AGE- AND GENDER-MATCHED HEALTHY CONTROLS.

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Introduction: Gait impairment is a primary symptom of cervical spondylotic myelopathy (CSM). People with CSM walk more slowly than those without the disorder, and demonstrate changes in range of motion at the knee and ankle (1). However, information on specific kinetic and kinematic parameters is lacking. Furthermore, gait in CSM has previously been compared with healthy controls walking at self-selected, faster speeds. Gait speed is a known confounding factor for kinematic and kinetic parameters, therefore comparison with healthy controls at matched speed is necessary to determine true, non-speed dependent differences in CSM. The objectives of this study were to compare gait patterns of people with untreated CSM to those of age and gender-matched healthy controls, and to examine the effect of speed on the observed kinematic and kinetic parameters.

Patients/ Material and methods: Ethical approval was obtained from a local ethics committee. Participants with a diagnosis of CSM were recruited consecutively from a neurosurgery clinic between December 2008 and October 2010. Healthy controls, matched to age (within 5 years) and gender, were recruited for comparison from a local population. Participants with CSM and controls underwent three-dimensional gait analysis using a Vicon motion analysis system, at self-selected speed over a 10 metre track. Controls were also assessed at the speed of the person with CSM to whom they were matched. The average temporal-spatial, kinematic and kinetic parameters from 10 trials of each participant were used for analysis.

Results: Sixteen people with CSM and 16 healthy controls were recruited. Compared to healthy controls at self-selected speed, the CSM group walked significantly more slowly ($p < 0.001$), with shorter stride lengths ($p < 0.001$) and longer double support duration ($p < 0.001$). They were also found to have significant decreases in several kinematic and kinetic parameters, including total sagittal range of motion at the hip ($p = 0.004$) and knee ($p = 0.004$), peak ankle plantarflexion ($p = 0.013$), anteroposterior ground reaction force (GRF) at toe-off ($p < 0.001$), power absorption at the knee in loading response (K1, $p = 0.002$) and terminal stance (K4, $p < 0.001$), and power generation at the ankle (A2, $p < 0.001$). At matched speed, the CSM group showed significant decreases in knee flexion during swing ($p = 0.006$), total sagittal knee range of motion ($p = 0.028$), peak ankle plantarflexion ($p = 0.018$), and anteroposterior GRF ($p = 0.02$). Ankle A2 power was also reduced, but this was not statistically significant ($p = 0.075$).

Discussion & Conclusion: People with CSM were found to have significant gait abnormalities that have not been previously reported. At matched speed, differences persisted in kinematic and kinetic parameters of the knee and ankle at terminal stance and initial swing, suggesting that there are key differences in the motor strategies of people with CSM in these phases of gait that cannot be explained by speed alone. Further investigation of motor control strategies in CSM is warranted, using electromyography to evaluate muscle function during gait and principal components analysis to determine key factors contributing to gait impairment. The findings have implications for the understanding of gait in this condition, and for the evaluation of outcome following surgery.

References: 1.Maezawa Y, Uchida K, Baba H. Journal Of Orthopaedic Science 2001;6(5):378-84.

Disclosure: No significant relationships.

O81

SINGLE EVENT MULTILEVEL SURGERY IN CHILDREN WITH SPASTIC CEREBRAL PALSY: 5 YEAR FOLLOW UP OF A RCT COHORT.

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Introduction: By mid childhood most children with CP will develop fixed deformities which may require surgical correction. The use of instrumented gait analysis has allowed surgeons to determine what specific procedures are required for each child. Surgeons combine these procedures into a single definitive procedure known as Single Event Multilevel Surgery (SEMLS). SEMLS improves the gait of children with CP 12months after surgery with improvement in function observed at 24months[1],but is this improvement maintained over time?. The objective of this study is to evaluate the outcome of SEMLS at 5years post surgery.

Patients/ Material and methods: Nineteen children with spastic diplegic CP, GMFCS Levels II (14) and III (5), mean age of 9.7(range 7.7 - 12.2) years who participated in a RCT to have either SEMLS immediately or after a 12month delay have been followed prospectively. All children regardless of group were assessed pre SEMLS, 1, 2 and 5years post SEMLS. Outcome measures were the Gillette Gait Index(GGI), Gait Deviation Index(GDI) Gait Profile Score(GPS), Gross Motor Function Measure 66(GMFM66).

Results: All 19 children have completed 2 year follow up, 15 have completed 5 year follow up. One child has been excluded from analysis because his diagnosis has been changed from CP.
Gait measures were calculated for 4 gait traces for each leg for each child then averaged, prior to comparison. Data were analyzed using linear regression. Results are presented in Table1. There were no significant difference between gait measures between 1-5 and 2-5years. There was a small trend for deterioration in the gait parameters. GMFM showed a non significant deterioration and at 5years was not significantly different from pre SEMLS.
Table 1 Mean(95%CI) gait measures & GMFM66 pre, 1, 2 & 5yrs post SEMLS; linear regression of 5yrs compared to pre, 1, 2 yrs post SEMLS.

Measure Mean(95%CI)	Post SEMLS			
	5yrs n=15	2yrs n=18	1yr n=18	pre n=18
GPS	9.67(8.2, 11.1)	9.23(8.1, 10.3)	9.9(8.6, 11.2)	14.9(12.9, 16.8)
-diff 5yrs(95%CI)		-0.44(-1.6, 0.67)	0.26(-1.2, 1.7)	5.2(3.3, 7.1)#
GGI	148(99, 196)	135(100, 170)	152(111, 192)	360(259, 460)
-diff 5yrs(95%CI)		-12.7(-40.8, 15.5)	4.1(-36.5, 44.6)	212(127.5, 297)#
GDI	79.0(73.7, 84.3)	80.8(76.4, 85.3)	78.0(73.7, 82.3)	65.2(60.4, 69.9)
-diff 5yrs(95%CI)		1.8(-2.6,6.3)	-1(-6.2,4.2)	-13.8(-19.1,-8.5)#
GMFM66	68.7(61.1, 76.2)	71.0(66.1, 75.8)	67.1(62.3, 71.8)	66.9(61.2, 72.6)
-diff 5yrs(95%CI)		-2.3(-6.7, 2.1)	1.6 (-3.4, 6.6)	1.7 (-2.4, 5.9)

Discussion & Conclusion: This study shows gait improvements are maintained 5years post SEMLS. There is a trend for deterioration in gross motor function between 2 and 5years. This may be due to children having their adolescent growth spurt or may be an expression of the natural history of functional deterioration in CP. However, function remains 1.7% better than pre SEMLS. SEMLS is the standard of care to improve gait and functioning in children with spastic diplegic CP. Improvements in gait are maintained at 5years post SEMLS. Non significant trend for deterioration in function may be related the natural progression of musculoskeletal pathology in CP.

References: [1] Thomason P, et al Single-Event multilevel Surgery in Children with Spastic Diplegia A Pilot RCT. J Bone Joint Surg Am. 2011, 93:451-60

Disclosure: No significant relationships.

O82

LONG-TERM OUTCOME OF FEMORAL DEROTATION OSTEOTOMY IN SPASTIC DIPLEGIA

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Introduction: Internal rotation gait is a common gait disorder in spastic diplegia[1] and accompanied by several functional problems. Femoral derotation osteotomy (FDO) is accepted as the standard corrective procedure[2]. Initial satisfactory results were reported by various studies[3]. However, there are only a handful studies addressing the "longer-term" outcome. While Kim found recurrence of internal rotation after 5 years[4], Ounpuu postulated its maintenance after the same time[5]. There are no reports about the clinical course beyond this period, which is of particular interest, especially since many patients are still in growth after surgery. The purpose of this study was the evaluation of clinical course in grown-up patients at least 6 years after FDO carried out in childhood.

Patients/ Material and methods: 33 children with diplegic CP (n=59 legs, age: 10.5±3.6y) with functional disturbing internal rotation gait were examined pre-, 1±0 year and 9±2 years (mean age: 18.9±3.2) after distal (27 legs) or proximal (32 legs) FDO as a part of multilevel surgery. Standardized clinical exam and 3D gait-analysis were carried out in all subjects at all examinations. The intra-operative derotation amount averaged 25 degrees.

Results:

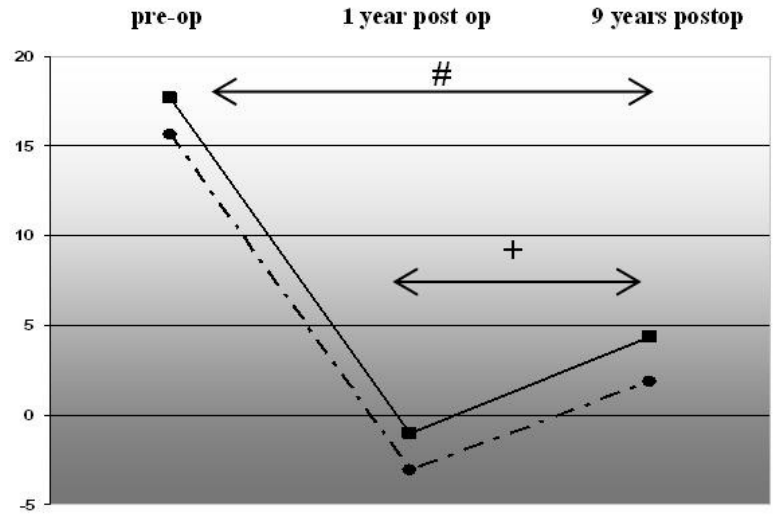

Figure 1. Transversal plane kinematics. The mean values of mean hip rotation (■, solid line) and mean foot progression angle (●, dashed line) in stance of all 59 legs at all three examination dates are displayed

Significant improvements were found for all parameters 1 year after FDO, which showed a slight but significant deterioration after 9 years (Figure and Table 1)

Parameters	pre-op	1 year post	9 years post
Mean hip rotation ST	17.7 (12.0)	-1.0 (11.3) #	4.3 (13.6) #+
Mean foot progression ST	15.6 (16.1)	-3.1 (9.8)#	1.9 (11.2) #+
Mean pelvic rotation ST	0.3 (8.2)	0.7 (6.0)	0.8 (7.5)
Mid-point in 90° hip flex.	10 (11)	-5 (10)#	-3 (7) #+
Mid-point in hip ext.	20 (13)	6 (9)#	11 (9) #+

Table 1. Mean values of all legs pre- and post-surgical ± (1SD); Clinical mid-point according to Kerr (Gait

Posture 2003;17:88-91) **#** significant difference to pre-op (t-test, $p<0.01$) + significant difference to 1-year postop (t-test, $p<0.01$)

Discussion & Conclusion: Increased femoral anteversion and dynamic components (spasticity of internal rotators, compensatory mechanisms) are discussed as possible factors leading to internal rotation gait. Since FDO is frequently carried out in growing children and only addresses femoral anteversion, the long-term development after FDO is of major importance. Only few studies exist reporting inconsistent results 5 years after FDO[4,5]. The results of the present study indicate that FDO leads to satisfactory initial correction. However, a mild but significant deterioration 9 years after FDO could be found. This development may be explained by the clinical course of specifically 7 cases showing prominent recurrence of internal rotation gait. Those cases need to be further addressed for a better outcome prediction. It is not sufficient to take only the increased femoral anteversion into account when planning correction of internal rotation gait. Dynamic components as well as growth should be considered as possible factors leading to recurrence.

References: [1] Wren TAL. et al. J Pediatr Orthop. 2005;25:79-83. [2] Pirpiris M. et al. J Bone Joint Surg Br. 2003;85:265-272. [3] Kay RM. et al. J Pediatr Orthop. 2003;23:150-154. [4] Kim H. et al. J Pediatr Orthop. 2005;25:739-743. [5] Ounpuu S. et al. J Pediatr Orthop. 2002;22:139-145.

Disclosure: No significant relationships.

O83

THE TIMING OF SINGLE-EVENT MULTILEVEL SURGERY IN CHILDREN WITH CEREBRAL PALSY WALKING WITH FLEXED KNEE GAIT

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Introduction: The information on timing and long-term outcome of single-event multilevel surgery (SEMS) in children with bilateral spastic cerebral palsy (BSCP) walking with flexed knee gait is limited. Based on our clinical experience we hypothesized that older children with BSCP would benefit more from SEMS than younger ones. Moreover, any improvement in older children would be maintained with less additional surgeries.

Patients/ Material and methods: A retrospective analysis of long-term outcomes of SEMS. Alltogether 32 children (17 boys, 15 girls) of the mean age at the surgery of 10y and 6m (SD 3y 1m) with GMFCS level II (12) and III (20) were included in the study. The follow-up time was over 10 years until the adulthood of participants – the mean age at the last follow-up was 21y and 4m (SD 3y 4m). Data were collected at 6 separate occasions: preoperatively, 1y, 2-3y, 5y, 7-8y and 10 or more years postoperatively. Primary outcome was a Gait Deviation Index (GDI) [1] and secondary the number and type of initial and additional surgeries. A linear mixed model and Spearman's rank correlation coefficient were used to prove the hypothesis.

Results: The preoperative GDI values of older children tended to be lower than those of younger ones but this effect was not significant: $\beta_{Age} = -1.00$; $p=0.076$. We prooved that the older is the child at the time of the surgery the better is the long-term result: $\beta_{Age,\ Time} = 0.15$; $p=0.03$ (Figure 1). However, contrary to our second hypothesis, we did not find any correlation between the age at the surgery and the number of bony or soft tissue procedures performed initially as well as during the 10 years of follow-up.

Discussion & Conclusion: The substantial postoperative improvement in gait deviation documented in this study must be interpreted in the light of the fact that natural progression of gait in children with cerebral palsy shows deterioration [2]. An important aspect of the present study is that children were followed up for more than 10 years to late adolescence or adulthood. The onset of puberty has been described as a contributing factor to deterioration of the natural progression of gait [2]. As the onset of puberty occurs earlier in children with CP [3] the older children could have already been over the period of the growth spurt at the time of surgery which might have produced more predictable outcomes. Children with BSCP requiring SEMS at older age fare better in long-term run than those undergoing the surgery at younger age. We speculate that the timing of the pubertal growth spurt should be taken into consideration when planning surgical procedures in children with BSCP.

References: 1. Schwartz, M.H. and Rozumalski, A. The gait deviation index: A new comprehensive index of gait pathology. Gait Posture 2008; 28: 351-357 2. Bell, K.J., et al. Natural progression of gait in children with cerebral palsy. J Pediatr Orthop 2002; 22: 677-682 3. Worley, G., et al. Secondary sexual characteristics in children with cerebral palsy and moderate to severe motor impairment: A cross-sectional survey. Pediatrics 2002; 110: 897-902

Disclosure: No significant relationships.

O84

THE IMPACT OF THE PATELLAR TENDON SHORTENING AT CROUCH KNEE GAIT IN PATIENTS WITH CEREBRAL PALSY

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Introduction: Knee flexion deformity and knee extensors weakness are potential causes of crouch gait. The treatment of fixed knee flexion can differ in the literature and options such as, hamstrings lengthening, distal femur extension osteotomy and posterior knee release, have been described. Patellar tendon shortening or advancement has been mentioned to reduce knee extensors deficiency. The purpose of this study was compare two different approaches for treatment of increased knee flexion during stance phase in a group of diparetic cerebral palsy patients.

Patients/ Material and methods: A retrospective study was performed with data of the gait analysis laboratory and physical examination. Diparetic spastic cerebral palsy patients levels I-III (GMFCS) undergone to advancement or shortening of patellar tendon with distal femoral extension osteotomy (Group A - n=12), and isolated distal femoral extension osteotomy (Group B - n=14) were evaluated. In both groups hamstring lengthening was performed as part of crouch gait treatment. Clinical e kinematic parameters were analyzed and results were compared among groups.

Results: The mean age at surgery was 15.5 years in Group A and 12.3 years in Group B. Patients of Group A were evaluated in a mean of 4 years after surgery whereas the mean follow-up time was 2.3 years in Group B. Knee flexion deformity at physical examination reduced 11.3^0 in Group A and 16^0 in Group B. It was observed significant reduction ($p<0.001$) of knee flexion during stance phase in both groups (reduction of 34.6^0 in Group A and 25.5^0 in Group B). An increase of anterior pelvic tilt occurred at both groups after surgical procedures.

Discussion & Conclusion: Although both techniques improved knee flexion deformity at physical examination and knee extension during stance phase, the association of patellar tendon advancement or shortening, with distal femur extension osteotomy, achieved more impressive results at knee kinematics, as described by Novacheck at al(1). According this data, knee extensors weakness seems play an important rule at etiology of crouch gait in cerebral palsy and patellar tendon shortening or advancement must be considered during decision making process. We concluded that both treatment options improved the knee flexion deformity and knee extension in stance phase, but the osteotomy associated with advancement or shortening of patellar tendon exhibited better results at kinematic parameters.

References: (1)Novacheck TF,Stout J.L. Distal Femoral Extension Osteotomy and Patellar Tendon Advancement to Treat persistent Crouch Gait in Cerebral palsy. J Bone Joint Surg Am. 2008;90:2470-2484.

Disclosure: No significant relationships.

O85

THE EFFECTS OF ANKLE TAPING ON THE KINEMATICS FINDINGS OF THE ANKLE AND KNEE JOINTS DURING WALKING ON LEVEL GROUND.

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Introduction: Ankle sprain is the most common injury occurring among all sporting activities. Ankle taping is widely used in ankle joint either to prevent or treat patients with ankle sprain to help keeping the ankle and foot joints in correct biomechanical alignment during walking/running. Despite its frequent use in sports, there is little evidence to objectively support this claim. This study aimed to investigate the effectiveness of ankle taping on kinematics of the ankle joint and its compensatory effects on the knee joint during walking on level ground.

Patients/ Material and methods: 36 normal subjects (18 males and 18 females with mean age of 22±3 years old and BMI of 22±2) with no history of ankle sprain were randomly tested in 3 conditions including without taping, with taping; and with a placebo taping. A Gibney close basket weave technique was used in this study. The subjects walked at their preferred speed and their 3-D ankle kinematics and knee saggittal plane data were captured and analyzed with the use of an automated motion analysis system (Qualysis®, Sweden).

Results: Findings of the current study revealed a significant decrease in ankle supination at initial contact, a significant decrease in maximum ankle plantar flexion and pronation angles in stance phase and a significant decrease in maximum foot supination in swing phase ($p<0.01$). In knee joint, ankle taping significantly increased knee flexion angle at initial contact and the maximum knee flexion at the swing and stance phases ($p\geq0.03$). Placebo taping resulted in data similarly to the ankle with no taping condition.

Discussion & Conclusion: In agreement with most previous research, the results of the current study showed taping to be effective in controlling foot movements. Ankle taping showed to be able to produce some compensatory effects on knee joint kinematics. In conclusion, the changes following ankle taping made the subjects to walk with a stiffer ankle and a more flexed knee to close their centre of mass to their base of supports.

References: 1. Dizon J, Reyes J. Asystemic review of the effectiveness of external ankle supports in the prevention of inversion ankle sprains emong elite and recreational players. Journal of science and medicine in sport.2009.

Disclosure: No significant relationships.

11:20-1:2:20 - SCORSE/ EMG

O86

A METHOD TO REFERENCE THE GAIT DEVIATION INDEX TO A SPEED-MATCHED CONTROL

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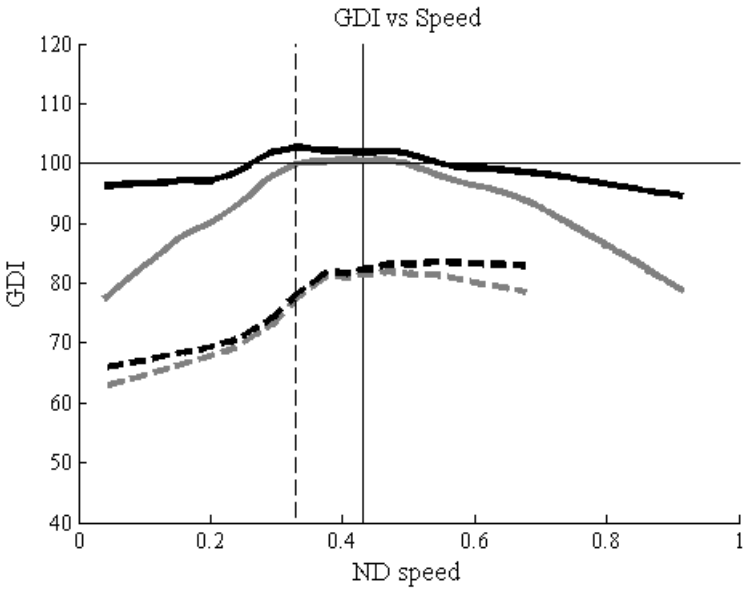
Introduction: The Gait Deviation Index (GDI) is designed as an intuitively scaled distance between a pathological gait pattern and the average normal gait pattern (1). A GDI value of 100 or greater indicates normal gait, and each 10 points below 100 is one standard deviation away from normal gait. In the original derivation of the GDI, the normal gait mean was defined using a control group that was walking at a self-selected speed. Kinematic deviations that arise from a change in walking speed are well documented (2). The GDI does not control for the effects of walking speed, and thus the GDI for normal gait occurring at a slow speed is reported as less than 100. The focus of this abstract is to develop a method to calculate the deviations of a subject from the mean of a speed-matched control in order to account for speed-related effects when measuring gait deviations in clinical populations.

Patients/ Material and methods: Two groups of subjects were evaluated retrospectively. The first was a control group that consisted of 83 typically developing children (age 10.5 (3.5) years, height 1.56 (0.21) m, mass 34.2 (9.6) kg) who each walked at several different speeds during a single session. The second was a clinical group that consisted of 3617 patients who had been seen at our center (age 11.9 (7.8) years, height 1.35 (0.23) m, mass 37.2 (19.5) kg). Each subject in the clinical group had walked at their own self-selected speed. Two versions of the GDI (free-speed, and speed-matched) were calculated for each subject (control and clinical) by using two different references. The free-speed GDI used a reference consisting of the free-speed trials from the control group. The speed-matched GDI used a reference consisting of control data matched to the speed of the stride for which the GDI was being calculated. The speed-matching was carried out in a manner that allowed a unique reference to be calculated for any speed. The difference between the free-speed and speed-matched GDI was calculated for each of the strides. A difference of more than 4.0 was of particular interest, as this is approximately equal to the difference seen between FAQ levels (1).

Results: The average non-dimensional walking speed of the control group walking at their self-selected speed was 0.43. The average speed of the clinical group was 0.33. When analyzing the difference between the two methods for the control group, the inter-quartile range was 1.3 – 6.7. The difference was greater than 4.0 in 42.2% of the strides [Fig. 1]. For the clinical group, the inter-quartile range of the difference between the two methods was 0.4 – 1.7. There was a difference of greater than 4.0 in 4.5% of the clinical group strides [Fig 1].



Discussion & Conclusion: This abstract presents a new method for determining a speed-matched GDI. It is clear that speed-matching is more important when evaluating the control group than the clinical group. When the typically developing children were walking either very fast or very slow, the difference between the two methods was four or more GDI points. Even though the clinical subjects walked more slowly than the controls (on average), the differences between the two methods were not nearly as dramatic. If the kinematic deviations due to walking speed were the same in the clinical group as they were in the control group, it would be expected that the speed-matched GDI would be several points higher in the clinical group at speeds far removed from the free speed mean. The GDI is a distance measure that quantifies how far a specific stride is from the mean of the free-speed control group. There is no direction associated with this distance, meaning that the actual deviations (i.e. increased knee flexion, decreased plantarflexion, etc.) cannot be deduced from the measure itself. The fact that the speed-matching has a larger effect on the control group implies that, although the clinical group is a distance away from the control mean, the 'direction' of the kinematic deviations due to walking speed in the control group is different from the 'direction' of the kinematic deviations due to walking speed in the clinical group. Further analysis needs to be conducted to determine the mechanisms that cause this difference between the two groups.

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Disclosure: No significant relationships.

O87

GAIT DEVIATION INDEX AND GROSS MOTOR FUNCTION IN CHILDREN WITH CEREBRAL PALSY

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Introduction: Due to complexity and variability of gait abnormalities in children with cerebral palsy (CP), comprehensive gait pathologies are essential in clinical practice (1). Many clinical and instrumental scores, levels and indices were described in literature for this purpose. Gait Deviation Index (GDI) was described by Schwartz M. 2008 to measure the deviation of pathological gait from normal profile. Gross Motor Classification System (GMFCS) was described by Palisano 1997 to stratify CP children regarding Gross Motor Function (2).The aim of this study is to evaluate the ability of GDI to distinguish between different topographic classifications within children with CP and different levels of GMFCS. A correlation study between GDI and GMFCS score is also performed.

Patients/ Material and methods: A retrospective study on gait data was lead. 134 ambulant children with CP are included (31 hemiplegia, 86 diplegia, 6 triplegia, 11 quadriplegia), age range mean age 10.5Â±4.5 years. GMFCS score was reported for each patient during the clinical exam. Participants underwent 3D gait analysis using 6 cameras Vicon MX3 to extract kinematic parameters. GDI was calculated in Matlab function using the method provided by Shwartz M. 2008 for a representative stride cycle for each subject. GDI is referenced to our own data set which comprises 61 Typically Developing (TD) subjects. A repeatability study was performed on 16 TD children (t test, CI at 95%). One way Anova with Duncan's post hoc test determined GDI difference between topographic classifications and GMFCS levels within CP children. Pearson's correlation was calculated between GMFCS level and GDI.

Results: Inter session repeatability with 2SD of differences between sessions (TD children) was Â± 10. GDI level is normally distributed at each GMFCS level and for TD children. Histogram is shifted toward 100 when GMFCS level decreases (figure1).

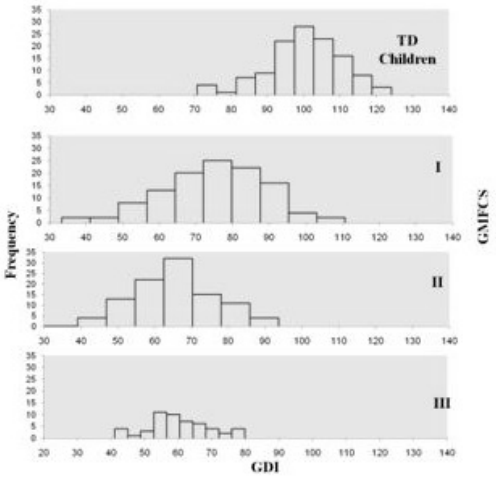

Figure 1: Histogram of the GDI regarding GMFCS levels

Anova Duncan's post hoc test confirmed a significant difference between all groups except between triplegia and diplegia, triplegia and the affected side of hemiplegia. Pearson's correlation coefficient showed a moderate relationship between GDI and GMFCS (R= -0.42, p< 0, 0001). Anova showed significant difference of GDI scores between GMFCS levels I vs II and I vs III, however no significant difference was found between level II and III.

Discussion & Conclusion: The ability of GDI to distinguish between different groups except between the affected side of hemiplegia, diplegia and triplegia confirms the confusion in clinical topographic classifications for these children. The ability of GDI to distinguish between GMFCS level I and II concurs with the results found by Shwartz (1) for the Gillette Functional Assessment Questionnaire (FAQ). The lack of differentiation between GMFCS level II and III could indicate its poor discriminating elements. The moderate correlation between GMFCS and GDI indicates the utility of GDI, giving further information, to classify motor impairments in children with CP.

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Disclosure: No significant relationships.

O89

GAIT DEVIATION INDEX – A SUITABLE MEASUREMENT OF GAIT DEVIATIONS IN PATIENTS WITH KNEE AND HIP OSTEOARTHRITIS

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Introduction: About 10 000 knee joints and 14 000 hip joints are replaced in Sweden every year due to osteoarthritis (OA). Common symptoms of OA are pain, loss of function, swelling and joint stiffness. TodayÂ´s patients are more physically active and improved function has become an important goal along with pain relief. Adults with OA demonstrate deviations in gait, such as decreased joint motion (1). The patient's opinion about their knee and hip and associated problems are commonly evaluated using questionnaires, such as the Knee Injury and Osteoarthritis Outcome Score (KOOS) and the Hip Disability and Osteoarthritis Outcome Score (HOOS) (2,3). In 2008 the Gait Deviation Index (GDI) was published (4). The GDI demonstrates good validity for patients with CP but its suitability for patients with OA has not been evaluated. We aimed to quantify gait deviations, as GDI scores, in patients with hip or knee OA in relation to healthy persons without gait deviations and to examine the relationship between the GDI and KOOS, HOOS and self-rated pain.

Patients/ Material and methods: 40 patients with knee or hip OA, assigned for total knee and total hip replacement were included. Twenty patients with knee OA, (mean (SD) age 67 (8) yrs) and 20 with hip OA (mean (SD) age 68 (9) yrs) participated. Twenty age and gender match controls were included in the study. Three-dimensional lower extremity joint kinematics of independent barefoot walking were collected. Mean GDI of the left and right side of three representative strides were used in the calculations. Patient´s opinion of their knee or hip was evaluated using KOOS or HOOS. The patient´s with OA rated their pain during walking using a visual analogue scale (VAS 0-100mm). Descriptive statistics characterized the sample and correlational analyses were used to examine relationships between variables.

Results: The patients with KOA and HOA demontrated significantly lower GDI ($p<0,001$) compared to healthy controls, mean (SD) KOA GDI; 89,0 (11), HOA 90,0 (8) controls 100,8 (7). There were no significant differences in GDI-values between the two groups with OA. There was a moderate correlation in the KOA group between GDI and KOOS pain and sport & recreation ($r=0,44$, $p=0,054$ vs $r=0,41$, $p=0,072$). The HOA group demonstrated a significant correlation between HOOS symptoms and GDI ($r=0,56$, $p=0,010$). There was no correlation between pain, measured with VAS, and GDI.

Discussion & Conclusion: Patients with hip and knee OA demonstrated a reduced GDI compared to healthy controls . The magnitude of gait deviations reflected to a moderate degree the patients assessment of their impairment, however, there was no correlation between gait deviations and self rated pain. These findings demonstrate the need for reliable functional measurements since pain might influence subjective measures, such as questionnaire more than measures of function, such as walking.

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Disclosure: No significant relationships.

O90

MEDIAN EMG FREQUENCY QUANTIFIES MUSCLE WEAKNESS DURING GAIT IN CHILDREN WITH CEREBRAL PALSY.

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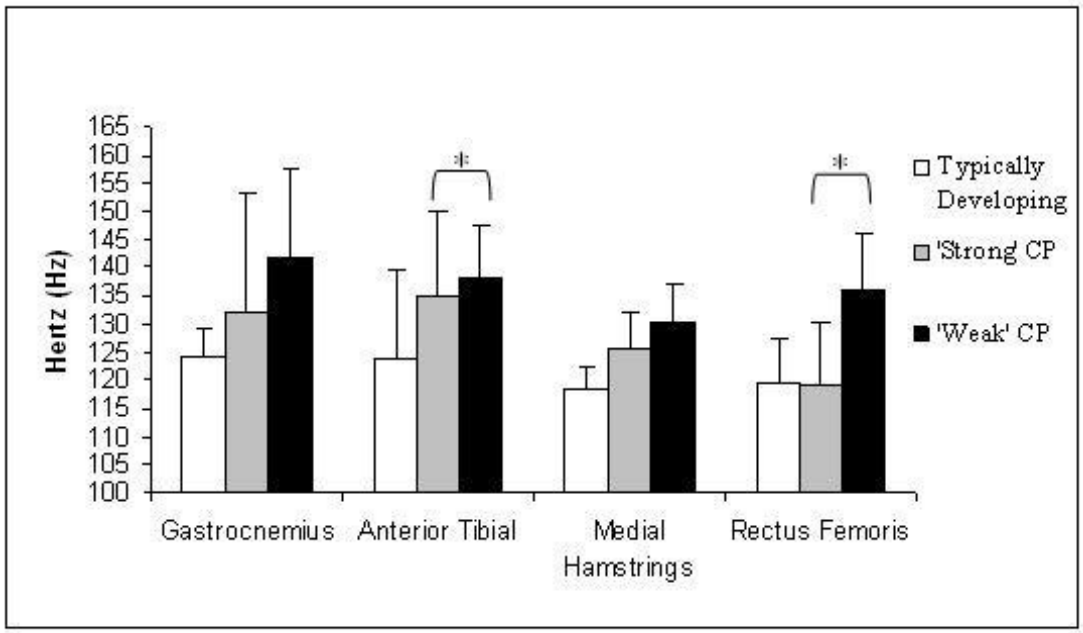
Introduction: 3D gait analysis (3DGA) produces a detailed and objective dataset on walking. Unfortunately, it was not yet known how to use this vast dataset for the identification of muscle weakness in children with Cerebral Palsy (CP) while walking. EMG data recorded during 3DGA might provide more insight into the functional strength of muscles. Previous studies already reported higher (mean) EMG frequencies[1,2] and lower amplitudes[2] in CP (lower limb) muscles during walking or cycling when compared to typically developing (TD) participants. It is still unclear whether the EMG frequency can also differentiate between weak and strong CP muscles during walking.

Patients/ Material and methods: EMG data of four muscles (gastrocnemius, anterior tibial, rectus femoris, medial hamstrings) were collected during 3DGA. For each muscle, 15 weak and 15 strong children with CP, who met the following inclusion criteria, were selected: (a) spastic type of CP (5-15 years old), (b) (near) normal muscle force or muscle weakness in at least one of the studied lower limb muscles, (c) no lower limb Botulinum Toxin-A treatment within 6 months prior to 3DGA, (d) no history of lower limb surgery, (e) high-quality noise-free EMG-data. A weak muscle was defined as a manual muscle testing score[3] of 3- and less, a strong muscle was defined as a manual muscle testing score of 4 and above. Fifteen age-related TD children were included as controls. Raw EMG signals, collected at 1500 Hz, were filtered with a 6th order Butterworth bandpassfilter 20-500Hz. A fast Fourier transformation (FFT) of the filtered EMG was calculated with a windowlength of 200 points, 199 points overlap and a resolution of 256 points. Only the absolute value of each of these FFTs was taken into account, and for each FFT the center of gravity was determined. The median was calculated for the array of center of gravities. Differences were identified by Kruskal-Wallis with post-hoc Mann-Whitney U test.

Results: The median EMG frequency of (all) CP muscles during walking was significantly higher than the frequency of TD muscles. The weaker CP muscles exhibited higher median EMG frequencies than the muscles of the stronger CP children. (Figure 1) This difference reached statistical significance for the Anterior Tibial and Rectus Femoris muscle, and a clear tendency was observed for the Gastrocnemius muscle.



Discussion & Conclusion: Based on these results, it seems possible to objectively differentiate weak from strong CP muscles based on median EMG frequency. Moreover, as the studied EMG data was recorded during 3DGA, a functional and clinically relevant differentiation of weaker and stronger CP muscles seems to be feasible through assessment of EMG frequency. This study indicates that future objective and functional evaluation of muscle strength in children with CP might be possible based on the median frequency of the EMG signal recorded during a 3D gait analysis.

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Disclosure: No significant relationships.

O91

RELIABILITY OF SURFACE ELECTROMYOGRAPHY TIMING PARAMETERS IN GAIT IN CERVICAL SPONDYLOTIC MYELOPATHY

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Introduction: Gait impairment is a primary symptom of cervical spondylotic myelopathy (CSM). Visual observation of surface electromyography (SEMG) signals has indicated that the timing of muscle activity during gait may be problematic in CSM (1). An objective method to evaluate timing parameters in this condition is currently lacking. The Teager-Kaiser Energy Operator (TKEO) was shown to aid the detection of muscle activity in children with cerebral palsy and older adults (2, 3). The aims of this study were to validate a computerised method based on the TKEO to detect muscle activity from SEMG signals in gait in people with CSM, and to evaluate the test-retest reliability of the activation times designated by this method.

Patients/ Material and methods: Ethical approval was obtained from a local ethics committee. Participants with CSM were recruited from a neurosurgery clinic and attended a Movement Laboratory for gait analysis on 2 separate test days, 2 to 7 days apart. SEMG signals were captured with a Motion Lab Systems MA-300 system from rectus femoris (RF), biceps femoris (BF), tibialis anterior (TA) and medial gastrocnemius (MG) during walking at comfortable gait speed for 10 trials. Four computerised activity detection methods, 3 based on TKEO thresholds above resting levels (1, 3, 4) and a novel method based on a combined slope and amplitude threshold, were applied to signals from the right TA and compared to visual interpretation of muscle activation by an independent assessor for validation. The most accurate method was then applied to all signals. Test-retest reliability of the resulting timing parameters was evaluated using the intra-class correlation coefficient, standard error of measurement (SEM), and Bland-Altman limits of agreement.

Results: The detection method based on the combined slope and amplitude threshold showed the highest agreement (87.5%) with visual interpretation. Analysis of test-retest reliability found that the SEM of the timing of RF, TA and MG was 5.5% stride duration or less, while the SEM of BF was 9.4%.

Discussion & Conclusion: The application of a computerised TKEO-based sloped and amplitude threshold to SEMG signals in gait identified periods of muscle activity and quiescence that broadly corresponded with those designated by visual inspection. This method is therefore an objective and valid means of determining the timing of muscle activation in CSM. Test-retest reliability of timing parameters of RF, TA and MG are acceptable for use in clinical practice and repeated measures design studies. BF timing was less reliable, which may be due to variation in testing procedures, or to inherent variability in BF timing in this neurological population. These findings have implications for the analysis of muscle activity in gait in CSM and for evaluation of change following surgical intervention.

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Disclosure: No significant relationships.

O92

KINEMATICS AND EMG ACTIVITY ASSOCIATED WITH PERTURBED GAIT IN CHILDREN WITH CEREBRAL PALSY

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Introduction: Botulinum toxin has no effect on triceps EMG activity during gait in children affected by Cerebral Palsy (CP), while the combination with intensive training determines kinematic changes [1]. These observations could be related to the Crenna lesson on the impossibility to separate central and peripheral contribution to the movement. In fact, toe walkers show anticipated and prolonged activity of triceps [2], but it is not completely clear if this activity is the cause or the effect of motor and biomechanical strategies. A deeper knowledge on the relationship between biomechanical body configuration and function is necessary.

Patients/ Material and methods: 12 children with CP (9 ± 2 years old, toe walkers) and 3 Normally Developed Children (NDC) (8 ± 1 years old) participated in this study. Subjects walked barefoot in the gait analysis laboratory equipped with Vicon Mx system (8 cameras) and surface EMG system (ZeroWire/Wave). The perturbation was generated by a compliant 3DOF robotic platform [3] placed at the floor level, Fig. 1. The compliant moving platform was controlled in order to simulate a physical dumper, adsorbing the body weight at the foot contact. Kinematics and surface EMG was collected for three gait conditions: unperturbed stride, perturbed stride and stride immediately following the perturbation.

Results: Kinematic differences in the stride following the perturbation was observed in CP, where only small difference appeared at pelvis during early stance. During perturbed gait, CP showed changes for all the kinematic parameters, while NDC absorbed the perturbation mainly at the ankle and knee level, Fig. 2 & 3. The main surface EMG differences were: (i) NDC increased hamstring activities during pre and early swing Fig. 4; while (ii) CP exhibited a reduction of the amplitude in early triceps phase during the perturbed stride and during the stride following the perturbation Fig 5.

Discussion & Conclusion: NDC absorbed the perturbation during the perturbed stride. The increase of hamstring activity was addressed to assure the foot clearance. In CP the perturbation involved the pelvis also in the early phase of the stride following the perturbation as consequences of motor impairment. The triceps activity reduction probably is not due to a dynamic stretch response subsequent to body load, but it is task dependant. These responses take advantage from previous experiences because they were immediately adopted without the necessity of learning processes. Ankle kinematics of the stride following the perturbation in CP was not affected and it seems more dependent on biomechanical body configuration and soft tissue characteristics rather than on muscle activation patterns. The observation of adaptive phenomena in pathological condition could provide same new concept concerning the treatment of spastic gait.

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Disclosure: No significant relationships.

POSTERS

P01

ANALYSIS OF BALANCE, SYMMETRY OF BODY AND FUNCTIONALITY IN HEMIPARETIC PATIENTS AFTER BALANCE TRAINING TROUGH VISUAL BIOFEEDBACK

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Introduction: Stroke is a disease that has, globally, a major chronic physical disability, and it is estimated a dramatic increase in this event over the next two decades[1]. The balance problems are reported as the main motor impairment wich can cause falls and major limitations of individual participation in the community[2,3] .The study assessed the effectiveness of balance training through visual biofeedback and compared it with conventional physiotherapy in order to provide another therapeutic for rehabilitation.

Patients/ Material and methods: This study is a randomized controlled trial, and the sample contained 20 hemiparetic subjects aged 59.3 ± 8.3 years, randomly divided into two groups: the conventional group (CG) with conventional physiotherapy and the Wii group (GW) which performed the conventional physical therapy combined with visual biofeedback balance training that adopted the Wii Fit program as resource. The groups were assessed on two occasions, before and after the intervention, examining the functionality into three aspects: the balance by the Berg Balance Scale (BBS), the orthostatic mobility by The Time Up and Go test (TUG), and execution of daily activities by the Functional Independence Measure (FIM). The analysis of balance and body symmetry was performed in a pressure platform. The collection on the platform was performed in two conditions: opened eyes (EO) and closed eyes (OF), lasting 30 seconds each.

Results: The results demonstrated an increased performance of functional activities, as BSE , FIM and TUG ($p < 0.01$). In the body symmetry we found that both groups initially presented a significant symmetry ($p < 0.001$) and after the intervention this asymmetry was not significant. Figure 1 shows the intra-group comparison.

Discussion & Conclusion: The results of this study demonstrate that both physical therapy and physical therapy associated with balance training for visual biofeedback provides significant improvement in balance, body symmetry and functionality in post stroke hemiparetic subjects. However, no difference was observed between the two types of training, we believe that a longer time to adapt and play with the Wii Fit program, could provide more significant results in the process of neurological rehabilitation.

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Disclosure: No significant relationships.

P02

ENHANCEMENT OF ANTICIPATORY POSTURAL CONTROL FOLLOWING A SINGLE TRAINING SESSION

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Introduction: While dealing with perturbations linked to many daily activities, the central nervous system uses two mechanisms of postural control: anticipatory and compensatory postural adjustments (APAs and CPAs). It was demonstrated that utilization of APAs (muscle activation prior to an upcoming perturbation) in healthy young adults significantly minimizes the body's center of mass (COM) and center of pressure (COP) displacements following a perturbation. On the other hand, a lack of APAs relates to massive CPAs (muscle activation after a perturbation), resulting in large displacements of the body's COM and COP, thereby increasing the risk of losing balance [1, 2]. These results draw additional attention to the importance of APAs in control of posture and raise a question of whether APAs could be improved with training. The aim of the present study was to investigate the immediate effects of a single training session in enhancing anticipatory postural control in healthy young adults. It was hypothesized that training related improvements in APA generation would reduce COP and COM displacements following a perturbation, thereby indicating increased postural stability.

Patients/ Material and methods: Six healthy young adults participated in a training session involving 130 catches of a medicine ball (2 or 4lb), selected depending on the subjects' body mass. The subjects were tested pre and post training using the pendulum paradigm [1, 2] wherein they were exposed to external predictable perturbations applied at the shoulder level while standing. 7 trials were collected in each testing session. A six-camera VICON 612 system was used to collect three-dimensional kinematic data, EMG, force platform and accelerometer signals. Integrals of anticipatory and compensatory EMG activity and muscle onsets in relation to the moment of perturbation (T_0) were calculated for 13 trunk and leg muscles. Total displacements of the COP and COM in the anterior-posterior direction were obtained.

Results: Following training, early onsets and increased magnitudes of anticipatory activity and smaller compensatory activity were seen in most of the muscles. This was associated with larger anticipatory displacements of the COP and COM, resulting in reduced magnitudes of COP and COM displacements following the perturbation.

Discussion & Conclusion: The findings of the present study demonstrate the immediate effects of a single training session on the organization of anticipatory postural control in balance maintenance. Training related improvements in APA generation were characterized by early and increased magnitude of anticipatory postural activity, thus enhancing postural preparation. Such an increase in APA utilization resulted in improved postural stability after the perturbation. Thus, the outcome of this study suggests that anticipatory postural control can be enhanced with training. Future studies are needed to assess the long term effect of training interventions designed to optimize the utilization of APAs in individuals known to have balance impairments.

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Disclosure: No significant relationships.

P03

ANALYSIS OF THE STATIC BALANCE OF ELDERLY WITH DIFFERENT LEVELS OF PHYSICAL ACTIVITY

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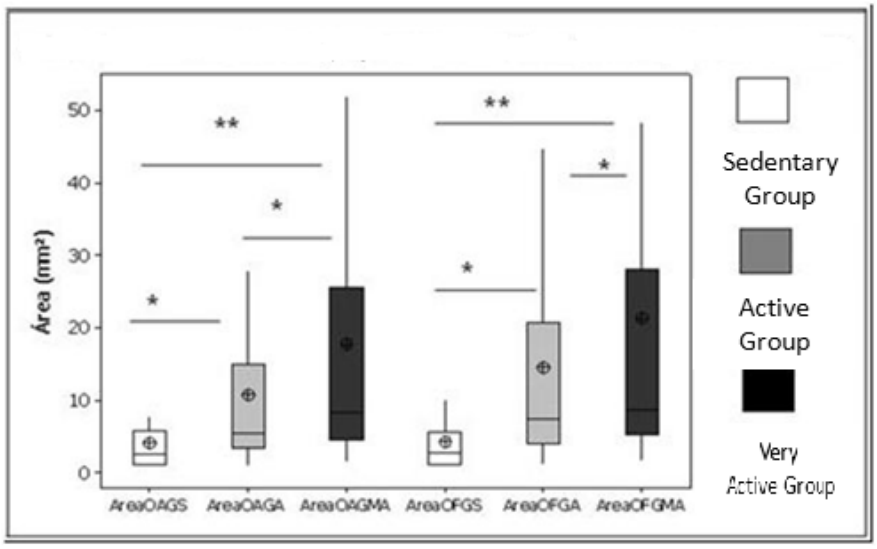
Introduction: The elderly population is growing every day and postural sway balance changes with increasing age. This study aimed to analyze the static balance of elderly people with different levels of physical activity.

Patients/ Material and methods: The study was conducted at the Reference Center for the Elderly (RCE) in the Mandaqui Hospital Complex, São Paulo, SP. The sample consisted of 70 healthy elderly subjects who were divided into three groups according to classification using the International Physical Activity Questionnaire (IPAQ): sedentary group (SG), the active group (AG) and very active group (VAG). The average age was 69.44 ± 6.43. To collect data we used a pressure platform, Fusyo brand, whereas prior to testing patients responded to the IPAQ to characterize the levels of physical activity (PA).

Results: The elderly from VAG showed higher AP, ML and area body sway compared with both the AG and with SG, with eyes open and eyes closed, taking significance as $p < 0.05$. Figure 1 - Variation of COP oscillation of the total area of SG, AG and VAG.



Discussion & Conclusion: This study allows the analysis of a larger displacement of the COP in the antero-posterior and medial-lateral directions in very active elderly, showing greater sway the higher the level of physical activity. Therefore, we believe that this oscillation is increased by the improvement of joint mobility in the physically active elderly as well as postural strategies.

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Disclosure: No significant relationships.

P04

RELATIONSHIP BETWEEN SIT-TO-STAND (STS) MOTION CHARACTERISTICS AND WALKING ABILITY IN STROKE PATIENTS

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Introduction: Sit to stand (STS) motion is among the most commonly executed daily activities. Mean loading of the hemiplegic limb during STS has been shown to range from 24% to 37% of body weight.[1, 2)] Stroke patient also show a larger center of pressure (COP) sway in the mediolateral direction, have a significantly lower rate of rise in force, and take longer to complete the STS.[1)] The previous study reported that STS performance correlates with walking speed, independent ambulation for elderly persons. Although there have been only a few reports that have focused the relation between STS and clinical walking ability test for stroke. Therefore, the aim of this present study was to investigate the relationship between sit to stand motion and walking ability for stroke patients.

Patients/ Material and methods: Participants included 15 stroke patients (11 male and 4 female; 61±9 years) hospitalized in the Nishi-Harima Rehabilitation Central Hospital stood still and performed STS motion on two force plates (G-620, Anima Co Ltd, Japan). Walking ability was classified into two groups: unaided walking in the hospital (n=9), unaided walking in inpatient's room (n=6). And the time required STS motion was calculated from the vertical ground reaction forces. STS motion was divided into three phases and the vertical ground reaction forces were calculated for each phase. In addition, postural sway after STS motion used a coefficient of variance (CV) of the vertical ground reaction forces. 6 minutes walking distance and 10m gait speed indices of gait ability. TUG indices of balance ability. Data are expressed as mean ± SD. Student's t-test processed by the SPSS® statistical package for Windows®, was used for the testing of differences between Two groups. Significance was set at P less than 0.05.

Results: The characteristics of the stroke patients and statistical comparisons between unaided walking in the hospital and unaided walking in inpatient's room groups are shown in Table 2.As a result, Rate of rise in force (%BW/sec) required STS motion and CV after STS motion was significantly larger in the group of unaided walking in inpatient's room than in the group of unaided walking in the hospital ($P<0.05$). The correlation coefficients for the variables show a strong correlation between CV and 10m gait speed($r=0.85$, $P<0.01$), TUG($r=0.69$, $P<0.01$) (table3).

Discussion & Conclusion: These results suggest that STS motion may be useful measure for identifying walking ability in chronic stroke inpatients. Postural sway after STS motion is closely related to gait and balance ability in stroke patients. Finally, to make these tests truly useful to the clinician, we also need studies to establish whether these tests are sensitive enough to measure change over time in the presence of rehabilitation interventions.

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Disclosure: No significant relationships.

P05

STATIC BALANCE AMONG CHILDREN WITH DOWN SYNDROME

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Introduction: According to some authors,[1-3] children with Down Syndrome (DS) oscillate more than children with no neuromotor impairment during static posture control, which is attributed to difficulty capturing the sensory information that determines the position of the body in space.[1-2] The aim of the present study was to assess static balance among children with DS through a stabilometric evaluation and determine the influence of vision over static balance.

Patients/ Material and methods: A non-controlled cross-sectional study was carried out involving 14 children – seven with DS and seven with normal development (control group) – between eight and 12 years of age. A Medicapteurs Fusyo force plate was used for the evaluation of static balance. The participants were assessed in the orthostatic position on the platform, barefoot and with no restrictions regarding the base of the feet. Oscillations in the anteroposterior and mediolateral directions and total area of oscillation were recorded under the conditions of eyes open and eyes closed. The non-paired Student's t-test was used for the inter-group comparisons of mean values and the paired t-test was used for the intra-group comparisons, with the level of significance set at 0.05.

Results: Mean age was 9.8 $\pm$ 0.5 years in the group with DS and 10.0 $\pm$ 0.4 in the control group. Table 1 displays the results of the oscillation analysis. Statistically significant differences were detected between groups in anteroposterior oscillation with eyes open and eyes closed ($p = 0.00$). No statistically significant intra-group or inter-group differences were detected regarding the other variables ($p > 0.05$). Table 1: Oscillations from center of pressure with eyes open and eyes closed

	Group with Down Syndrome		Control Group	
Oscillation	Eyes Open	Eyes Closed	Eyes Open	Eyes Closed
Anteroposterior	1.2 ± 0.3	1.2 + 0.3	1.0 + 0.7	1.0 + 0.8
Mediolateral	7.5 + 4.9	9.4 + 5.2	5.1 + 1.9	6.4 + 2.9
Total Area	6.5 +2.5	8.2 + 3.9	8.5 + 6.1	10.3 + 6.2

Discussion & Conclusion: The children with Down Syndrome analyzed in the present study exhibited greater anteroposterior oscillation with and without visual information. The greater anteroposterior oscillation did not lead to a significant change in the area of overall oscillation in comparison to the children with normal development. Vision did not affect static balance in the sample studied.

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Disclosure: No significant relationships.

P06

INTERFERENCE OF HIGH-HEEL SHOES IN STATIC BALANCE AMONG YOUNG WOMEN

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Introduction: The use of high-heeled shoes leads to alterations to the support base, center of pressure of the feet on the ground and height of the center of gravity in relation to the support base, thereby directly influencing the stability of the body.[1-2] The aim of the present study was to analyze the interference of high-heeled shoes in the static balance of young women, comparing the degree of body oscillation in the anteroposterior and mediolateral directions with and without visual information.

Patients/ Material and methods: A non-controlled cross-sectional study was carried out involving 53 women between 18 and 30 years of age. Anthropometric characteristics of the sample were determined. An OR-6 force plate (AMTI) was used for the evaluation of static balance. The participants were assessed in the orthostatic position on the platform under four conditions: (1) barefoot with eyes open; (2) barefoot with eyes closed; (3) in high heels with eyes open; and (4) in high heels with eyes closed. The same model of shoe was used by all participants, measuring seven centimeters in height and one centimeter in diameter. Oscillations in the anteroposterior and mediolateral directions were recorded. Two-way ANOVA was employed in the statistical analysis, with the level of significance set at 0.05.

Results: Mean age of the participants was 23.3 ± 5.1 years. Mean oscillations in the anteroposterior and mediolateral directions were greater with the use of high-heeled shoes and statistically significant differences were detected between the conditions of eyes open and eyes closed ($p < 0.05$). With the use of high heels, greater oscillations occurred in the anteroposterior direction than the mediolateral direction with eyes open ($p = 0.04$) and eyes closed ($p = 0.00$).

	Barefoot Eyes open	Barefoot Eyes closed	High heels Eyes open	High heels Eyes closed
Anteroposterior	0.022 ± 0.001	0.027 ± 0.002	0.029 ± 0.002	0.038 ± 0.003
Mediolateral	0.013 ± 0.001	0.014 ± 0.001	0.022 ± 0.010	0.024 ± 0.012

Discussion & Conclusion: The results of the present study corroborate those reported in a previous study, [3] which demonstrated that the use of high-heeled shoes causes instability of the feet due to the inversion of the ankle stemming from fatigue of the gastrocnemius and peroneus longus muscles. The change in the support base in terms of height and diameter compromises proprioceptive sensory information necessary for adequate postural control. The use of seven-centimeter high heels compromised the static balance of the women studied, leading to greater oscillations in the anteroposterior and mediolateral directions, especially with visual information was removed.

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Disclosure: No significant relationships.

P07

POSTURAL STABILITY IN CHILDREN WITH CEREBRAL PALSY TREATED WITH BOTULINUM TOXIN A.

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Introduction: Children witch Celebral Palsy (CP) frequently have an impaired sense of equilibrium, abnormal motor control, persistence of primitive reflexes, and may develop abnormal posturing [3, 6, 7]. Burtner and co-workers showed that children with CP are less able to control their COP, which included an increase in COP path ratio and the number of directional changes of the COP path taken by the subject in response to balance threats [1].The aim of this pilot study was to evaluate postural stability in children with CP on the basis of posturographic values of parameters before and two weeks after Botulinum Toxin A (BoNT-A) injection.

Patients/ Material and methods: Six children with cerebral palsy (five bilateral and one unilateral) aged 2-7 (SD = 0,81) participated in the study. All children were rated into II level of GMFCS.The center of pressure (COP) data were collected from AMTI OR6-7-1000 force platform.Subjects participated in two examinations: before BoNT-A injection and two weeks after BTX-A injection. The dosage ranged 6.8 – 12.8 U/kg b.w. of Botox was injected into muscles of lower limbs. Each examination consisted of three eyes open trials for analysis of COP-X Avg., COP-Y Avg., Avg. Radial Displacement, 95% Ellipse Area, Avg.Velocity.The subjects were informed to stay still with bare feet together and hands down on the platform looking at a small object placed at eye high about 3,5 m from the platform.The data for each postural trial were collected for a duration of 30 sec. Researches used video camera to record each trial.

Results: The results of the posturographic examinations in the group of children with CP indicate changes in ellipse area. In the group of five children oscillation area of COP decreased 6%, 20%, 31%, 55% and 63% respectively. In one children oscillation area of COP increased about 13% in one case. Additionally, average velocity of COP oscillation increased about 88%, 125% and 174% respectively in one case. In the second case average velocity of COP oscillation decreased about 4%, 10% and 12% respectively. In the group of two patients COP oscillation decreased in A-P direction, in the other patients COP oscillation did not change in A-P and M-L direction.

Discussion & Conclusion: The obtained results suggest that botulinum therapy (BTX-A) influences on postural stabilization and better center of mass (COM) control.

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Disclosure: No significant relationships.

P08

THE RELATIONSHIP BETWEEN STANDING POSTURE AND HIP FLEXION IN YOUNG AND OLD ADULTS.

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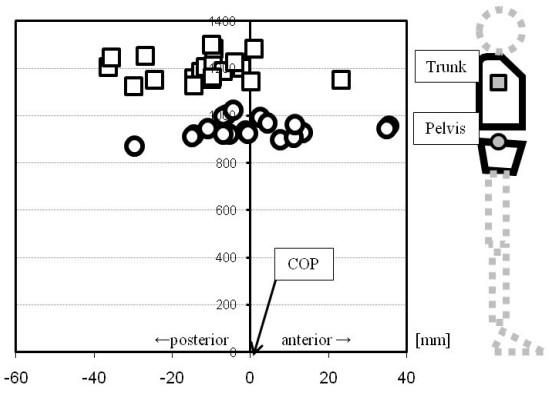
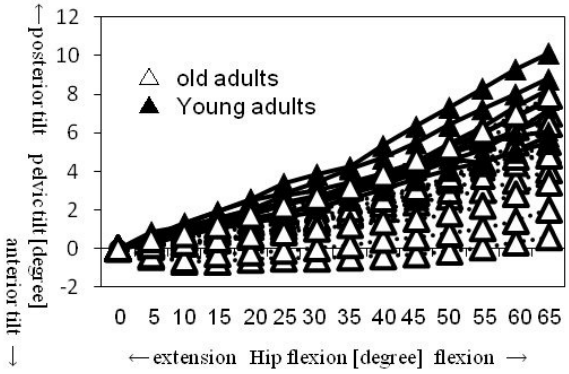
Introduction: It is important to evaluate the standing posture in the physical therapy. Because standing posture is associated with starting position of motion. Furthermore the hip flexion is related to upstairs and over obstacles movement as well as gait. However, there are few studies to demonstrate the relationship between standing posture and hip flexion, or to investigate the effects of aging on it either. The purpose of this study was to investigate the relationship between standing posture and hip flexion in standing in young and old adults. To analyze the standing posture, we measured not an alignment of spine but a position of the thorax, pelvis and the center of pressure (COP). And to analyze hip flexion in standing, we measured three-dimensional plane (3D) analysis of the pelvis, thigh and trunk motion in young and old adults.

Patients/ Material and methods: Subjects were 10 healthy young male adults (24.3±4.5age) and 10 healthy old male adults (72.2±4.1age). The 3D motion capture system (VICON MX) and two force plates were used to measure the standing posture and hip flexion. Subjects stood for 5 seconds and flexed hip joint in standing for 5 times. Twenty-four markers were attached to the body and the segments of the trunk, the pelvis, and the thigh were defined from three markers, the angles and positions of these segments were calculated as well the position of COP during standing and the hip flexion.

Results: Subjects were divided into 2 groups, such as anterior (group A) and posterior (group P, Fig.1) based on the relative position of the pelvis to COP in standing postures. During hip flexion, In group P, trunk was more extension than group A ($p<.05$). In group A, the pelvic posterior translations were larger than group P. In Old adults, the motion of pelvic tilt on sagittal and coronal plane were less than young adults ($p<.05$, Fig.2). But the motion of rotation of pelvis, trunk and thigh of old adults were larger than young adults.





Discussion & Conclusion: These results suggest that clinicians need to focus on the trunk motion and the standing posture in evaluating hip flexion. However, the standing postures in young and old adults didn't show statistically significant difference. It needs to further analysis of various standing postures of old adults.

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Disclosure: No significant relationships.

P09

BRADYKINESIA IN DIFFERENT PARKINSONIAN SYNDROMES. A KINEMATIC MOTION ANALYSIS OF HAND MOVEMENTS

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Introduction: Bradykinesia is an important clinical diagnostic criterion in Parkinson's disease (PD). Clinical assessment of bradykinesia in PD focuses mainly on the frequency and amplitude of movements, thereby subjectively evaluating the smooth and correct performance of hand movements (diadochokinesia (DK), hand tapping (HT), index tapping (IT)). Quantitative analysis of hand movements may help with the differential diagnoses of PD, but has not been implemented in every-day clinical practice yet. The aim of the study was to quantify hand bradykinesia in different Parkinsonian Syndromes.

Patients/ Material and methods: We compared patients with Idiopathic PD (IPD; n=18), Atypical Parkinson Syndrome (APS; n=17), Secondary Parkinson Syndrome (SPS; n=18) and healthy controls (C; n=18). Hand movements were recorded using a 3D-ultrasound-system (Zebris® Germany). Subjects were asked to perform as quick as possible: (1) pronation/supination of the forearm (DK); (2) flexion/extension of the hand (HT); and (3) tapping of the index finger (IT). Mean amplitude (MA), mean frequency (MF) and mean variability of movements (VM) were determined. For statistical analysis we used one-way ANOVA with Post Hoc Test (Bonfferoni).

Results: (1) APS patients had significantly reduced MA of DK compared to C ($p<.001$) and IPS ($p<.024$) and SPS ($p<.001$) patients. In addition, MF of DK were significantly reduced compared to IPS patients and C, while VM of DK was significantly higher in APS patients. (2) All patient groups had decreased amplitudes and frequency on HT compared to C. Reduced VM of HT differentiated APS patients from IPS ($p<.012$) and SPS ($p<.003$) patients. (3) APS patients had significantly reduced MA of IT compared to all other study groups.

Discussion & Conclusion: Our results suggest that computerized quantitative analysis of hand movements can characterize and identify different types of hand bradykinesia and hence may help clinicians in the differentials of Parkinsonian Syndromes.

References:

Disclosure: No significant relationships.

P10

UPPER LIMB FUNCTIONAL LIMITATION TASK IN ADULTS WITH DISKYNETIC CEREBRAL PALSY.

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Introduction: Movements involving the task of bringing a cup to mouth simulates a functional task that is feasible yet challenging enough to reveal key motor deficits in individuals with movement disorders. Accurate measurement of upper extremity movement during activities of daily living is valuable information and can help to identify compensatory strategies and functional improvement after interventions. This study investigated the kinematics parameters involved on sequence movements of a task to bringing a mug handle to mouth in six adults with Dyskinetic Cerebral Palsy (DCP).

Patients/ Material and methods: Seven patients with DCP (age: 27.8Â±3.4 years) and six healthy subjects (HS) (age: 25.8Â±0.4 years) were asked to performed six consecutive movements of bringing a mug handle (350 ml) with 50% of total volume to his mouth using their dominant side. The mug was placed at 75% of subjectÂ´s maximum reach. Kinematic data were captured by 10 cameras (ViconÂ® MX 40; Oxford Metrics Group, Oxford, UK) and processed using biomechanical software (SMART Analyser; BTS spa, Milan, Italy). Twenty retro-reflexive markers were attached over pre-determined bony landmarks of the head, trunk and upper extremities. The unpaired Mann-Whitney U-test was used to compare DCP and HS groups. The probability (p) smaller than 0.05 was considered to indicate statistical significance.

Results: DCP subjects showed higher time to perform going, adjusting and returning phases; less smooth movements as indicated by the index of curvature, average jerk, normalized jerk score and number of movement unit. The DCP patients spent more time doing the task as report by peak velocity, mean velocity, time to peak velocity and going/returning ratio than HS subjects (Table 1).

Table 1 - Kinematics parameters involved on sequence movements of a task to bringing a mug handle to mouth expressed in median and inter-quartile ranges

Time parameters				Smoothness parameters				Velocity parameters			
	Median [25, 75]				Median [25, 75]				Median [25, 75]		
	Control	Dyskinetic	*p*		Control	Dyskinetic	*p*		Control	Dyskinetic	*p*
Going phase [s]	0.93 [0.8; 1.10]	1.77 [1.3; 2.25]	*	IC	1.04 [1.02; 1.05]	1.25 [1.05; 1.50]	*	Mean velocity [m/s]	0.55 [0.49; 0.63]	0.42 [0.25; 0.55]	*
Adjusting phase [s]	0.29 [0.27; 0.35]	1 [0.4; 1.45]	*	Average Jerk	46.88 [43.89; 49.16]	58.23 [45.57; 108.4]	*	Peak velocity [m/s]	1.04 [0.91; 1.08]	0.79 [0.52; 1.18]	*
Returning phase [s]	1.13 [0.99; 1.30]	2.08 [1.55; 2.71]	*	NJS	56.91 [38.06; 82.8]	259.5 [173.2; 911.7]	*				
				NMU	1.1 [1; 1.35]	8.2 [6.2; 11.8]	*	Time to Peak vel [s]	0.37 [0.31; 0.4]	0.45 [0.38; 0.61]	*
Ratio Going/Returning	0.86 [0.79; 0.91]	0.65 [0.48; 0.73]	*	Changes freq [Hz]	3.59 [1.89; 5.36]	3.67 [2.77; 4.9]	ns	Skeweness	38.12 [33.7; 42.44]	33.56 [20; 42.31]	ns

*Items:IC =Index of curvature; NJS =normalized Jerk score; NMU = number of movement unit; *p ≤0,05; ns = p>0,05*

Discussion & Conclusion: In addition to three-dimensional joint patterns, the time, velocity and smoothness of movement may help to delineate the contribution of different movement deficits to functional impairment. Quantitative evaluation of effect of dyskinetic movement caused by DCP can help the identification and quantification of important functional limitations interfering with the autonomous execution of common activities. Movement patterns such as increased movement duration, reduced acceleration and increase of time and smoothness parameters in DCP compare to HS indicates less efficient and less smooth movements. Based on this results rehabilitation programs should be developed and clinical signals evaluated.

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Disclosure: No significant relationships.

P11

ISHOULD: FUNCTIONAL EVALUATION OF THE SHOULDER USING A SMARTPHONE

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Introduction: Functional assessment of shoulder in case of surgery and treatment is crucial. Kinematic scores have been proposed [1] as an objective outcome of the shoulder function. Based on measurement of the 3D accelerations and 3D angular velocities during a sequence of seven movements, these scores assess the kinematics difference between the healthy and painful shoulders: the RAV score quantifies the shoulder movement based on angular velocities, and the P score is based on the power of shoulder movement. In practice, a dedicated measurement system (i.e. inertial sensors) is required to measure the kinematic data, which are then transferred to a computer and processed by a specific program to compute the scores value. Therefore the use of this system for routine clinical practice is limited. The goal of this project was then to improve the suitability of the approach by implementing an application on Smartphone, called iShould (Instrumented Shoulder Test), providing the kinematic scores of shoulder.

Patients/ Material and methods: Five participants were asked to perform twice the protocol to measure the kinematic scores. A Smartphone (iPod touch or iPhone 4 (Apples, US)), which includes a 3D accelerometer and a 3D gyroscope, was attached to the anterior part of the humerus, using an armband. iShould recorded the inertial signals, computed the RAV and P scores, displayed them on the Smartphone screen and stored them in a database. The scores were between 0 and 100%, 100% representing a totally healthy case. Simultaneously, the reference system [1] was used to compute the scores in order to compare the results of the two devices.

Results: The differences between the score measured by iShould and the ones given by the current system [1] are described by the mean and the maximal values:

	RAV score	P score
Mean difference	1.09%	0.60%
Maximal difference	3.42%	1.41%

Table 1: mean and maximal differences between the scores measured by the two devices.

Discussion & Conclusion: The Smartphone with iShould allowed measuring and computing the kinematic scores. The differences with the reference device were low, knowing that, in average, the RAV score of the patients is 59%, whereas it is 94% for the control subjects (46% and 92% for the P score) [1]. The application offers then an interesting alternative to the existing system, improving the usage of the kinematic scores for clinical practice. The application is easy-to-use and faster than the reference system, providing surgeons with a technically validated evaluation of the shoulder function. Future experiments implying patients are planned in order to clinically validate the use of the application on painful shoulders.

References: [1] Coley B. et al. (2007) Gait Posture 25:523-32

Disclosure: No significant relationships.

P12

BICEPS-TRICEPS ACTIVATION RATIO IN REACH-TO-GRASP TASKS THAT REQUIRE FOREARM SUPINATION IN PATIENTS WITH CEREBRAL PALSY AND HEALTHY CONTROLS

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Introduction: Patients with spastic cerebral palsy (CP) may suffer from spasticity in the upper extremity, resulting in decreased range of motion and typical joint postures (i.e. extreme wrist flexion and inability to supinate). We aimed to describe the underlying compensatory movement mechanisms during functional reach-to-grasp tasks in patients with CP. We hypothesized that patients show co-activation of biceps and triceps during reach-to-grasp tasks whereas healthy controls should show higher (eccentric) biceps than triceps activation. Furthermore, we expect that the activation ratio in favor of biceps in CP patients is higher in tasks that require supination of the forearm, as the biceps will then be used to enforce the weak supinators.

Patients/ Material and methods: CP patients (n=10; mean age 14 years) and age-matched healthy controls (n=10; mean age 14 years) performed functional movement tasks that provoke elbow extension and pronation (picking up a disk) or supination (picking up a glass). Objects were placed at 1.5 forearm's length in front of the subject. Subjects were tested in a laboratory setting for 3D kinematics using an 8-camera Vicon MX system. EMG signals of biceps and triceps of the affected arm in patients and the preferred arm in controls were measured during both tasks using a Noraxon Telemyo 2400R system and SENIAM guidelines for electrode placement. Activation ratio (AR) was calculated as the difference between in-phase muscle activation (biceps) and out-phase muscle activation (triceps) divided by the sum of activation of both muscles (Steenbrink et al., 2010). Reaching endpoint was determined using the Multiple Sources of Information Method (Schot et al., 2010). Activation ratios in both tasks and in both groups were compared using a two-way ANOVA for repeated measures.

Results: There was no overall significant difference in biceps-triceps AR between tasks. Control subjects showed a significantly higher biceps than triceps activation during both tasks ($P < 0.05$); whereas in patients the mean AR was close to zero (i.e. biceps activation equaled triceps activation). Based on the significant interaction effect ($P < 0.05$) between task and group, we can conclude that performing a certain task had more influence on biceps-triceps AR in controls than in patients.

Discussion & Conclusion: The expected higher co-activation in patients compared to controls was confirmed by our results. However, the expected increase of AR during the supination task (higher biceps than triceps activation) was not confirmed in patients. A possible explanation for this may be that patients have an altered coordination of movement, with peak biceps activation occurring earlier in the reaching movement than at the endpoint. Insight in the differences in movement control will improve knowledge of the functioning of spastic muscle and consequently affect treatment of the spastic arm.

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Disclosure: No significant relationships.

P13

A STUDY OF THE REPRODUCIBILITY OF THE MARKER APPLICATION OF THE CLEVELAND CLINIC MARKER SET INCLUDING THE PLUG-IN GAIT UPPER BODY MODEL IN CLINICAL GAIT ANALYSIS

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Introduction: With the aid of clinical gait analysis abnormal movement patterns and pathological load distributions can be revealed. An accurate gait analysis is very important for the physician in charge. Therefore the measured data must be as precise and error-free as possible. The aim of the project is to find out if and to which extent the application of the markers can cause significant differences in the results of 3D gait analysis by using a modified Cleveland Clinical Marker Set.

Patients/ Material and methods: The measurements were carried out at the laboratory for gait and movement analysis of the Orthopaedic Hospital Speising of Vienna. The used marker setup was the modified Cleveland Clinic Marker Set for the lower extremities and the Plug-In Gait Upper Body Model of Vicon. The markers were applied on two different days (sessions) and on each day twice per applicator A and applicator B. A number of 13 healthy subjects with no injuries to their locomotion system participated in the study. The intra- and inter-applicator repeatability and the between-session repeatability of the time-distance, the kinematic and the kinetic parameters were examined. The parameters of the upper and lower body were analysed in the sagittal, the frontal and the transversal plane and amount to a number of 206 test parameters. The used measurement system was a three-dimensional optoelectronic system (VICON) and three force plates (AMTI) measured the ground reaction forces. The data was statistically analyzed by performing the Root Mean Square Error (RMSE), the Technical Error of Measurement (TEM) and the Intraclass-Correlation-Coefficient (ICC) or the Wilcoxon-Test.

Results: The results of the investigation of the RMSE over all body planes showed the highest standard error of the parameters of the shoulder and the wrist. The parameters of the knee indicated the best results. The between-session repeatability was the worst. The calculation of the TEM showed the best measuring quality over all body planes in the parameters of the ankle and the worst of the wrist. In the frontal plane the measurement error was very low and in the transversal plane high. There was no significant difference between the intra-applicator and the between-session repeatability. The statistical analysis of the correlation showed the best results in time-distance parameters. The results of the kinetic parameters showed a better correlation than the kinematic parameters. The ICCs of the ankle was the worst but still acceptable. The results of the intra-applicator repeatability were the best and the inter-applicator repeatability the worst. Noticeable were the good results of the rotation of the thigh and the shank in comparison to other studies.

Discussion & Conclusion: The results of the RMSE and the TEM showed in upper limb high errors and should be improved. Especially the parameters of the shoulder and the wrist showed a high variance. The best repeatability occurred in time-distance parameters and in the parameters of the sagittal plane. With the use of the modified Cleveland Clinic Marker Set the rotation of the thigh and the shank showed good intra- and inter-applicator repeatability and also good between-session repeatability compared to previous studies.

References:

Disclosure: No significant relationships.

P14

EVALUATION OF SHOULDER MOBILITY DURING DAILY ACTIVITY USING ELECTROMYOGRAPHY AND KINEMATIC DATA

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Introduction: Wearable systems using electromyography (EMG) [1] or inertial sensors [2] have been applied to measure muscular activity and kinematics of upper limbs in daily life condition. As activity of shoulder muscles is linked to arm mobility, which may change between subjects and arms, simultaneous measurement of EMG and arm kinematics can bring new insight for shoulder function evaluation. This study proposed a new approach to evaluate the duration of shoulder muscular activity and arm movement recorded during daily life conditions. The new approach was used to investigate muscular activity change due to rotator cuff tear.

Patients/ Material and methods: Ten patients suffering from unilateral rotator cuff tear took part in the study. Measurements were performed during 7 hours in daily conditions using an ambulatory system including 3D inertial sensors and surface EMG electrodes. Inertial units were fixed on each humerus and on the sternum. Surface electrodes were placed on medial deltoid (MD) and upper trapezius (UT) on each side. Periods of arm movement (T_{ARM}) were detected using an adapted method [2] based on arm angular velocities. Periods of muscle activation (T_{EMG}) were defined according to a minimum amplitude and a minimum duration of the EMG signal. Two parameters were computed, the relative time of muscular activity in percentage of the duration of arm movement: $T_{EMG/ARM}$ (= T_{EMG}/T_{ARM}) and the relative time of muscle activity to the total recording time: $T_{EMG/TOT}$. The reliability of both parameters was evaluated separately in laboratory conditions for specific movements repeated four times using intraclass correlation (ICC). Additionally, patients evaluated VAS pain and VAS stiffness. Spearman correlation coefficient was used to test relationship between scores and estimated parameters.

Results: ICCs for the duration of activation during repeated movements were high for both $T_{EMG/TOT}$ and $T_{EMG/ARM}$: from 0.81 to 0.83 for UT and 0.86 to 0.88 for MD. For daily conditions, the mean and standard deviation are reported in Table 1. Significant correlation ($r=0.58$, $p<0.05$) was found between the difference between healthy and painful sides for $T_{EMG/ARM}$ of UT and VAS stiffness.

	MD healthy	MD painful	UT healthy	UT painful
$T_{EMG/TOT}$	24% ± 14%	22% ± 16%	27% ± 16%	36% ± 16%
$T_{EMG/ARM}$	48% ± 17%	46% ± 16%	46% ± 19%	59% ± 13%

Table 1: Average and standard deviation of the 10 subjects for the durations of muscular activations

Discussion & Conclusion: We introduced two parameters ($T_{EMG/TOT}$, $T_{EMG/ARM}$) assessing the muscular activity of two shoulder muscles during daily activity. Measurements in laboratory showed that both parameters were reliable. In average, UT was activated proportionally longer on the painful side. This could be explained by compensatory movements and spasms. Even if the difference was statistically non significant, the results on UT are interesting and need to be confirmed by additional data. $T_{EMG/ARM}$ which expressed the relative duration of muscle activity to the corresponding arm movement seemed to be clinically relevant, since it showed significant correlation with clinical score.

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Disclosure: No significant relationships.

P15

ESTIMATION OF CO-CONTRACTION BY COMPUTATIONAL MUSCULOSKELETAL MODELING IS ENHANCED BY INCLUDING EXPERIMENTAL EMG RECORDINGS

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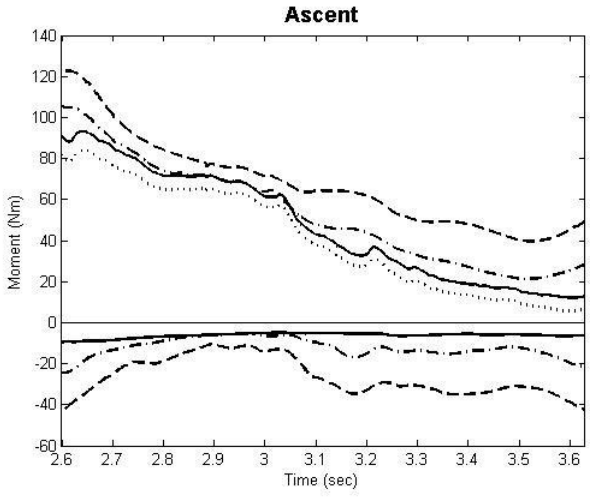
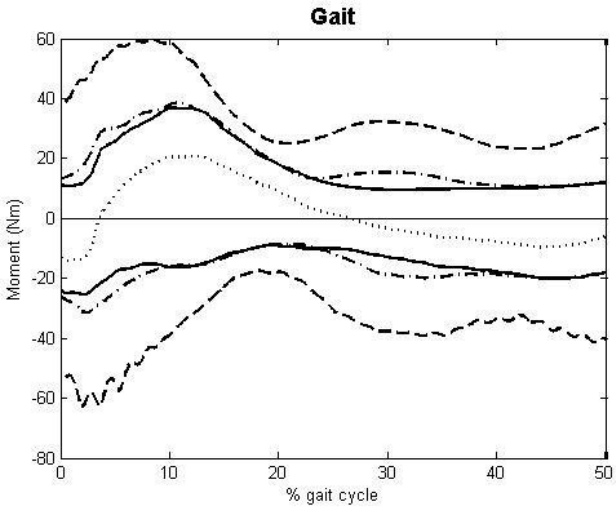
Introduction: Knowledge of individual muscle forces during functional movement could be of great importance in clinical practice. Estimation of muscle force from inversed dynamic analysis is challenged because the musculoskeletal system is mechanically redundant, while optimization criteria for load sharing do not always yield valid results, especially since these criteria penalize (functional) co-contraction. Alternatively, estimating muscle forces from muscle electromyography (EMG) recordings, which reflect the active state of the muscle, does not lead straightforward to the amount of force produced by the muscle during dynamic contraction. Contemporary computational musculoskeletal modelling enables a forward dynamic simulation of movement that is consistent with experimental kinematics and kinetics[1]. This pilot-study aims to demonstrate how the inclusion of information from the EMG in such analysis will yield increased values for co-contraction.

Patients/ Material and methods: One healthy female adult (age 27 years, 60 kg) performed two movements, ascending and walking. Kinematics by means of a 3D opto-electronic system (OptoTrak 3020), ground reaction forces, and surface EMG of five muscles were recorded. Offline, EMG was processed into a linear excitation envelope (2nd order Butterworth filter bidirectional cut-off 6 Hz). Knee muscle forces were computed using the computed muscle control tool of the OpenSim software package (Simtk, Stanford, CA, USA)[2]. Three conditions were applied to include information from the EMG recordings in the model 1) no additional constraints, 2) excitations are constrained by ± 0.1 from the experimental excitation envelope, and 3) the model excitation is fully constrained by the experimental excitation envelope. The effect of the constraint levels (NO, LOW, HIGH) was evaluated by calculating a co-contraction index[3]:

$$CCI = 1 - \left(\frac{\left[\left| M_{agonists} \right| - \left| M_{antagonist} \right| \right]}{\left[\left| M_{agonists} \right| + \left| M_{antagonist} \right| \right]} \right)$$

Results: The figures shows the extension (positive) flexion (negative) and net knee moment (dotted line) for ascent and for gait from heel strike to terminal stance for the three conditions (solid: NO, dashed/dotted: LOW, dashed: HIGH). For ascent, the CCI increased with the level of constraint (NO: 0.24, LOW: 0.38, HIGH: 0.56). For gait, in the NO and LOW condition the CCI was 0.95 and increased to 0.99 in the HIGH condition. During the loading response (first 10 % of gait cycle), the CCI increased from 0.94 in the NO condition to 0.96 en 0.99 in the LOW and HIGH condition.





Discussion & Conclusion: This study demonstrated that using information from the EMG in addition to kinematics and ground reaction forces enables the OpenSim model to compute a higher amount of muscular co-contraction with comparable net moments, whereas co-contraction is normally penalized by the standard cost function. Although these standard optimizations do predict co-contraction during gait based on only kinematics and ground reaction force, adding EMG constraints increased the extension and flexion moment, and hence co-contraction. This might indicate more accurate muscle force predictions, which however is obviously hard to validate. Future studies should explore the optimal way to include information from the EMG to be used in cases where pathological levels of co-contraction can be quantified.

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Disclosure: No significant relationships.

P16

ACTIVITY OF MUSCULUS TRICEPS BRACHII WITHIN POSTERIOR PLATFORM TRANSLATION IN TRANSTIBIAL AMPUTEES

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Introduction: In lower limb amputees postural asymmetries are present due to the preferential usage of their non-amputated leg (NL) for postural control [1,2]. The aim of our study was to assess how this preference of non-amputated leg in transtibial amputees (TTAs) was reflected within unexcepted posterior platform translation in the standing position. The association between upper limb muscle activity (m. triceps brachii - TB) and the center of pressure positioning (COP) in the mediolateral direction was evaluated.

Patients/ Material and methods: Postural reactivity to backward translation was assessed in twelve TTAs (age 52.8 ±11.1 year, height 177.9 ± 6.3 cm, weight 85.8 ± 9.8 kg). Amputation due to trauma in ten subjects, and due to vascular disease in two subjects. Four TTAs did not have any pain/sensory deficit on their NL. In eight TTAs pain or sensory deficit or both was present (two with vascular cause of amputation). Within the postural reaction to the translation simultaneously were measured both the positions of COP (NeuroCom) of the whole body and the activity of TB with surface electromyography (Delsys). The relation between COP excursion in the mediolateral direction and differences in activity between the left and right TB was assessed by applying the Spearman rank correlation coefficient (Statistica, version 9.0). The connection between TB activity and COP position was also evaluated in the group of TTAs with intact NL as well as TTAs with affected NL.

Results: Within the frame of all tested TTAs, we found no relation between COP excursion in the mediolateral direction and the activity of TB ($r = -0.03$). In TTAs without pain/sensory deficit on the NL, there is a positive correlation between the excursion of COP to the NL side and the higher activity of ipsilateral TB within posterior platform translations ($r = 0.79$). In contrast, TTAs with pain/sensory deficit in a NL had a tendency to activate contralateral TB with respect to COP excursion ($r = -0.55$) in the tested situation.

Discussion & Conclusion: The results of this pilot measurement exhibit that TTAs who could place confidence in their NL preferred to position the COP towards this leg. In this case, TTAs also activated more TB on the side of the NL as healthy subjects. Pain and sensoric deficit alter the lower limb loading during the platform translation [3,4]. Accordingly from the results, we presume that lower limb amputation together with senzoric alteration could lead to the modulation of pripriospinal circuits. We conclude that TTAs tend to position their COP during unexcepted platform translations to the side of the NL. There is a connection between higher COP excursion to the NL side and the increased activity of ipsilateral TB in subjects who did not experience pain/sensory deficit in the NL.

Aknowledgements
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Disclosure: No significant relationships.

P17

MUSCLE FATIGUE IN CHILDREN WITH CEREBRAL PALSY COMPARED TO TYPICALLY DEVELOPING CHILDREN AND YOUNG ADULTS

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Introduction:
Muscle fatigability is besides muscle weakness an important motor disorder that is expected to cause activity limitations in children with cerebral palsy (CP). This muscle characteristic is however scarcely investigated in this population. Recently a study reported an unexpected lower fatigability in children with CP compared to typically developing (TD) children. One possible explanations of this finding is the lower maximal muscle strength in the CP group. The purpose of this study is to investigate muscle fatigability in three groups of subjects with different maximal strength levels: children with CP, TD children and young adults.

Patients/ Material and methods:
Seven children with spastic cerebral palsy (gross motor function classification system [GMFCS] levels I [n=2] and II [n=5], age: 9±2yrs, 6 male), 9 TD children (age: 10±2yrs, 6 male) and 10 young adults (age: 22±3yrs, 7 male). All subjects performed an isokinetic protocol that was described by Moreau et al. consisting of 35 maximal isokinetic knee flexion and extension contractions at 60 deg/s. Muscle fatigability was described as the rate of decline between the highest and lowest peak extension and flexion torque relative to the maximal torque.

Results:
As expected peak torque of both knee flexion and extension (expressed in Nm/kg) was significantly different between groups showing the highest peak values in young adults, and the lowest values in the children with CP. Muscle fatigability also differed between groups with the young adult group showing the greatest decline in peak torque while the children with CP showed the lowest decline in peak torque, which may be indicative of lower muscle fatigability.

Discussion & Conclusion:
Our results confirmed earlier findings that children with CP have better resistance to muscle fatigue than TD children. The noticeably larger decline of peak torque over 35 maximal contraction in the young adults also confirmed that higher muscle fatigability coincides with higher peak strength levels. These findings may be associated to different metabolic properties of stronger muscles, but the limited ability of the children with CP to perform maximal strength exertions can affect the current findings and may have violated the validity of the applied protocol in this study. To further explore the mechanisms of muscle fatigability in children with CP, the application of an endurance protocol with fixed submaximal contractions is recommended.

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Disclosure: No significant relationships.

P18

PERONEUS LONGUS AND THE MIDFOOT IN CHILDREN: EMG NORMATIVE DATA

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Introduction: The EMG overactivity of peroneus longus (PL) is described by Young [1] as the major deforming force in spastic midfoot break in adult after stroke. Before to test this hypothesis in children with cerebral palsy (CP), it was necessary to provide the normal EMG activity of PL in children without neuromuscular disorders. These data are not studied in literature.

Patients/ Material and methods: 1104 strides of 21 children (age 6.5yrs±1) without neuromuscular disorders were examined using surface EMG (ZeroWire, Aurion) during walking. The PL activity was normalized as a percentage during strides. A software selected the more repeatable strides. The onset, offset activity of rectified raw EMG signal was detected by a manual selection: the threshold was 20 µV [3, 4].

Results: Resulting in 1104 normal strides: the mean toe off was at 62.8%, the PL onset activity was at 26.3% in midstance and the offset at 51.7% during terminal stance. There was never activity during swing phase.

Discussion & Conclusion: These data confirmed the PL activation as a locking effect on midfoot, in midstance during the ankle rocker for progression and without motor action on the ankle [5-7]: PL supports the longitudinal and transversal arches. In terminal stance during forefoot rocker for progression, PL has a locking effect on the first ray: the forefoot is stabilising during the heel rise. It prevents excessive inversion thus maintaining the first metatarsal down on the ground. PL maintains the stabilisation of the first and second ray by a pronation to counteract the lift effect of the supination muscles. The PL contraction should be rather isometric. The relation between PL overactivity and midfoot break has to be assessed in CP children.

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Disclosure: No significant relationships.

P19

ONE-YEAR GAIT ANALYSIS STUDY IN SPASTIC DIPLEGIC CHILDREN AFTER SELECTIVE DORSAL RHIZOTOMY

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Introduction: Alterations of the central nervous system, which produce the characteristic features of cerebral palsy (CP), result in gait deviations due to the presence of reduced selective muscle control, abnormal muscle tone, imbalance between muscle agonists and antagonists across joints. Spasticity has been considered to be a main contributor to both the impairment of function and the decreased longitudinal muscle growth in children with spastic CP, leading to deformity. The only treatment option to reduce spasticity permanently is selective dorsal rhizotomy (SDR) [1,2]. We were interested whether CP subjects show significant changes in gait pattern after SDR.

Patients/ Material and methods: We recruited children with neuroimaging evidence of periventricular leukomalacia, clinical diagnosis of spastic diplegia and ambulation ability with or without aids. Five children undergoing SDR (3 males and 2 females; mean age 5.4±3.6 years; mean weight 20.6±6.6 Kg; height 114.6±16.43 cm) were studied preoperatevely (T0) and at 12 months (T1) after surgery. We performed a 3D-motion analysis of walking with an optoelectronic system of 6 cameras (Smart-E™, BTS, 60Hz) synchronized with a Kistler force plate using standard Davis protocol [3]. The statistical analysis was performed with SPSS 13.0 ($p<0.05$); joint angles were analyzed relatively to every phase of gait cycle according to Perry [4].

Results: In the T1 condition compared to the T0 condition, the kinematics data showed a significant reduction of the equinus foot in all the gait cycle and of the knee hyperflexion in all phases of the stance and in the terminal swing phase (Figure 1). Most of the spatio-temporal parameters improved, even if only the stride and step lengths showed a statistically significant increase (Table 1).

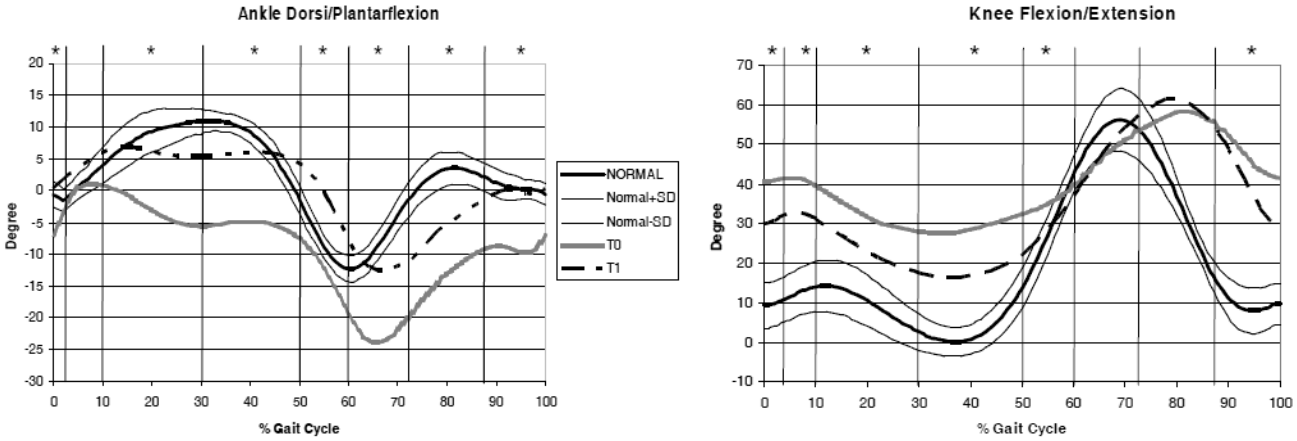

Figure1: Average ankle (left) and knee (right) angles at T0 (shaded lines) and at T1 (dotted lines) compared with the normative band (mean and SD, solid lines). Vertical lines indicates different gait cycle phases. *p<0.05.

Discussion & Conclusion: These preliminary results showed that CP children after SDR present a gait pattern more similar to able-bodies, in particular at the ankle and knee joints. A more extensive study is currently planned to confirm these first data.

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Disclosure: No significant relationships.

P20

MIXED-REALITY THERAPY FOR ADULTS WITH COGNITIVE IMPAIRMENTS

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Introduction: Virtual Reality (VR) systems have been frequently used as an effective tool for neurological rehabilitation over the past decade. Over the past decade, the acceptance of VR systems as effective tools for both research and training has rapidly expanded. Continuing advances in VR technology has supported the development of a more usable, useful, and accessible system. While therapeutic VR has largely focused on developing virtual environments as an assessment tool, increasing evidence is favoring the use of VR systems in clinical research. Of immediate interest is the application of VR in rehabilitation patients. Grealy and colleagues (1999) observed significant cognitive and physical gains of Brain Injury (BI) patients who were treated in a VR-based physical therapeutic setting. Although there is evidence supporting the therapeutic benefits of VR applications on physical, behavioral and psychological outcomes, very little attention has been given to the application of this approach as a valuable psychophysical ergotherapeutic intervention tool. The purpose of this study is to develop an evidence-based pilot study by using meta-analysis method to develop a mixed-reality (semi-immersive method) rehabilitation program designed for brain injury individuals.

Patients/ Material and methods: Meta-analysis evaluating the literature on VR application to rehabilitation outcomes was performed, and a quasi-experimental and observational design was used with 12 male patients (mean + SD age, 33 +11.7) from a post-acute brain injury rehabilitation center. The effects of a 4-wk-mixed-reality program were observed on mood, engagement, presence, and enjoyment level.

Results: Meta-analysis resulted on moderate to large effect sizes; however the quality of available studies were mixed with a prevalence of low rigor classification. Pilot study results: 70 % of participants reported enjoyment and satisfaction with the program as compared to other rehabilitation modalities. Five participants response to Presence Questionnaire showed a high level of presence in the mixed-reality environments. In addition, four participants improved performance based on mixed-reality games scoring system.

Discussion & Conclusion: Although the literature supports the use of VR for rehabilitation purposes, there is a need to develop future studies with clinical randomized methods, including multi-site designs, to support the use of VR as a clinical treatment in rehabilitation. Applying the information obtained through the systematic review and meta-analysis was adjunctive and useful in the development of the pilot study. Even though the pilot study has several design limitations such as small sample size and single control design, these preliminary results suggest that mixed-reality system may provide insight into BI rehabilitation outcomes due to increased activity enjoyment that might improve the quality of patient participation and engagement during therapy.

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Disclosure: No significant relationships.

P21

DOES THE PROXIMAL FEMORAL VARISATION OSTEOTOMY NEGATIVELY AFFECTS GAIT PARAMETERS IN PATIENTS SUFFERING FROM LEGG-CALVé-PERTHES DISEASE?

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Introduction: Aim of our study was to compare gait parameters in patients who suffered Legg-Calve-Perthes desease (LCP) and it's abnormality in laboratory conditions with the aid of computerized gait analysis. We compared 3 groups of patients in accordance with type of chosen treatment, 1 - conservatively treated, 2 - pelvic osteotomy, 3 - combination of pelvic osteotomy and proximal femoral osteotomy.

Patients/ Material and methods: From 2002 until 2010 were treated 136 patient with LCP disease in our clinic. This study included patients who fullfiled the following conditions: They were examined in gait lab, at least 1 year after operation or the completion of conservative treatment. During the clinical examination there were no restrictions in range of motion in hip joint in any plane larger than 20 compared to the healthy side. Unilaterally involvement. 30 patients, 23 boys, 7 girls, 11 right, 19 left lower limb, age 6,5-19,7 (mean 13,7) were divided into 3 groups in accordance with type of chosen treatment. 1 - conservatively treated (n=6, age 6,5-15,3, avg 11,6), 2 - pelvic osteotomy (n=16, age 9,7-17,7, avg 13,9), 3 combination of pelvic osteotomy and proximal femoral osteotomy (7x Salter, 1x Steel) (n=8, age 9,4-19,7, avg 15,1). All patients in the time intervals after operation and in case conservatively treated patients in the time intervals after completion of conservative treatment underwent 3D motion analysis (Vicon, plug in gait model). 3D analysis interval from completion of conservative treatment was 4,2 years(1,1-7,4) in case of group nr. 1 and interval from operation was 6,3 years (3,4-11.3) in case of group nr.2 and 6,3 years (1,3-12,0) in case of group nr.3. Kinematic and Kinetic parameters around hip joint and temporal spatial parameters were evaluated. In total 5 parameters (pelvic obliquity, hip moment sagital, single support time, step lenght, limp index). Parameters were compared against normative database and against contralateral limb.

Results: were compared according to different parameters in each group: pelvic obliquity: pelvic drop wasn't observed in any patient, hip sagital moment: we did't observe substantial decrease of hip sagital moment in gr.3 neither to normative database nor to contralateral limb, single support: : gr.1 - there appeared shortening of single support time against contralateral limb in average of 4%, gr.2 shortening of 3% gr.3 shortening of 9%, step length: in gr.1 step length was longer in affected side against contralateral side of 1%, gr.2 shortened of 6%, gr.3 longer of 2%, limp index: deviation detrimental treated limb against contralateral in gr.1 - 4%, in gr.2 - 1%, in gr.3 - 10%.

Discussion & Conclusion: Only a few papers dealing with gait abnormality in the context of LCP disease based on 3D motion analysis were published in last 10 years. None of these works did include temporal spatial parameters. Our assumption that proximal femoral osteotomy significantly worsens gait patterns, mainly in terms of Trendelenburg gait, wasn't confirmed. Due to small amount of probands in group 3 we cannot consider the results as final.

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Disclosure: No significant relationships.

P22

LOWER EXTREMITY KINEMATICS AND EMG IN MULTI-MOMENT FOLLOW-UP STUDY DURING ACL REHABILITATION PROGRAM.

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Introduction: Patient motor function is studied by evaluating relevant cyclical kinematics (and EMG patterns) assessed in a series of on-site follow up ambulatory measurements during a typical post ACL surgery rehabilitation procedure. Nature and magnitude of features and tendencies in the data are discussed relative to estimated smallest detectable difference (SDD) bands, and in the context of potential clinical relevancy for monitoring and treatment adjustment.

Patients/ Material and methods: Seven male patients (age 18-40) in post ACL surgery rehabilitation program (semitendinosus-gracilis technique) participated in 4 short on-site sessions witin 4 months after start of rehabilitation. “Segment calibration” trials [3] were performed twice at start end end of sessions. Recorded/estimated [1] were 3D accelerations, angular velocities and orientations of both thighs, shanks, feet plus the pelvis and thorax (8 Xsens Mtx sensors, 100 sps) in walking, at different speeds and running plus several coordinative tests. SRE was estimated of 4 muscles (Rectus femoris, Semitendinosus, Gastrocnemius, Gluteus) in each leg (2 TMSI Mobi, 1024 SPS, SRE estimation, subsampling to 100 sps). Two synched tcp/ip video streams were recorded for reference. Discussed in this paper are 3D orientations and angular velocities of thigh vs. shank (“knee joint kinematics”).

Results: Orientation differences between the 2 repeated segment calibrations per subject suggest a calibration related orientation uncertainty of 1-2 degree (pre and post session calibration) and 2-3 degrees between average pre and average post calibration results. Angle and angular velocity standard error of the mean (n=5) 95% confidence bands of 1-2 degree were found for average knee flexion angle/angular velocity in walking at different speeds. In all subjects several typical gait cycle features in kinematics and EMG of the affected leg changed significantly and consistently over time towards values found in the unaffected leg (e.g. knee flexion angle in swing phase), while others remained identical. No change was found in the unaffected legs. These features were strongly associated to clinically used decision making ankers as Range Of Motion and amount of loading/knee flexion of the knee in the stance phace, ‘stability’ etc.

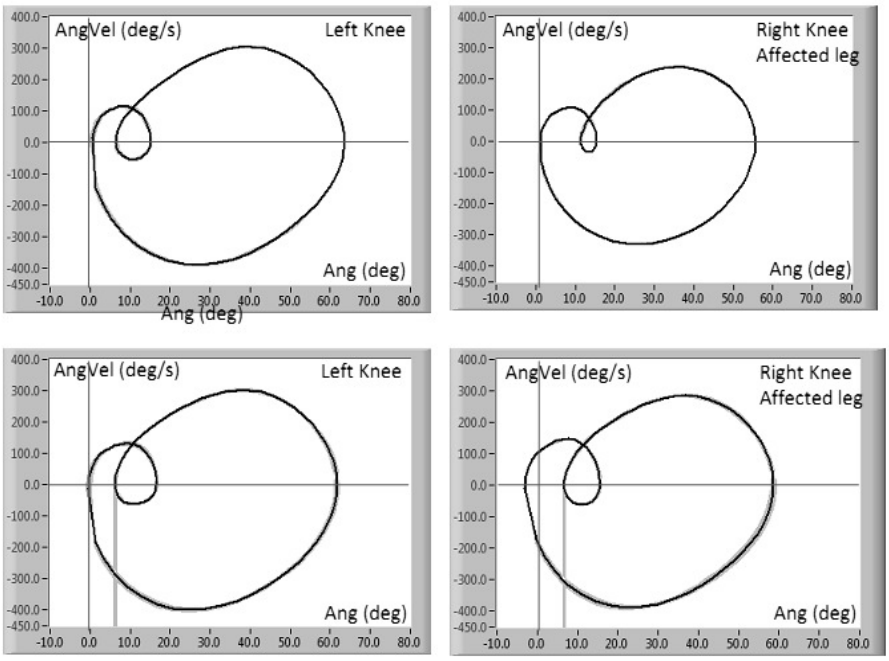

Figure 2: Phase plots of 1 subject during normal walking. The left and right plots represent the left and right knee respectively, the upper and lower plot represent the respectively the 1st and 4th session, separated with a time interval of 15 weeks. This subject is rightly affected.

Discussion & Conclusion: Estimation reliability of kinematic data were smaller than absolute values/value changes in measures and phenomena relevant to clinical decision making. Consistency level of segment calibration data over and within sessions provides a data quality check. These observations together form strong evidence that the proposed ambulatory method indeed can be used effectively and efficiently in routine clinical decision making in ACL rehabilitation.

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Disclosure: No significant relationships.

P23

CORRELATION BETWEEN GAIT DEVIATION INDEX AND PAIN PERCEPTION IN PATIENTS WITH LUMBAR SPINAL STENOSIS PRE- AND POST-PHYSICAL EXERCISE.

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Introduction: The spinal stenosis term is based on the fact that a minimum space of the spinal canal is necessary for normal functioning of the nervous structures, and when this space becomes narrow, results in nerve compression symptoms such as pain, numbness, weakness and neurogenic claudication, which increase with stress and decreases with rest[1,2]. The aim of this study is evaluate the relationship between functional gait and pain perception in patients with lumbar spinal stenosis before and after physical activity.

Patients/ Material and methods: Seven subjects were evaluated with diagnostic of vertebral canal stenosis with a mean age of 71.0 (±7.0) years. The Vicon MX 40 system was used for the data acquisition during gait kinematic which consists of 10 infrared cameras (2000 fps). The exam consisted of three phases: 1) Capture of six gait cycles after a rest period without pain or symptoms; 2) Walk on treadmill for a maximum of 20 minutes or forced interruption by the effect of pain or fatigue; 3) New capture of other 6 gait cycles was performed immediately after the exercise on the treadmill. From these data, a gait deviation index[3] (GDI) was extracted and analyzed individually and then compared to the pain perception of each patient obtained by visual analogue scale (VAS).

Results: In the comparison between the GDI pre- and post physical activity, a functional decrease of 78.5 (±18.3) to 76.1 (±18.3) at the right side and of 79.4 (±19.6) to 77.6 (±19.8) at the left side were found, but no significant difference were found between patients (Wilcoxon; $p>0.05$). However, based on the negative correlation value (Spearman, - 0.812) on both sides, the results show significant correlation in pain score after physical activity.

Discussion & Conclusion: Compression of nerve roots[4] and physical stress are factors that increase the sensitivity of the motor evoked potential[5] causing decreased overall function of the gait. Despite the lack of correlation between the other variables, our data suggest a tendency of decreasing gait functionality according to increasing pain perception. However, it is need a long-term follow up and a larger sample to confirm this hypothesis.

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Disclosure: No significant relationships.

P24

THE USE OF GOAL ATTAINMENT SCORES TO EVALUATE THE EFFECT OF REPEATED BTX-A TREATMENTS IN CHILDREN WITH CEREBRAL PALSY

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Introduction: In a previous study[1] four repeated botulinum toxin A (BTX-A) treatments in children with Cerebral Palsy (CP) were found to be successful when scored with the Goal Attainment Scale (GAS). However, largest functional improvement was seen at the 1st treatment and the success score was decreasing for the 3th and 4th treatment. Currently, we investigated if the decreasing effect with increasing number of treatments was caused by two methodological drawbacks of the original GAS: (1) a subjective component when GAS is scored manually, (2) loss of clinically valuable information because GAS is a categorical 5-point scale. Therefore, three methods of GAS calculations were compared: the original manual GAS (M-GAS), an automatic GAS (A-GAS) and a continuous GAS (C-GAS).

Patients/ Material and methods: 11CP children (2-10 year at treatment) received 4 repeated BTX-A treatments in the lower limb, each with gait analysis before and 2 months after BTX-A treatment. The goal attainment approach was used to evaluate the achievement of individualized treatment goals, based on comparison of pre and post BTX-A gait analysis. For the original GAS score (M-GAS) each goal (3-6 per treatment), extracted from gait analysis data, was scaled on a 5-point scale from –2 (increased pathology, >50%) through 0 (20-30% corrected) to +2 (>50% corrected). Scores of all the individual goals were summed and converted to a T-score. A T-score of 50 indicates that goals are, on average, achieved. M-GAS was scored by an experienced physical therapist by evaluating goals on graphs of gait analysis (template matching) pre and post BTX-A. For the A-GAS and the C-GAS, the achievement of goals was scored automatically, using customized software (Matlab), which automatically extracted clinically relevant parameters from the gait continuous waveforms. Z-scores were determined for each extracted parameter, based on pediatric typical reference data (Z=(mean CP child–mean typical children)/SD typical children). Subsequently, the percentage of change post BTX-A, with respect to pre-BTX-A was calculated for each goal (=(|Zpre|-|Zpost|)/|Zpre|), resulting in the C-GAS. A score of -2 to 2 was given according to this percentage of change, similar as for M-GAS, and also converted into a T-score, resulting in the A-GAS. A comparison of M-GAS with A-GAS was done by a Wilcoxon signed ranked test.

Results: No significant differences were seen between M-GAS and A-GAS approaches at all treatments (Table 1), with exception of the 1st treatment (p=0.03). All category-based GAS scores showed a trend of decrease with increasing treatment (with exception of M-GAS at 1st treatment). The C-GAS showed more detailed changes.

	M-GAS 1	A-GAS 1	C-GAS 1	M-GAS 2	A-GAS 2	C-GAS 2	M-GAS 3	A-GAS 3	C-GAS 3	M-GAS 4	A-GAS 4	C-GAS 4
Median	49,75	58,00	36,35	53,00	56,00	29,19	49,50	49,25	19,79	43,00	47,50	9,17
Q25	46,00	50,50	14,75	47,00	52,25	21,00	42,50	45,75	5,11	39,25	39,25	4,47
Q75	51,75	61,25	40,83	59,00	62,13	43,80	55,00	58,75	43,59	51,00	55,75	31,09

Discussion & Conclusion: The fact that M-GAS and A-GAS only differs at the first treatment can be explained by patients being very young (3.66±1.20) at 1st treatment. Young children show a less mature and inconsistent gait pattern, which makes it more difficult to score the goals manually. Apart from being objective, C-GAS makes it possible to detect smaller changes in gait parameters, expressing absolute Z-scores as a percentage (continuous scale) instead of categorically, but still allowing to define an overall score with different individual goals for BTX-A treatment.

References: [1]Molenaers et al(2008);Gait&Posture28(2):S1

Disclosure: No significant relationships.

P25

DOES EXPERIMENTALLY INDUCED STIFFNESS OF THE SPINE MAKE HEALTHY SUBJECTS WALK LIKE LOW BACK PAIN PATIENTS?

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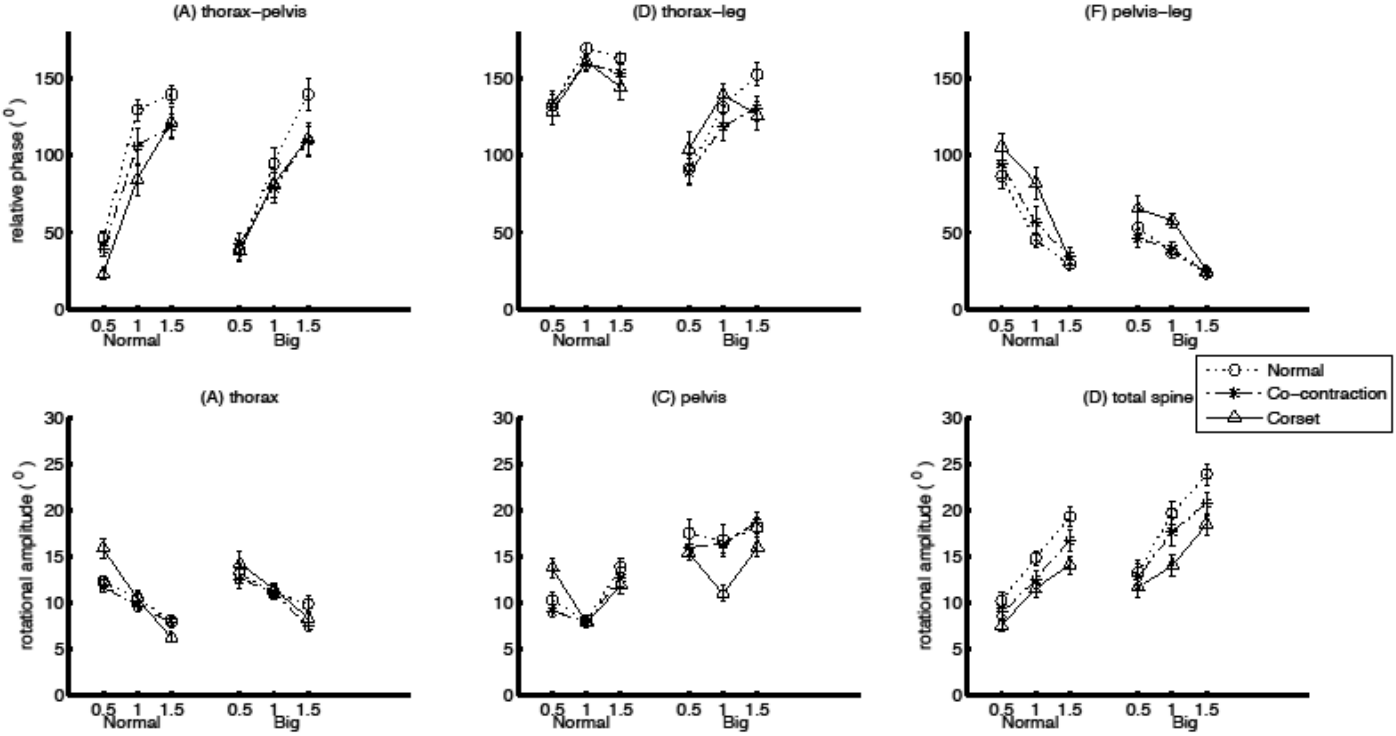
Introduction: Walking with low back pain is characterized by altered trunk coordination, especially at higher walking speeds [1]. In healthy subjects, horizontal movements of pelvis and thorax start to go out of phase at such speeds, with the pelvis starting to move more with the legs and opposite to the thorax [2]. In low back pain, the pelvis still starts to move with the leg at higher speeds, but also the thorax does this, so that they move more in phase [1]. However, it is yet unknown how trunk coordination during gait in LBP is altered. Possible mechanisms include: active control, stiffening by co-contraction, or stiffening of the spine itself. We studied whether the latter two mechanisms (cocontraction and/or stiffening of the spine itself) could result in movement patterns as seen in LBP subjects. We choose for an experimental design, in which stiffness of the spine was manipulated by having subjects cocontract, or by having subjects wear a brace. Based on pilot studies, we hypothesized that neither of these manipulations would lead to movement patterns as seen in LBP subjects.

Patients/ Material and methods: Subjects walked on a treadmill, in three conditions (normal, wearing an orthopedic brace that reduces torsion, and while co-contracting their abdominal muscles), at 3 speeds (0.5 1 and 1.5 m/s) at each speed with normal and big steps. Kinematics of the legs, pelvis and thorax were recorded by means of an Optotrak system, and relative Fourier phases and amplitudes of segment motions were calculated

Results: Both our manipulations led to a reduction in thorax pelvis relative phase (see figure 1, top panels), and were thus successful. However, unlike in LBP patients (c.f. [1]), the decrease in relative phase was caused by a shift of both pelvis and thorax with respect to the leg. Moreover, unlike in LBP patients, the alterations in phase did reduce the spinal rotation amplitude.



Discussion & Conclusion: The movement patterns observed when subjects wore the corset or cocontracted differed qualitatively from those seen in LBP subjects, suggesting that LBP subjects do not simply stiffen their spine. Thus, LBP subjects seem to use an alternative strategy to control trunk motions. Such a strategy may be associated with higher control costs [c.f. 3].

References: [1] Huang, Y., et al (in press), Gait adaptations in mild symptomatic lumbar disc herniation (LDH): Trunk coordination and arm swing. Eur Spin J [Epub]. [2] Bruijn, S.M., et al (2008), Coordination of leg swing, thorax rotations, and pelvis rotations during gait: the organisation of total body angular momentum. Gait Posture, 27(3):455-62. [3] Lamoth, C.J., et al (2008) Effects of attention on the control of locomotion in individuals with chronic low back pain. J Neuroeng Rehabil, 5:13.

Disclosure: No significant relationships.

P26

PEDOBAROGRAPHIC RESULTS AFTER OPERATIVE CLUBFOOT CORRECTION

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Introduction: There exist different score systems to assess the outcome of clubfoot treatment. Dynamic pedobarography finds its way into follow-up examinations of different feet pathologies. Recently, dynamic pedobarography was used to evaluate Ponseti treatment (1) and physical therapy (2) for talipes equinovarus, and there is only one study (3) of operated clubfeet. We wanted to know which pedobarographic differences there are between operated clubfeet and healthy feet and whether pedobarography could be used as a valuable measurement instrument for CF follow-up.

Patients/ Material and methods: We examined 11 children (7 male, 4 female) with 16 operated CF pedobarographically and compared the results with an age matched control group (17 children; 10 male, 7 female). The surgery was performed 8.3 years ago (5-12 y.). The children of the CF group were 9.1 years (SD 3.3) old, those of the control group 8 (SD 3.3). Pedography was done using the EMED system, Novel, Munich, Germany (6 trials per foot at self selected speed; Software novel gaitline and geometry Version 20.3.27; mask with 5 regions). SPSS 17.0 was used for statistical analysis (Mann Whitney test, $p< 0.05$).

Results: The force time integrals were significantly higher in the CF group in all regions except for the hindfoot and first toe. So was the arch index in the CF group. The peak pressures, centre of pressure (gait line), foot progression angle and geometric indices did not differ significantly.

	FTI total	FTI hindfoot	FTI midfoot	FTI forefoot	FTI 1st toe	FTI toes	AI
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Clubfeet n=16	252 (155)	62 (45)	43 (40)	115 (71)	18 (19)	11 (13)	0,29 (0,05)
Control n=17	197 (149)	48 (36)	17 (21)	77 (79)	15 (17	7 (10)	0,23 (0,06)
p	0.016*	0.109	0.006*	0.021*	0.234	0.003*	0.022*

Table 1 FTI (in Ns) and AI with p values (* significant)

Discussion & Conclusion: Compared to the pedobarographic results after conservative treatment (1,2) in our study operated CF have an increased impulse and arch index. Sinclair et al. examined younger children and used a different mask, though. Huber et al. (3) used another measurement system and took the pressure time curve as an objective data. Increased force time integral as a measure of energy expenditure confirms the results of gait analysis in patients with CF. But pedobarography is easier to perform and can more widely be used as a measurement instrument. Dynamic pedobarography has revealed significant differences in the impulse and the arch index between extensively operated clubfeet and healthy feet at a midterm follow-up. By collecting further data it will be possible to gain objective parameters in order to evaluate the outcome and predict the need for further surgery.

References: (1) Sinclair MF et al. Pedobarographic analysis following Ponseti treatment for congenital clubfoot. Clin Orthop, 2009. (2) Jeans KA, Karol LA Plantar pressures following Ponseti and French physiotherapy methods for clubfoot. J Paediatr Orthop, 2010. (3) Huber H, Dutoit M Dynamic foot-pressure measurement in the assessment of operatively treated clubfeet. J Bone Joint Surg (Am), 2004.

Disclosure: No significant relationships.

P27

CHANGES IN SURFACE EMG PATTERNS IN CHILDREN WITH CEREBRAL PALSY DURING ROBOTIC GAIT TRAINING

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Introduction: Robotic devices for gait rehabilitation enable task specific and intensive training, without placing high physical demands on physiotherapists. Recent evidence indicates that robotic-assisted gait training improve ambulation in children with CP (1).
The aim of this study was to evaluate whether gait training using a robotic driven gait orthosis (DGO) (Pediatric Lokomat) change muscle muscle activation during gait in children with CP.

Patients/ Material and methods: Ten Ambulatory children (5-16 years) with a diagnosis of spastic CP, GMFCS level II to III were enrolled in the study. All participated in an intervention of robotic-assisted walking. During session subjects walked on Lokomat treadmill with and without bodyweight-support and with or without DGO applied. Children were encouraged to walk continuously and as actively as possible. The assistance provided by the DGO was set to 100%, the amount of bodyweight support was set between 10-30% and treadmill speed was adjusted for each subject. Sagittal video recordings of gait were made, together with simultaneous surface electromyography recordings of the Rectus Femoris (RF), SemiTendinosis (ST). Data were collected with ME6000 and calculated in Megawin (Mega Electronics Ltd). RMS averaging was used.

Results: A significant ($p<0,05$) decrease of average EMG levels of RF were observed during DGO walking regardless to bodyweight-support (BWS). A significant ($p<0,05$) decrease of average EMG levels of ST were observed during DGO walking with bodyweight-support. Mean of average level (μv) for walking without BWS for RF were 27,45 (SD 15,07) for DGO and 65,30 (SD 41,16) for treadmill. Mean of average level (μv) for ST were 43,35 (SD 21,12) and 61,00 (SD 55,08) for DGO and treadmill without BWS respectively.Mean of average level (μv) for RF during walking with BWS were 23,95 (SD 13,92) for DGO and 49,00 (SD 25,14) for treadmill. Mean of average level (μv) for ST were 32,95 (SD 16,51) and 49,55 (SD 35,72) for DGO and treadmill with BWS respectively. There only significant ($p<0,05$) difference in EMG between walking with and without bodyweight-support was for RF during treadmill walking.

Discussion & Conclusion: This study demonstrated that the assistance provided by the DGO result in lower limb muscle activation during gait in CP. Results suggest that the assistance provided by the DGO change EMG activity more then bodyweight-support.

References: 1. Borggraefe I, at. al Eur J Phys Rehabil Med. 2010

Disclosure: No significant relationships.

P28

THE EFFECT OF AN ANKLE-FOOT ORTHOSIS WITH DORSIFLEXION-STOP ON GAIT ANALYSIS PARAMETERS, ENERGY EXPENDITURE, AND PATIENT SATISFACTION IN FORMER POLIO PATIENTS WITH PLANTAR FLEXOR WEAKNESS

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Introduction: Many polio survivors suffer from residual calf muscles weakness resulting in instability of the ankle joint, and, consequently, a compensatory gait pattern and reduced walking efficiency. An ankle-foot orthosis with dorsiflexion-stop (DS-AFO) is designed to provide a stable base at the ankle joint. However, the evidence of a DS-AFO regarding the efficacy at different ICF classification levels is inconclusive[1] and has not yet been investigated in patients with post-poliomyelitis syndrome (PPS). The purpose of this study was to investigate the efficacy of a DS-AFO on gait kinematics and kinetics, energy expenditure, and patient satisfaction in patients with PPS.

Patients/ Material and methods: Sixteen patients with PPS and weakness of the plantar flexor muscles were included (7M/9F mean age 56 years), and were prescribed with a custom-made full-contact fitted carbon-composite DS-AFO. Patients were tested wearing shoes (control) and wearing the DS-AFO inside the same shoe. 3D gait analysis was performed using an 8-camera Vicon MX system and 4 AMTI force plates to assess spatio-temporal, kinematic and kinetic characteristics. Evaluation was based on six specific gait parameters[2]. A 6-minute walking test (MWT) including a breath-by-breath gas exchange analysis (Cosmed system) was performed to evaluate energy cost (EC) of walking. Patient satisfaction and experience were assessed using a visual analogue scale (VAS) and purpose-designed questionnaires. Comparisons between groups were done using paired-samples t tests and Wilcoxon Signed rank tests. Associations between variables were tested using Pearson Correlation coefficients (all at $p < 0.05$).

Results: 3D-gait analysis results are present for 14 patients. Compared with control, walking with the DS-AFO had no significant effect on amplitude and timing of gait kinematics and kinetics except for a significant decrease in peak sagittal plane ankle power in terminal stance (control 1.4±0.8, DS-AFO 1.0±0.6 Watts/kg, $p=0.012$). Walking in the DS-AFO resulted in a significant reduction of gross EC (8.0%, $p=0.047$), and a significant increase in walking distance (8.1%, $p=0.005$), stride length (5.7%, $p=0.001$) and walking speed (7.6%, $p=0.001$). There was no association found between the 3D gait parameters and energy expenditure. Patients were more satisfied, felt safer, more stable, and less exhausted when walking with the DS-AFO ($p<0.03$). Overall VAS for satisfaction was 73±26 with DS-AFO and 31±26 with control ($p=0.003$).

Discussion & Conclusion: The results showed that walking capacity, in terms of EC, walking speed and distance, as well as patient satisfaction were improved in PPS patients wearing a DS-AFO. Difference in gait kinetics and kinematics were expected between walking with and without a DS-AFO, but were not found in this study. This might be due to the heterogeneity of the group (e.g. degree of plantar flexor muscle weakness and additional quadriceps weakness n=8) resulting in different compensatory gait patterns. The reduced EC of walking, improved spatio-temporal parameters, and improved patient satisfaction showed an improved and more energy efficient gait when walking with the DS-AFO in patients with PPS and plantar flexor weakness. This suggests that orthotic management is useful in improving patient functioning.

References: 1. Harlaar et al. Prosthet Orthot Int, 2010; 34(3): 327–335 2. Brehm et al. J Rehabil Med 2007; 39(8): 651-657

Disclosure: No significant relationships.

P29

EFFECTS OF FOOT ORTHOSES ON GAIT PATTERN OF MALALIGNMENT SYNDROME PATIENTS

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Introduction: Subtalar joint pronation has been linked to several overuse injuries including patellofemoral syndrome [1], plantar fasciitis [2] and mechanical low-back pain [3]. Foot orthoses are widely prescribed to reduce symptoms of knee and to control subtalar joint pronation and excessive forefoot varus during walking. Based on the kinetic chain, subtalar movements occurs internal or external rotation of the tibia and fibular. And the rotations accompanied by rotation of the femur in the same direction [4]. Several authors have suggested the possibility of the pronation affecting the posture of pelvis, but none have provided data to support the relationship. The purpose of this study is to investigate the effects of the foot orthoses on the pelvis motion of patients with malaligament syndrome patients during level walking.

Patients/ Material and methods: Eight patients with malalignment syndrome volunteered to participate in this study. Three condition of were tested: barefoot, shoe with normal insole and shoe with foot orthoses. The study was carried out at the Motion analysis laboratory in Yeungnam university hospital. Kinematic variables were collected with twelve motion capture cameras (Vicon MX, Oxford Metrics, UK). Retro-reflective markers were attached according to the Plug-in-Gait Marker set. Kinematic data were divided into gait cycles of each side of pelvis. The asymmetric index of pelvis was calculated using ROM (range of motion) differences between the each side pelvis angle. One way ANOVA ((SPSS, Chicago, IL, USA was used to test for the difference of pelvis angles and all significance levels were set at p=0.05.

Results:

Difference	Barefoot		Normal insole		Foot orthoses	
	Mean	SD	Mean	SD	Mean	SD
Pelvis tilt	1.0259	0.4798	0.9703	0.3195	0.9157	0.4213
Pelvis obliquity	3.7192	3.7390	3.8747	3.6667	4.0397	3.8676
Pelvis rotation	4.4638	3.0838	3.8925*	2.7779	2.7917*†	2.2003

There was no significant difference of pelvis tilt and obliquity between three conditions. Normal insole and foot orthoses were lead to significantly reduce of the difference of the pelvic rotation between the left and right side. And the difference was significantly low in gait with foot orthoses.

Discussion & Conclusion: We expected that the subtalar joint rotation may lead the pelvis tilting, because the internal rotation of femur caused by the subtatar joint would cause the pelvis to tilt anteriorly [5]. But we found the evidence of the foot rotation could influence on the pelvis motion during gait, and the foot orthoses could correct the pelvis asymmetry.

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Disclosure: No significant relationships.

P30

POWERED PROSTHETIC KNEE FOR TRANS-FEMORAL AMPUTEES, A CASE REPORT.

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Introduction: Basically all prosthetic knee joints for trans-femoral amputees (TFA) are passive devices which in principle control stance-phase via e.g. dampening, friction or a polycentric geometry, whereas the forward propulsion of the lower prosthetic leg is carried out by the users' residual limps hip muscles and supported by the prosthesis moment of inertia. Powered prostheses could facilitate gait patterns like e.g. alternate stair climbing which is in general not possible for a TFA. In this case study the results of a TFA using the power-generating prosthetic knee Power Knee 2 TM (PK/Ossur, Reykjavik, IS) walking in level ground, stair and ramp ascent and descent, are presented and compared to results of the TFA walking with a passive prosthetic knee Rheo Knee 2 TM (RK/Ossur, Reykjavik, IS).

Materials and Methods: One unilateral trauma induced male TFA (39y, 173cm, 70kg, K-Level 4 [1]) was investigated while walking with the passive microprocessor-controlled prosthetic knee RK in combination with a Ceterus TM foot and the active, power-generating knee RK with a Variflex-EVO TM foot (all parts by Ossur, Reykjavik, IS). The identical ischial-containment socket for both prostheses was used. TFA and 20 controls (NORM / 30.2 y ± 9.3 y) underwent a conventional instrumented gait analysis (CGA) for level ground, walking up and down a ramp of 7.5°and a staircase of 5 steps. CGA was performed with a 12 camera System (Vicon, Oxford, UK) operating at 120Hz and two force-plates (Kistler, Winterthur, CH). Force-plate data during ramp and staircase walking was recorded using the method as described by Simon et al. [3]. Kinematics and kinetics were calculated according to the Plugin-Gait [2].

Results: Level Walking: Norm-distance [4] is lower for the Knee-angle, moments and powers of the involved side using PK compared to RK. Ramp ascent: Internal hip-flexing moments in terminal stance and hip power generation in initial swing are lower with PK than with RK-prosthesis. Stairs ascent: Kinematics of PK mimics the physiological kinematical pattern of NORM during stair ascent. Internal extending knee moments and knee power generation for the first half of the gait-cycle didn't reach values of NORM, while internal extending hip moments were higher with PK compared to NORM.

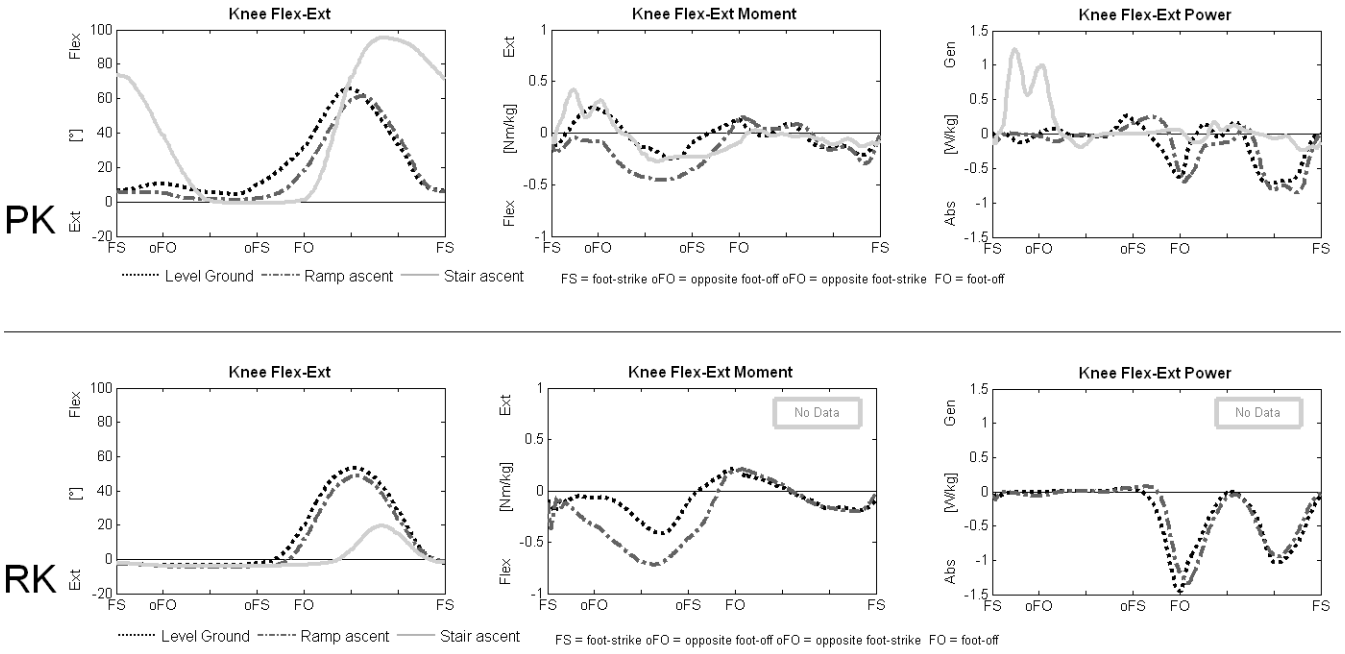

Figure 1: Knee kinematics and kinetics of the involved side in different conditions.Power Knee TM (PK) and Rheo Knee TM (RK) (Ossur, Reykjavik, IS).FS = Foot Strike; oFO = opposite Foot;

Discussion and Conclusion: A more norm-like gait-pattern in level ground and ramp ascent result in lower internal flexing hip-moments and power generation of the involved side. These results correspond to the subjective feedback of TFA that walking with PK is less exhausting. In alternating stair ascent power generation of PK is slight below NORM values for the first half of gait-cycle and higher internal hip extending moments of the involved side occur. Though PK provides concentric knee-power, hip musculature of TFA residual limb has to be sufficient to perform gait-patterns like alternating stair ascent with this type of prosthetic knee.

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P31

CASE PRESENTATION: DISTAL FEMORAL EXTENSION OSTEOTOMY AS TREATMENT FOR RELAPSE OF KNEE FLEXION CONTRACTURE IN A 14 YEAR OLD BOY WITH SPASTIC HEMIPARESIS

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Introduction: At the age of 12 years the patient presented with hemiparesis on the right side. The Gait showed a fixed eqinus and beginning of knee flexion contracture.

Patients/ Material and methods: The clinical examination on the right side showed knee flexion contracture of 5 degrees and equinus of 15 degree. Hip movement was free. Clinical examination of the left leg showed normal movement.

Results: The 3D gait analysis shwed typical gait pattern with spasticity of rectus femoris and intoing on the hemiparetic side.

Discussion & Conclusion: According this situation the patient underwent multi level soft tissue surgery with release of rectus femoris, ischiocrural muscles and Achilles tendon lengthening and proximal femoral derotation osteotomy for intoing. Postoperative the gait increased, but the boy showed increasing knee flexion contracture on the right side. 2 years postoperative the boy presented with knee flexion contracture of 30 degrees on the right side and beginning hip flexion contracture. Crutches were used for walking also for short distance. An distal femoral extension osteotomy and patella ligament shortening was performed. Postoperative immobilisation was for three weeks with casting. Then functional mobilisation with gait orthoses was started. Free walking without orthoses was reached 4 month postoperative.

References: Distal femoral extension osteotomy with patella ligament shortening and early postoperative mobilisation showed in this case excellent outcome with major improvement of walking ability for the patient.

Disclosure: No significant relationships.

P32

DOES RIDER INFLUENCE HORSE'S MOVEMENT IN HIPPOTHERAPY?

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Introduction: The physiologic basis of hippotherapy is the three-dimensional transmission of the horse's motion over to the patient's body [1]. The horse's movements affect that of the patient's, thus opening possibilities to influence the rider's pelvic and torso motor activity [2]. In hippotherapy, in comparison to equitation, it is assumed that rider is a passive element, who is only stimulated by impulses from a moving horse's back. The aim of the study was to observe whether the rider influences a horse's movement in hippotherapy.

Patients/ Material and methods: Two thoroughbreds with a similar bodily constitution (age: 19 and 14 years, height: 1.65 m both, weight: 548 and 500 kg) participated in the study. The group of riders consisted of twelve healthy young women (age: 23.3±2.8 years, weight: 59.2±5.3 kg, height: 1.67±0.04 m). In total 36 stride cycles for each rider were evaluated during natural walking of the horses. The movement was recorded by 4 videocameras (frequency 50 Hz). APAS programme (Ariel Dynamics Inc., Trabuco Canyon, CA, USA) was used for kinematic variables processing. Spatiotemporal variables, vertical displacement of selected points on the horse's limbs and back and angle displacement of tarsus joint were evaluated. Statistical processing was performed by Statistica programme (version 8.0, Stat-Soft, Inc., Tulsa, Oklahoma, USA) using one way ANOVA.

Results: We did not find differences in stride duration, stride length and horse's walking velocity during walking with various riders. Upon walking of horse A with various riders, significant differences in vertical and angle displacement of points on hind limb and on horse's back were found. As for horse B, significant influence of rider was found only in vertical displacement of fore-hoof.

Discussion & Conclusion: With regard to kinematics variables, results are not explicit. For one horse the differences influenced by rider were significant for all variables in the hind limb and back. The reasons of these findings can be inter-individual differences between horses. Faber et al. [3] mentioned that for back movements, in general, between-horse variability is bigger than between-stride and between-day variability. For future research larger number of horses is necessary. In hippotherapy, basic spatiotemporal variables of horse's natural walking aren't influenced by rider. As for vertical displacement of points on the limbs and horse's back, results aren't explicit. Larger number of horses is necessary for future study. Patient and horse in hippotherapy would be rather considered as interact elements than passive and active elements.

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Disclosure: No significant relationships.

P33

24H BRACING FOR TIP TOE WALKING CHILDREN WITH CEREBRAL PALSY.

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Introduction: We present a patient that was examined several times in our gait-lab. He was studied before using the splints, while he was wearing them and one month after using them night and day. He showed an overall improvement in kinematics, Gillette Gait Index and Gait Profile Score.

Patients/ Material and methods: He was a typical tip-toe-walker with changes in gait pattern concerning the movement of the ankle joints that shifted towards plantarflexion during the whole gait cycle.

Results: The knees showed a decrease of range of movement during stance- and swing-phase. The splints caused muscle weakness while the patient was wearing them. This effect did not last after he stopped wearing them night and day.

Discussion & Conclusion: Children that walk on their tip-toes are often presented to orthopaedic doctors. Many of these have this symptom for a short period of time during growth spurts and in that cases the range of motion is not reduced. If the patient is tip-toe-walking all time and the range of motion is declining the first option is conservative treatment as long as there is no structural fixated contracture. The biggest group of tip toe walkers are patients with spastic muscles and these react very good with conservative treatment such as shoes and splints. With this presentation we want to show the effect of bracing with night-and-day splints. Patients are to wear the splints nearly 24h per day for 3 months. Afterwards the splints can be used as night splints.

References: The data of ankle and knee joint in the last examination was in normal range on both sides and therefore showed a normal gait and a successful treatment. The patient could avoid all invasive interventions for the moment. This treatment option can be repeated when the patient is getting worse again during growth as long as there is no structural fixated contracture.

Disclosure: No significant relationships.

P34

ACCESSIBLE GAIT ANALYSIS

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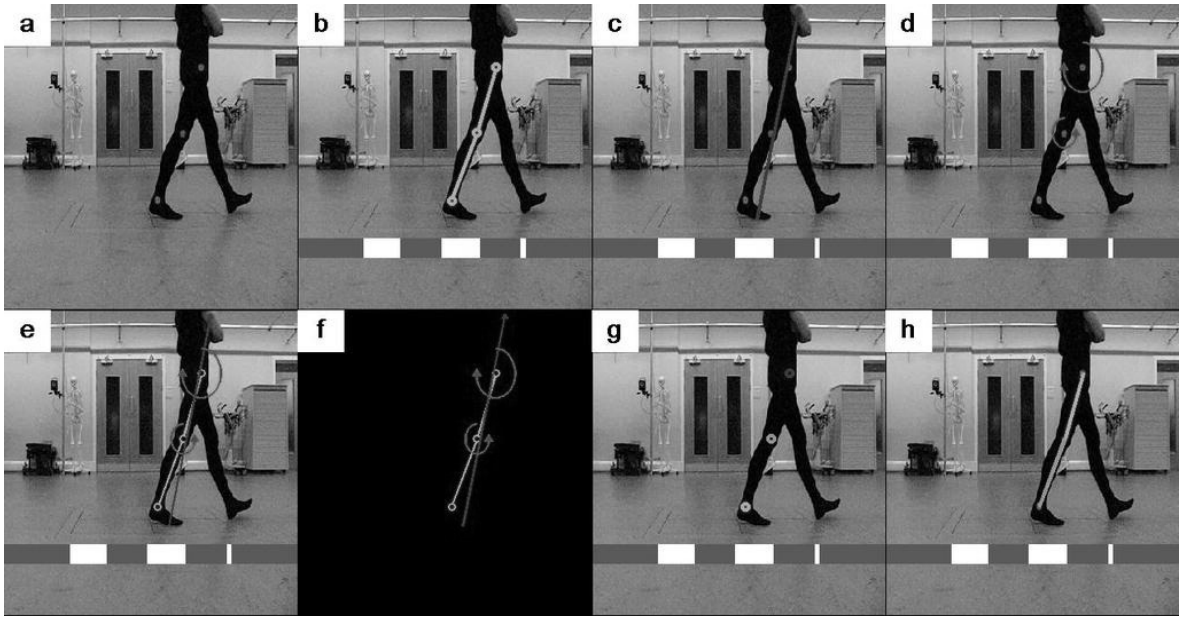
Introduction: Analysis of human movement has been shown to be an essential element of the clinical management of patients with movement disorders [1,2]. It has been suggested that enhanced service provision may result from making movement analysis and its interpretation more accessible to non-specialists and lay persons [3]. One method of achieving this may be through dynamic visualisation of biomechanics data that is presented in a "familiar" way [4]. The two aims of the current work are 1) to develop a new system for conducting motion analysis that is technically and financially accessible, and 2) to produce a software package for computing, visualising and communicating biomechanics data. The primary objective of the first aim is to develop a system that maintains the benefits of traditional Video Vector systems and introduces automatic identification and tracking of human body segments and joints, thus eliminating subjective interpretation of data. The primary objective of the second aim is to design a simple and consistent framework on which to build a feedback engine for visualising important gait parameters that may have been acquired from any form of instrumented gait analysis.

Patients/ Material and methods: In its current form, the new system for conducting motion analysis requires the synchronised collection of high-speed digital video and ground reaction forces. During trials small green paper markers are used to indicate the location of anatomical landmarks and these are automatically isolated using techniques similar the "green screen" used in commercial environments. This process removes the need for manual digitisation of recorded videos, eliminates subjective interpretation of data, and provides feedback videos that are enhanced by overlaying the original video frames with animations of important gait parameters (Figure 1). Progress regarding aim 2 is in the early stages however the visualisation and reporting platform will function in association with data acquired from: simple motion analysis systems to produce a sagittal video of the patient in motion showing kinematics and kinetics in two dimensions, and three-dimensional motion analysis systems to show kinematics and kinetics recorded and reconstructed in 3D superimposed on a video recorded from any point of view. In addition to this there is the potential to include data acquired using EMG and other apparatus, thus indicating muscular contributions to gait via similar illustrations to those presented in Figure 1.

Results: Preliminary results are illustrated by Figure 1.



Discussion & Conclusion: It is acknowledged that several issues must be addressed and optimised. However, pilot work has demonstrated the potential of the tool under development for conducting and communicating gait biomechanics with the aim of improving clinical mobility service provision.

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Disclosure: No significant relationships.

P35

3D CENTRE OF MASS MODEL USING KINEMATICS ONLY

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Introduction: Motion analysis plays an ever-increasing role in sports biomechanics where increasingly sophisticated methods are sought for the purpose of assessing and improving performance, for monitoring recovery after an injury and, indeed, for injury prevention. Commonplace methods are video observation and 3D kinematic studies. Force transducers are necessary for kinetic studies, often requiring significant adaptation of the activity in order to meet the technical requirements of the kinetic capture devices. The authors propose a 3D model which can be used to capture the motion of the body centre of mass (CoM) without the need to use forceplates at all times. This will be useful in studies where the trajectory of the CoM is important (long jump, high jump, triple jump, and various gymnastics activities).

Patients/ Material and methods: The model consists of 18 markers on the body defining segments: head, upper trunk, lower trunk, lower and upper arms, thighs, shanks and feet. Based on their locations, positions of virtual locations are derived, representing limb and trunk centres of mass. The summation of these determines the overall body-centre-of-mass. Calculations of the positions of the CoMs are derived from Body Segment Parameter Data for 2-D Studies from Dempster[1] and Clauser[2]. The design of the current model is partly determined by the bilateral capture paradigm of a pair of laterally opposed, sagittal viewing cameras of the CODA motion tracking system (Charnwood Dynamics Ltd., UK). The cameras track active markers in 3D. Calibration of the model is facilitated using real-time adjustments - a 'tuning' procedure requiring a portable forceplate and its real-time graphical GRF vector as the subject adopts different positions during which comparisons between GRF and calculated CoM are recorded. Tuning is achieved by adjusting the position of the sensors or by adjusting the relative weights of localized CoMs.

Results: Deviation of ~30mm between force vector and COM is found between individuals, but with reproducibility between different sessions as within normal gait data deviation.

Discussion & Conclusion: Whilst the precision is not as high as current gait models, for applications with a wide capture space, the model provides sufficient quality for some clinical applications (hop test) or sports activities (jumping). For expediency, the model does not attempt to make an exhaustive 6DoF analysis of the inertial properties of every limb segment, but leans towards a fast and efficient method using minimal hardware and modelling complexity. A consequence of using strictly bilateral motion tracking in conjunction with certain assumptions about inertial properties and the use of 2D approximations is that the proposed model is currently not suitable for analysing movements of subject which rotate excessively (e.g. shot-putting).

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Disclosure: No significant relationships.

P36

THE USE OF AN OFF-THE-SHELF GAMING TECHNOLOGY FOR TRACKING MOVEMENT AND UPPER LIMB STROKE REHABILITATION

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Introduction: We have developed a system that utilises low-cost gaming technology to track the movements of the upper limb. The device was a CyWee Z, a movement based computer game controller similar to the Nintendo Wii remote. Accelerometers and gyroscopes are used to track the movement and interact with the computer. To make bilateral upper limb exercises possible, the game controller was attached to a handlebar. This bilateral strategy allowed the unaffected side to support and assist the affected side (figure 1). The intervention consisted of playing computer games with the device. The device was used to interact with computer games while exercising the affected upper limb of chronic stroke patients with their less affected arm supporting and assisting the movements of the affected arm in a bilateral manner. We have investigated the effects on motor recovery and motivation to use the system, designed to provide repetitive, computer game-assisted upper limb rehabilitation, in a cohort of adults with chronic stroke.

Patients/ Material and methods: Fourteen participants who had a stroke more than a year ago received a control treatment first, followed by a washout period and then the intervention. Both the control treatment (playing mouse based computer games with the unaffected limb) and the intervention (playing computer games with the CyWee Z and handlebar) comprised 8-10 sessions of 45-60 minutes, over a period of 2.5 weeks. The upper limb section of the Fugl Meyer Assessment (FMA-UL) was used as the primary outcome. The Wolf Motor Function Test and the Disabilities of Arm, Shoulder, and Hand questionnaire were used as secondary outcomes. Three of these participants were asked to continue the use at home. Their motivation to use the system was measured with the Intrinsic Motivation Inventory

Results: Post intervention, motor performance, measured by the FMA-UL, was significantly improved compared with all pre intervention assessments ($p<0.001$), whereas no changes were found on both secondary outcomes.

Discussion & Conclusion: It can be concluded from this pilot study that a movement based game controller can effectively be used to track the movements of the upper limb, to interact with the computer, and is suitable for upper limb rehabilitation of stroke survivors. Upper limb motor performance of adults with chronic stroke improves with repetitive, computer game assisted, self-supported bilateral exercises. Moreover participants were motivated to use the system in a home-based manner.

References: J.M. Hijmans, L. Hale, J. Satherley, N. McMillan, and M. King, “Bilateral upper limb rehabilitation after stroke using a movement based game controller,” Accepted for publication in Journal of Rehabilitation Research and Development, 2011

Disclosure: No significant relationships.

P37

EVALUATION OF THE FAMP-COACH PROTOCOL IN CLINICAL GAIT ANALYSIS

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Introduction: Using the Vicon Clinical Manager (VCM) model, accurate and consistent marker placement is of crucial importance for adequate 3D-gait analysis. The identification of the anatomical landmarks for marker placement varies between observers; its variability can raise up to 25 mm [1]. Using the VCM model, the knee axis orientation is particularly prone to errors, due to inconsistent knee and thigh marker placement resulting in a large variability in the knee kinematics. To reduce the errors in the knee axis orientation, the From Functional Axis to Marker Placement (FAMP) coach has been developed. This tool uses the functional knee axis [2] to identify the optimal knee and thigh marker positions and guides the clinical user to place the markers on these positions [3]. The purpose of this study was to evaluate the FAMP-coach protocol with respect to the inter-observer reliability of the knee kinematics.

Patients/ Material and methods: Six experienced physiotherapists collected the data for a healthy adult with spastic hemiplegic cerebral palsy and eight physiotherapists collected the data for a healthy control. Each measurement consisted of two gait sessions using the modified Helen Hayes marker set [4]. For the first session, the markers were placed on the anatomical landmarks using the VCM protocol. For the second session, the knee and thigh markers were (re)placed using the FAMP-coach protocol [3]. Kinematic data were collected using an eight-camera VICON system (100 Hz). To determine the interobserver reliability of the knee kinematics, the mean standard deviation (SD) and intra class correlation (ICC(3,1), absolute agreement) were calculated for both subjects (left side).

Results:

Subject	Protocol	ICC			SD (°)		
		Sagittal	Frontal	Transverse	Sagittal	Frontal	Transverse
Control	VCM	0.98	0.44	0.15	2.7	3.7	8.7
	FAMP	0.99	0.80	0.21	2.0	2.4	5.7
CP	VCM	0.97	0.10	0.21	2.8	4.2	9.3
	FAMP	0.98	0.72	0.13	2.3	1.8	10.3

Discussion & Conclusion: The inter-observer reliability was high for the sagittal plane knee kinematics for both protocols. The FAMP-coach protocol did improve the inter-observer reliability for the frontal plane knee kinematics. For some physiotherapist, cross-talk was not reduced by the FAMP-coach, which may be due to its dependency on a correct hip joint center position. The FAMP-coach could not improve the poor interobserver reliability for the transverse plane knee kinematics. The large interobserver variability for the transverse plane knee kinematics was probably due to interobserver variability in the pelvic and shank marker placement. In conclusion, the interobserver reliability for the sagittal and frontal plane knee kinematics were good when using the FAMP-coach protocol, but remained poor for the transverse plane knee kinematics. The FAMP-coach protocol may be improved by reducing the interobserver variability of the hip joint center and shank marker position.

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Disclosure: No significant relationships.

P39

DEVELOPMENT OF A VIRTUAL MIRROR BOX FOR SPATIAL AND TEMPORAL MANIPULATION OF VISUAL FEEDBACK ON BODY MOVEMENT DURING GAIT: A TECHNICAL EVALUATION

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Introduction: Improvement of movement function has been reported following treatment with a mirror box which shows a mirror reflection of the intact limb in place of the affected limb. The mirror box method can reduce phantom limb pain in amputees [1] and improve movement function in stroke [2] and upper limb control in children with cerebral palsy [3]. A mirror illusion of unimpaired limb movement during gait might enhance the effect, but a physical mirror is only capable of showing parallel movement of limbs in real time while sitting, standing or lying. The aim of this study was to overcome the limitations of physical mirrors by developing and evaluating a Virtual Mirror Box which delays the mirrored image of limbs during gait.

Patients/ Material and methods: Gait of an unimpaired volunteer walking on a treadmill was recorded using a full body model captured by a Vicon system for 30s. A custom software module of the CAREN system (www.motekmedical.com) mirrored and delayed the left leg and arm markers with reference to a vertical mirror plane attached to the pelvis. Half of the gait cycle duration, identified from the fore-aft difference of toe and sacrum markers, was used to delay the mirrored limbs. After off-line quintic spline re-sampling of the flexion/extension angles of the knees and elbows at 100Hz, cross correlation of angles between the right and left sides was used to remove lag over a clean section (15-25s). Mirroring accuracy was quantified by Root Mean Squared Deviations (RMSD) of the mirrored and delayed angles of the knees and elbows.

Results: After removing the 0.7s lag, the RMSD was 5.98° between the left and right knee angles and 3.17° between the left and right elbow angles, reflecting inaccurate marker placement. Mirroring of the left into the right side without delay resulted in a RMSD of 1.28° in knee and 0.36° in elbow angles caused by pelvic movement translating the mirror plane. Mirroring and delaying of the left into the right side resulted in a 0.7s lag and a RMSD of 3.52° in knee and 0.93° in elbow angles. The difference was caused by imperfections of the mirror plane and cycle-to-cycle variation of the delay. A comparison of the original angles of the right side and the mirrored and delayed angles of the left side showed no lag and a RMSD of 6.84° in knee and 3.21° in elbow angles which were 0.86° and 0.04° different from those of the original right and left sides.

Discussion & Conclusion: Delayed mirroring resulted in a close match between the mirrored virtual limb and the true limb although further refinement is possible by modified mirror planes. Asymmetry between the right and left gait cycles of patients causes a temporal discrepancy between the initial contact of the virtual and true limb. Temporal morphing of the gait cycle can correct for this effect, enabling unconstrained virtual mirror therapy.

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Disclosure: No significant relationships.

P40

A NEW LOWER LIMB MODEL FOR MOTION ANALYSIS AND ITS COMPARISON WITH VICON® PLUG-IN-GAIT MODEL

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Introduction: Clinical gait analysis is recognized as an important diagnostic tool for the management of patients with gait pathologies [1]. Vicon® motion capture system is one of the most sophisticated systems used for gait analysis. Plug-in-Gait model, the most commonly used model for gait analysis in clinical setting is a wand based model with some inherent errors. The aim of this study was to design a new lower limb model for motion analysis and compare it with the Plug-in-Gait model, using Vicon® motion capture system during walking and running.

Patients/ Material and methods: Twenty three adult healthy volunteers were recruited for this study. Retro-reflective markers were attached to the pre-defined anatomical locations on subjects' bodies according to two models. Data was collected using Vicon® motion capture system while subjects were walking and running. Collected data was then processed using two models. All joint paramters, e.g. angle, force, moment and power, were calculated using the two models. The errors in high frequencies from the two models were obtained using a lower-frequncy filter. Statistical analysis was done using SPSS software.

Results: All joint parameters (angle, force, moment and power) were analysed for three lower limb joints (hip, knee and ankle). Data analysis from these joint parameters revealed significant difference in 83% of components in walking and 53% in running between both models. The differences in the range of motion at the joints from two models were 1.5-3 deg; the differences in range of moments were approximately 0.1-0.8 Nm/Bodymass (BM); the differences in range of forces were approximately 0.1-3 N/BM; and the differences in range of forces were approximately 1-2.3 Watt/BM. The joint paramter graphs produced from these tests showed identical patterns of gait or running cycle in both models, however the data obtained from the new one had more stable pattern, whereas Plug-in-Gait model showed high frequency variations possibly due to vibratory movements at wand markers.

Discussion & Conclusion: It was found that the errors from the wand-markers in the Plug-in-Gait model were larger than that in the new model. The analysis of rooted mean squared errors on 24 kinematical and kinetic parameters showed that the Plug-in-Gait model has higher error than the new model. The errors encountered in the Plug-in-Gait model due to vibratory movements in the wand markers can be largely reduced by using proposed new model, a wand-marker free model. Therefore, the new model could be used as an alternative in motion analysis especially in high speed movements, e.g. running.

References: [1] Nair et al (2010). A method to calculate the centre of the ankle joint: A comparison with the Vicon® Plug-in-Gait model. Clin. Biomech, 25, 582-587.

Disclosure: No significant relationships.

P41

DESIGN CONCEPT FOR A MOBILE ARM SUPPORT

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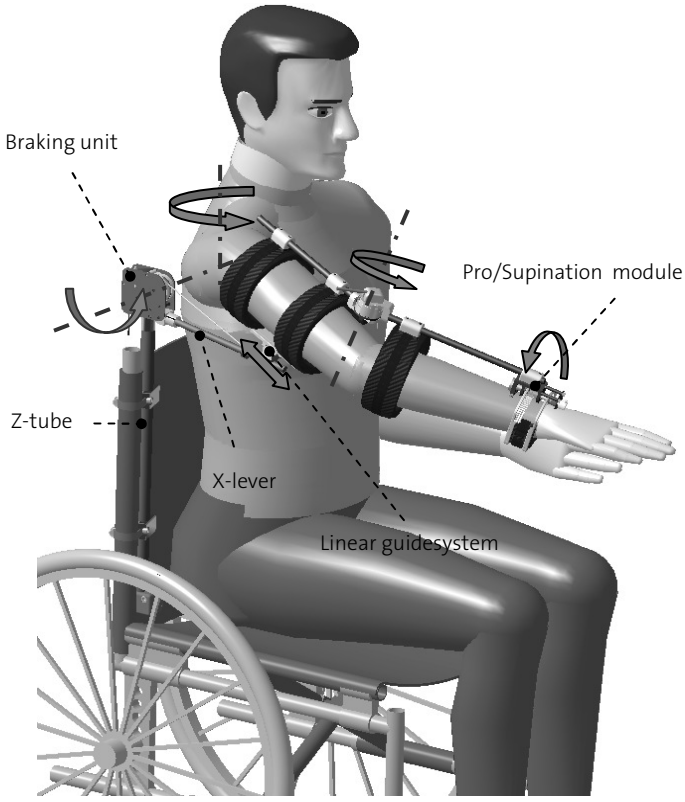
Introduction: A mobile arm support (MAS) such as the passive systems JAECO WREX [1] or the ARMON device [2] can help persons with neuromuscular weakness to perform activities of daily living (ADL) autonomously. The presented work is part of the EU project MUNDUS (MUltimodal Neuroprosthesis for Daily Upper limb Support) and focuses on the design of a MAS that provides weight support for the patients arm and the possibility to block the essential degrees of freedom at defined positions. In clinical application this exoskeleton will be combined with Neuro Muscular Electrical Stimulation (NMES) to support patients with degenerative neuronal diseases or high level Spinal Cord Injuries (SCI).

Patients/ Material and methods: With a 3D-infrared-motion-cature-system we determined the necessary range of motions (ROM) to perform ADL e.g. eating, or combing the hair. The weight supporting spring was calculated with Matlab taking several mechanical solutions into account. Focusing on simplicity and modularity the presented concept was designed in Catia V5 R19.

Results: The preliminary investigation resulted in a design with two degrees of freedom (DoF) at the shoulder, one at the elbow joint and one for pro- and supination. Figure 1 shows the digital mock-up of the MAS mounted on a wheelchair. Due to the lightweight construction (3.4 kg) the MAS can also be worn with a body harness. Depending on the degree of motor deficiency and the effected muscle groups motors are foreseen to actuate the required DoF in addition to NMES. The weight compensating spring is integrated in the z-tube. Its pre-stressing can either be adjusted manually or by an electric motor. The compensation force of the spring is transmitted via a rope to the x-lever, on which the upper arm shell is mounted on a linear guide. The braking unit for the shoulder flexion and extension is realized as a strap brake mechanism. The bearings of the mechanical elbow joint are integrated into the electromagnetic brake. A pro- and supination module, which can be attached to the forearm rod, is also prepared to carry a hand module that can activate the fingers.



Discussion & Conclusion: The design concept offers a lightweight MAS with four lockable DoF. The modular concept is easy to adjust to different anthropological sizes and is both-sided. A prototype is being built to evaluate its functionality in a following study with patients at the rehabilitation centre.
Acknowledgment This work is part of the European Project MUNDUS, funded by the call EC FP7 ICT 2009-4.

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[2] Herder J, el al.: Principle and design of a mobile arm support for people with muscular weakness JRRD 43, 2006.

Disclosure: No significant relationships.

P42

PATHOLOGICAL GAIT CHARACTERIZATION VIA MOMENT-ANGLE RELATIONSHIP: A NEW DECOMPOSITION METHOD

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Introduction: The relationships between joint moment and angle, also referred as dynamic joint stiffness(DJS), have been used to characterize gait pathologies at lower limb joints by calculating the slope of joint moments plotted as a function of joint angle[1]. Analogous to 'spring stiffness', DJS was to describe the resistance that muscles and soft tissue provided during joint excursion. However, the uncertainties underlying the concept make it difficult to interpret changes of DJS in the pathological gait. An analytical decomposition method was proposed to decompose ankle DJS to individual components. The aim of this pilot study was to test whether the decomposition method can better clarify the DJS at ankle and the potential application in the clinical gait characterization.

Patients/ Material and methods: Ankle DJS was evaluated on five healthy controls (age: 43 ± 4 yrs) and one subject (age: 45 yrs) with inflammatory disease before and after TNF-α inhibitors treatment. Kinematic data was recorded from markers trajectories using a motion capture system (Vicon MX40). Ground reaction forces and center of pressure data were obtained from two forceplates (Kistler). All subjects walked barefoot at a self-selected speed with written informed consent. The stance phase was divided into three rockers by the definition from Perry[2]. In the regression method, ankle DJS was calculated as the average from a linear regression, least squares fit as the average slope of the moment vs. angle curve during each interval[3]. In the new analytical method, ankle DJS q and each component was derived from Eq.1 based on the equilibrium equations in 2D inverse dynamics.

$$q = \frac{dM_{ax}}{d\theta_a} = \frac{\frac{dM_{ax}}{dt}}{\frac{d\theta_a}{dt}} = \frac{I_f \frac{d^3\theta_{Foot}}{dt^3}}{\frac{d\theta_a}{dt}} + \frac{\frac{dM_{accAx}}{dt}}{\frac{d\theta_a}{dt}} + \frac{\frac{dM_{GA}}{dt}}{\frac{d\theta_a}{dt}} + \frac{\frac{dM_{GRFAx}}{dt}}{\frac{d\theta_a}{dt}} \quad (1)$$

Component 1 **Component 2** **Component 3** **Component 4**

where M_{ax} is the joint reaction moment, θ_a is ankle dorsi/plantarflexion angle, θ_{Foot} is foot segment rotation in the global coordinate, I_f is the moment inertial of the foot, M_{accAx} is the moment about ankle due to inertial forces, M_{GA} is the moment about ankle due to gravitational force, M_{GRFAx} is the moment about ankle due to ground reaction force.

Results: Compared to the regression method, ankle DJS is 5% higher in the 1st rocker, 6% lower in the 2nd rocker and 4% higher in the 3rd rocker in the analytical method in controls. Ankle DJS was reduced in patient with inflammatory disease after the treatment. Component 4 was the major contributors to the ankle DJS (Fig 1).

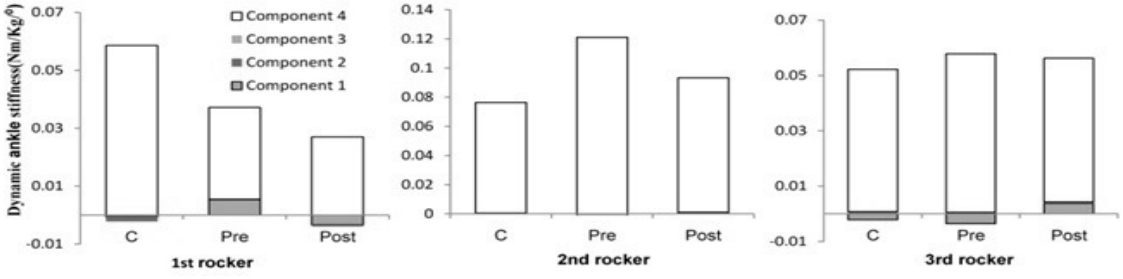

Fig 1. Ankle DJS was computed in the 1st, 2nd and 3rd rockers using the analytical method. DJS was compared between one patient before (Pre) and after treatment (Post) and mean value from five healthy controls (C). Each component was averaged during each sub-phase.

Discussion & Conclusion: This prelimilary study showed that ankle DJS was comparable in two methods. The largest contribution was from changes in M_{GRFAX}. The changes in M_{GA},Component 3, were negletable. Compared to controls, some differences can be seen in the percentages of each component in patient before and after treatment. In conclusion, the analytical decomposition method might help to clarify ankle DJS in identifying ankle pathologies.

References: [1] Davis RB, et al. Gait Posture 1996:4 [2] Perry J. Slack, Inc., 1992 [3] Frigo C, et al. J Electromyogr Kinesiol 1996: 6(3)

Disclosure: No significant relationships.

P43

UNDERWATER MARKERLESS GAIT ANALYSIS: A PILOT STUDY

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Introduction: Recently, the aquatic environment has gained an important role within the rehabilitation world.[1] However, the measurement of common biomechanical parameters during water locomotion is more demanding than in laboratory conditions, since most instruments are not suitable for operating in a water environment. Therefore, the development of new technologies is highly sought. In this context, a video-based, markerless system for the analysis of underwater gait was developed and its accuracy in 3 dimension lower limb (LL) joint kinematics reconstruction has been tested.

Patients/ Material and methods: An healthy and an ACL-injured males were recruited (mean age and BMI respectively 39.0±11.3 and 22.3±5.6). Six walking trials at a self-selected speed have been acquired with 6 subaqueous video cameras (TS-6021PSC, Tracer Technology Co. Ltd), in a swimming pool, with water at a shoulder level. The method proposed by Ceseracciu et al. 2011 was applied [2]. Correlation was used to aid in selecting which of each subject's representative walking trials were to be included in the computation of the mean; thus the correlation coefficient was calculated for each subject's kinematic parameter. Walking trials with a correlation coefficient lower than 0.75 (75%) were excluded [3]. Each subject joint rotations' mean and standard deviation were evaluated, and pathologic patterns were compared with healthy subject ones. Accuracy and reliability of the proposed technique were evaluated by means of comparison with traditional manual digitization (SIMI Reality Motion Systems GmbH, Fig 1). In order to compare the two techniques, LL triplanar angles were evaluated and root mean square distance (RMSD) values between angles estimated (Table 1).

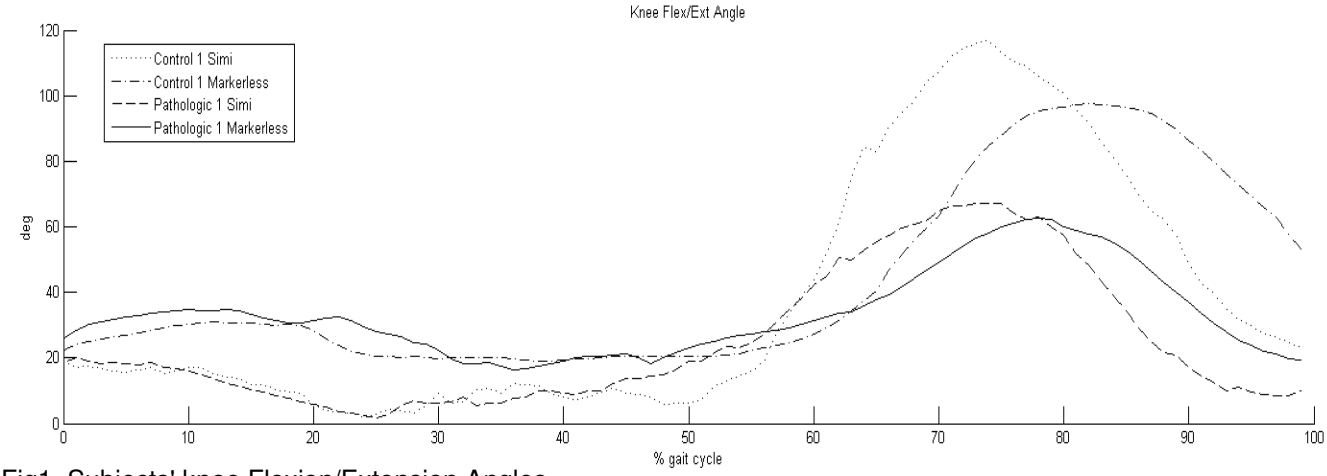

Fig1. Subjects' knee Flexion/Extension Angles

Table 1. Rmsd values

RMSD	Control1	Pathologic 1
hip	25.0	16.4
knee	21.8	15.3
ankle	12.4	23.1

Results: RMSD values between triplanar angles evaluated both with SIMI and markerless techniques are reported in Table 1, and an example of the corresponding angles is shown in Fig.1.

Discussion & Conclusion: Results show the feasibility of the present approach. It should be considered that SIMI triplanar angles estimation relies on anatomical landmarks identification on each video sequences by manual digitization. Meanwhile the markerless approach is based on automatic reconstruction of joint center positions. This could explain the high RMSD values. Future developments should include the recruitment of a larger number of subjects, and the comparison between 3 dimensional joint angles estimated with the 2 different techniques [2].

References: [1] Barela et al. (2008). J Electromyogr Kinesiol. 18(3):446-54. [2] Ceseracciu et al. (2011). J. of Biomechanics (Accepted). [3] Sawacha et al. (2009). Clinical Biomechanics, 24(9):722-728.

Disclosure: No significant relationships.

P44

DOUBLE CALIBRATION FOR A HELEN HAYES MARKER SET

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Introduction: The accurate tracking of the skeleton with skin mounted markers has long been a challenge in three-dimensional movement analysis [1]. When results are used to plan surgery or other interventions, it is important that there is confidence in the data reported.

One of the greatest challenges is soft tissue artefact (STA) - movement of the skin relative to the underlying anatomical landmarks. The Helen Hayes Model [2] places markers directly over joint and landmarks, and so is particularly susceptible to this [1]. A solution to STA around the thigh has been applied to the CAST method of gait analysis through a technique known as double calibration [3]. Calibration is performed twice, in both a flexed and extended position, and the relationship between the markers and landmarks is interpolated from the two calibrations.

The aim of the work presented here is to apply the motivation behind double calibration to a Helen Hayes based system, such that it could easily be absorbed into routine clinical assessments and used with Plug in Gait (PiG) (Vicon, Oxford UK).

Patients/ Material and methods: In addition to the PiG knee marker which is placed over the lateral epicondyle with the patient standing in an extended position, a second marker was placed over the epicondyle when the knee was in a flexed position. A second static calibration trial was recorded in this position.

Data were captured using Vicon Nexus (Vicon, Oxford UK) and the initial static calibration processed using PiG. The calculated knee flexion angle from the additional static calibration trials was recorded. Dynamic trials were processed and the knee flexion angle was recorded. A new knee marker position was then calculated by linear interpolation between the conventional and additional knee marker positions based on the calculated flexion angle, using a custom written script in Matlab (Mathworks, Massachusetts USA). Each trial was then re-processed in Nexus with the corrected knee marker position.

Results: in healthy subjects to date indicate that relocating the knee marker to a more anterior position can have the effect of decreasing hip internal rotation, increasing knee flexion, and decreasing peak knee varus in swing. However, the range of knee varus/valgus during swing may increase.

Discussion & Conclusion: A number of different factors have an effect on calculated gait kinematics. Soft tissue movement that is unaccounted for by this model, such as that at the thigh, can have a significant impact on the accuracy of these results, as can errors in marker placement. The lack of a clear gold standard makes it very difficult to assess the validity of any particular model. Instead, we must rely on clinical experience and comparisons with data published in the literature. The work presented here is an initial implementation of a modification to Plug in Gait and further work is underway to develop and adapt the model to further compensate for STA.

References: [1] Cappozzo et al (1996). Clinical Biomechanics 11(2): 90-99
[2] Kadaba et al (1990). Journal Orthopaedic Research 8: 383-392
[3] Capello et al (2005). IEEE Transactions Biomedical Engineering 52(6): 992-998

Disclosure: No significant relationships.

P45

HOW SENTITIVE IS INDUCED ACCELERATION ANALYSIS ON THE RIGID FOOT-FLOOR CONTACT MODEL: A PARAMETRIC ANALYSIS

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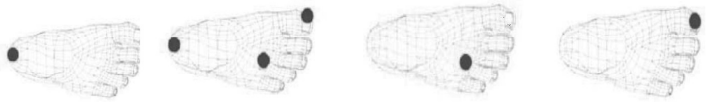
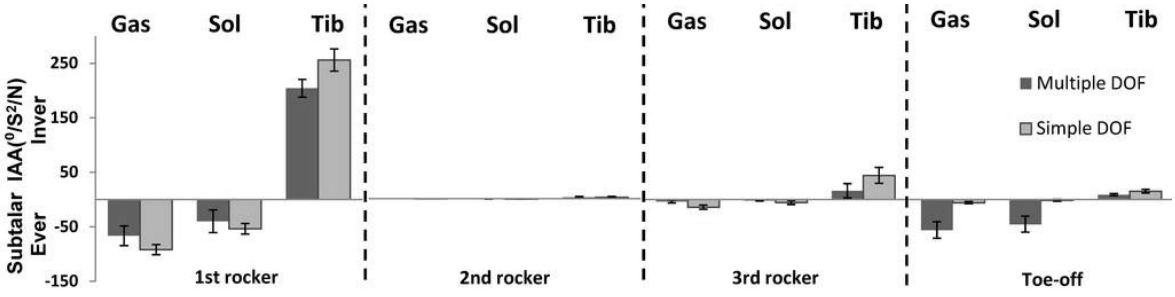
Introduction: Induced acceleration analysis (IAA) is a method for computing the accelerations produced by an application force or moment to a body or system of bodies [1]. Clinical research using IAA has demonstrated among other things that external tibia rotation can reduce the soleus' knee extension capacity [2]. The foundation for computational simulations relies on musculoskeletal models which are constructed based on investigators' assumptions, e.g. foot-floor contact (FFC) modeling. Schwartz et al. [2] have modeled the FFC as a moving revolute joint instantaneously located at the center of pressure (COP). Alternative approaches have included a ball-socket joint at initial-contact and toe-off, and rigid contact during foot-flat [3]. In rigid-contact modeling, accurate locations and appropriate DOFs at FFC joints are key factors in validating the investigation of interest. The aim of the study was to study the influences of locations and constraints of rigid FFC joints on lower limb joints acceleration potentials by gastrocnemius, solues and tibialis anterior.

Patients/ Material and methods: The study used a generic 3D linkage model which was scaled to fit each subject, configured by tracked marker data and driven by 1N muscle force. The dynamic equations were outlined by Zajac and Gordon [1]. Captured motion data from five healthy adults (age: 28±3 yrs) using a motion capture system (Vicon MX40) were imported and analyzed in SIMM Dynamic Pipeline and SD/Fast. COP data was obtained from two forceplates (Kistler). The stance phase was divided into four sub-phases [3]. Comparison 1: The muscle induced accelerations (MIAs) were compared while three joints were fixed to plantar surface of the foot ('fixed joint') (Fig.1) or one joint moved along recorded COP ('moving joint'). Comparison 2: The MIAs were compared while 'simple DOF' or 'multiple DOF' was applied in the 'fixed joint' model (Fig.1).

Sub-phase		1st rocker	2nd rocker	3rd rocker	Toe-off
Ground-foot joint		GFH	GFH, GFM, GFT	GFM	GFT
Rotational DOF	Simple	3	0	3	3
	Multiple	3	0	1 (sagittal)	2 (sagittal&transverse)
Locations relative to foot(top view)					

Results: In Comparison 1, although the magnitudes of joint sagittal plane accelerations in the 'fixed joint' and 'moving joint' models are slightly different, the general trends were similar. The largest difference was found in the tibialis anterior's hip adduction/abduction acceleration potential. In Comparison 2, very limited deviations were found in joints' sagittal plane accelerations, however, some differences can be found in the subtalar eversion/inversion potentials (Fig.2).



Discussion & Conclusion: A FFC model played a particularly important role in IAA since only unit muscle force and corresponding ground reaction force were presented in the dynamic equations. As expected, joints' sagittal plane acceleration potentials were similar in the 'fixed joint' and 'moving joint' models, however differences were found in non-sagittal planes. Differences found in soleus and gastrocnemius' acceleration potentials in 'toe-off' (Fig 2) were probably due to the fact that frontal plane foot rotation was not taken into account in the 'Multiple DOF' constraint (Fig.1). In conclusions, slight deviations were found in lower limb joints' sagittal plane accelerations, however, more pronounced differences were found in the frontal and transverse plane joint accelerations. A comprehensive analysis will help to confirm the conclusions.

References: [1] Zajac FE, et al. Exercise Sport Sci Rev, 1989. [2] Schwartz M et al. Gait Posture, 2003(17). [3] Wang RL et al. Gait Posture, 2011

Disclosure: No significant relationships.

P46

A STUDY TO INVESTIGATE THE RELIABILITY OF COMPUTERISED ANALYSIS OF HUMAN GAIT USING VICON MOTION ANALYSIS SYSTEM

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Introduction: Computerised gait three dimensional gait analysis (3DGA) is increasingly being used as an objective outcome measure for assessment of gait impairment. The purpose of this study was to investigate the intra-rater reliability of 3DGA and develop a normative database for use in a movement laboratory. 3DGA is a technically demanding outcome measure. Reliability of measurements during 3DGA is important to both estimate the magnitude of measurement error and determine minimal detectable change. Most studies investigating reliability of gait analysis have utilised small sample sizes. Each laboratory and rater should investigate reliability for quality purposes.

Patients/ Material and methods: A convenience sample of thirty healthy adults (18F;12M; mean age 30±6.8 years) with no injury or pathology volunteered to participate in the trial.
A test re-test design was employed. Three dimensional kinetic and kinematic data was collected using a 5 camera VICON® 250 system sampling at 50Hz and a Kistler force plate. Fifteen reflective markers were placed on the lower limbs on anatomical landmarks using a standardised procedure. The knee joint axis was determined using knee alignment devices. Subjects were asked to walk along a 10m walkway at their preferred gait speed. Only data from trials containing clean force plate strikes were analysed. Testing was performed by the same investigator on two separate days within a two week period. This tester was experienced in the use of VICON®. Averaged data from 10 trials were used for kinematic variables and 5 for kinetic variables.
Data were processed in VICON workstation and exported to Polygon and Excel. SPSS was used to calculate the intraclass correlation coefficient (ICC), the standard error of measurement (SEM),) and limits of agreement (Bland and Altman). StataSE release 11.1. was used to calculate coefficients of multiple determination (CMD), absorbing the effects of point in gait cycle.

Results: Spatio-temporal parameters such as cadence, step length, velocity, step time, width and were highly repeatable generating ICC's of 0.9 and above. A low standard error of measurement was also obtained for these variables (Cadence; 2.93 steps, Step length; 0.02 cm, gait velocity; 0.06 secs, stride time; .03 secs.) ICCs for Min, Max and range of values across the gait cycle ranged from 0.14→0.92. Range of joint movement across the gait cycle was generally more reliable, than either minimum or maximumvalues, and higher ICCs were obtained for movement in the sagittal plane. For kinematic data the standard error of measurement was low (≤5°) for the majority of parameters with the exception of peak hip rotation (8°) and peak ankle rotation (8°). ICCs for kinetic data followed much the same pattern. CMD's ranged from 0.527 →0.984 (Kinematic graphs) and 0.46→0.9 (Kinetic graphs).

Discussion & Conclusion: Reliability of 3DGA with acceptable ICCs, limits of agreement and low SEMs has been established for our gait laboratory and a normative database of young healthy adults established for comparative use in further studies. Future studies should compare measurements obtained from multiple raters to investigate intra-rater reliability.
This study has provided evidence that reliable data can be obtained by a physiotherapist using 3DGA and has provided estimates of measurement error for use in future studies.

References: The reliability of three-dimensional kinematic gait measurements: A systematic review .
Jennifer L. McGinley, Richard Baker, Rory Wolfe, Meg E. Morris
Gait & Posture - April 2009 (Vol. 29, Issue 3, Pages 360-369, DOI: 10.1016/j.gaitpost.2008.09.003)

Disclosure: No significant relationships.

P47

OBJECTIVE SELECTION OF A REPRESENTATIVE TRIAL OUT OF SEVERAL MOVEMENT ANALYSIS CURVES BY PRINCIPAL COMPONENT ANALYSIS

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Introduction: In movement analysis, the outcomes of the measurements are mainly curves, e.g. joint angles. These data sets are often reduced to either a single curve corresponding to a representative trial or to a mean curve of several trials. This study aimed to develop a computer algorithm for a fast and objective selection of a representative trial for one subject.

Patients/ Material and methods: The Principal Component Analysis (PCA) was computed for every trial of 1841 subjects and 11 specified joint angles derived from three dimensional gait analysis. Subsequent to the median determination of the principal component scores (pc-scores) across all trials, the Euclidean distances of each pc-score (representing one trial of a subject) to the median of the pc-score were computed. Adding the distances of each trial across all angles, the algorithm allows selecting the trial, which - across all angles - is the closest to the median.

Results: Figure 1 shows the joint angle curves of all trials for one subject. The curve printed in bold represents the trial, chosen by the algorithm. In this case the PCA permits the identification of a trial without visible signs of contamination. A visual consistency check for all subjects (n = 1841 for left and right leg each) revealed that the code successfully operated in 98.8% of the subjects.

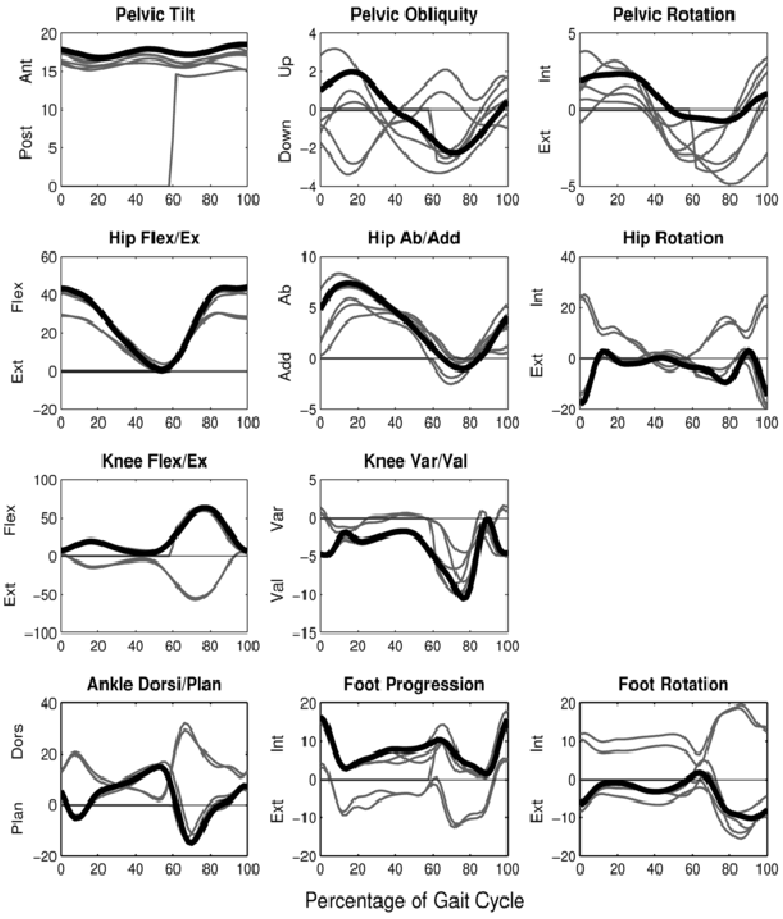

Fig. 1: Joint angle curves in degrees for one subject (7 trials) normalized to 100% of a gait cycle.

Discussion & Conclusion: Rather than choosing a trial visually, as done in many gait laboratories, an application of PCA on a self-selected set of different gait parameters (e.g. kinematic and/or kinetic data) would be more convenient. Even in data sets with many contaminated trials, the PCA filters well for the uncontaminated data. The only restriction of the PCA method occurs when calculating the median if more than half of the data are contaminated. We therefore conclude that the PCA is an effective tool for fast and objective selection of representative trials from a large amount of movement analysis data.

References: [1] Jolliffe, I.T. (2002). Principal Component Analysis. NY, Springer-Verlag. (SNF-Project: 32003B_127534)

Disclosure: No significant relationships.

P48

UNICONDYLAR SURFACE REPLACEMENT AND KNEE INTERPOSITIONAL SPACER IN GONARTHROSIS PATIENTS– EVALUATION OF ONE LEG STANCE IN MID TERM FOLLOW UP WITH BIODEX BALANCE SYSTEM

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Introduction: Gonarthrosis is a widespread diagnosis in the aging population. While typically both the medial and the lateral compartment show destruction, some patients only have unilateral osteoarthritis. In cases with a stable capsuloligamentous apparatus and intact subchondral bone unilateral knee replacements or unicondylar knee interpositional spacers are therapy options for pain relief, correct axial deformities and give a high degree of flexibility and stability while preserving as much of the knee-structures as possible (1). In this study the patients' ability to balance on one leg on a static plate (Biodex Balance System) was evaluated at least 6 months after implantation of an unicondylar sledge prosthesis (US) in comparison to a ConforMIS (iForma) knee spacer (KS).

Patients/ Material and methods: The US group consisted of 20 patients (11 female, 9 male) with unicondylar knee replacement (Depuy, Typ Preservation, all medial compartment) mean follow up 3years 2 months (ranging from 6months to 68months) after the implantation. The mean age was 62 years, mean height 1,68m and mean weight 85,2kg. The spacer group consisted of 20 patients (11 female, 9 male) who had unicondylar knee interpositional spacers (ConforMIS iForma) implanted (18 medial, 2 lateral compartment). Mean follow up was about 60months, mean age was 56,6 years, mean height 1,68m and mean weight 81,9kg. The postural balance was measured by the Biodex Balance System on the operated and the non-operated leg in 3x 10 sec one leg stance on the static plate. The track of the centre of pressure (COP) was recorded during 3 x 10 sec and calculated to a balance index. No normal distribution was found, therefore nonparametrical tests were used (Wilcoxon-test for paired, Mann-Whitney-U-Test for unpaired samples).

Results: In both groups there was no significant difference between the balance index of the operated and non operated leg (1,44 vs. 1,37 for US and 1,20 vs. 1,15 for KS). Although the mean balance index showed slightly better results in the KS-group, the difference between both groups (operated leg only) was also not statistical significant (p=.13).

Discussion & Conclusion: Both therapy options showed nearly equal balance indices. Similar results can be found in literature for comparing uni- to bicondylar surface replacement (2).The fact that there was no difference between the operated and non-operated leg in both groups could be due to either a deficient non-operated leg (eg. beginning osteoarthritis, pain) or that the postural stability training during rehabilitation restored the function of the operated leg. From the functional point of view both therapies result in satisfying balance abilities in mid term follow up.

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Disclosure: No significant relationships.

P49

KINEMATICS AND KINETICS DIFFERENCES BETWEEN NORMAL- AND FLAT- ARCHED FOOT POSTURE DURING LANDING

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Introduction: Leg stiffness during impact phase is important to investigate the association between foot posture and knee joint because of the stiffness represents the ability to attenuate the force and the potential influence on ACL injury. Williamas et al [1] showed that high-arched individual have greater leg stiffness and a higher vertical loading rate during running. Ground reaction force (GRF) and quadriceps force, which are contribute to aggravated risk of sustaining traumatic injuries such as ACL rupture, was increased in erect position during landing. [2] [3] In the studies of gender differences in landing biomechanics, female tend to contact the ground with less stiffened position during landing phase, which is a strategy to minimize the shock absorption and thus minimizes the risk of sustained lower extremity injuries. They suggested that the potential cause stems from the morphological differences. The purpose of this study is was to compare landing lower extremity joint angle, ground reaction force between normal and flat-arched feet.

Patients/ Material and methods: Ten normal- and ten flat-arched female volunteered to participate walk (mean age 25.30Â±3.02 years in the flat feet group and 24.90Â±3.18 years in the normal feet group) in this study. Kinematic variables were collected with eight motion capture cameras (Vicon MX, Oxford Metrics, UK). Tow AMTI force plates were used to collect GRF data. Retro-reflective markers were attached according to the Plug-in-Gait Marker set. The free style landing tasks were performed at landing heights of 0.2, 0.4 and 0.6m.A trial was considered successful when the subject stepped off the platform without an upward and/or forward jump action, and adopted a stable landing posture. One way ANOVA was used to test for differences in peak GRF and knee flexion angles between foot posture and between landing heights. All significance levels were set at p=0.05.

Results:

GRF (% B.W)	Landing height	Flat feet	Normal feet	Landing height	Group	Interaction
F(z)	20	316.30±18.53[a]	316.80±21.50[a]	0.00*	0.02*	0.02*
	40	408.60±13.13[b]	379.30±20.35[b]			
	60†	506.80±22.52[c]	403.20±17.27[c]			

The peak GRF (Table 1) was significantly greater in the flat feet group than in the normal feet group, and the interaction between landing height and group was significant. In subject with flat-arched foot, GRF and sagittal angle significantly increased with landing heights. In particular, hip joint angles at a height of 60 cm were significantly greater.

Discussion & Conclusion: GRF and joint angles in the lower extremities increases more with height in flat footed individuals than in people with a normal foot arch. Flat feet may aggravate the risk of shock on landing from a height; this might be ameliorated by a compensatory strategy at the hip joints to facilitate load distribution.

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Disclosure: No significant relationships.

P50

COMPARISON OF SKILL DIFFICULTY FOR TYPICALLY DEVELOPING CHILDREN AND CHILDREN WITH GAIT IMPAIRMENT USING THE GILLETTE FUNCTIONAL ASSESSMENT QUESTIONNAIRE

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Introduction: Understanding differences in typically developing children (TDC) on outcome measures used for children with disabilities is important to accurate interpretation. The item-level properties of the 22 item skill-set of the Gillette Functional Assessment Questionnaire (FAQ) in children with gait impairment[1] (GIC) and a description of skill abilities in TDC[2] have previously been reported. Whether it is valid to compare the two is controversial. Understanding whether skills represent a similar level of difficulty for TDC and GIC even though the attainment of the skill may occur at a different point in development is important. The purpose of this study is to compare the order of skill difficulty for typically developing children to those with gait impairment on the 22-item skill set of the FAQ.

Patients/ Material and methods: A restrospective review of FAQ data of 810 typically developing children with no co-morbidities and 485 children with gait impairment was conducted. TDC data were obtained from 25 child-care, hospital, or home-school settings. Children with gait impairment had undergone first time gait analysis in a tertiary specialty care setting; 289 GIC had a diagnosis of cerebral palsy; 196 had other neuromusculoskeletal diagnoses. All data were obtained by proxy report. Factor and Rasch analyses were used to characterize the dimensionality, and item level characteristics of each dataset (TDC and GIC) separately, and as a combined dataset. Differential item functioning (DIF) was assessed by calculating item difficulty differences based on sex in the combined dataset. Differences based on age and diagnosis were also calculated in the GIC dataset. The differences between mean person-ability scores of groups by FAQ-WL were tested using ANOVA.

Results: Model fit statistics indicate improved fit when the datasets are analyzed separately vs. a combined dataset. In the TDC dataset there were no statistical differences between FAQ-WL 1-3 (pre-ambulation), 4-5 (non-community), or 6-7 (limited community). All other levels show statistically different ability levels. The combined dataset indicated DIF based on group (TDC vs. GIC) in 13 of the 22 skills. When analyzed separately there were no differences based on sex in the TDC dataset and only for the “jump rope” item in the GIC dataset. Four items in the GIC dataset were more difficult than predicted by the model for children with a diagnosis of cerebral palsy than children for other diagnoses. The Rasch-based item difficulty rank order (easiest to hardest) was different between the TDC and GIC datasets (Table 1). Two of the three easiest items were the same and the five most difficult skills were the same, but in a slightly different order. The most discrepant skills were “runs”, “runs with control”, “walks up/down stairs with a railing”, “steps up/down curb”, and “ride a 3-wheel bike”.

Table 1: Rasch Derived Rank Order of Skills:

Skill	TDC	GIC
walks carrying an object	1	2
runs	2	11
manuever in tight areas	3	3
step over object R foot	4	6
step over object L foot	5	7
runs well w/control	6	16
kick ball R foot	7	8
walks up/down stairs with railing	8	1
step backward	9	5
kick ball L foot	10	10
step up/down curb	11	4
jump off single step	12	14
walks carrying a fragile object	13	12
walk up/down stairs w/o railing	14	17
ride 3 wheel bike	15	9
on/off escalator w/o help	16	15
on/off bus	17	13
hop right foot	18	19
hop left foot	19	18
ice skate/roller skate	20	22
ride 2 wheel bike	21	20
jump rope	22	21

TDC: Typically Developing Children;
GIC: Children with Gait Impairment
Easiest Skill (1); Most Difficult Skill (22).

Discussion & Conclusion: The rank order of FAQ skill difficulty is different between TDC and GIC, suggesting magnitude of skill difficulty may also be different. The two groups cannot be directly compared. Differences should be more thoroughly explored. Rank order of difficulty matches a typical developmental sequence for TDC.

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Disclosure: No significant relationships.

P51

WALKING ABILITY AND ENERGY EXPENDITURE IN POST-STROKE PATIENTS WITH A ANKLE-FOOT ORTHOSIS

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Introduction: In stroke, around 70 to 80% of patients regain walking function within a few months, although residual hemiparesis often involves an asymmetrical gait pattern. In particular, an ankle-foot orthosis (AFO) is used to correct spastic drop foot or equinus foot, which are both commonly seen in spastic stroke–related hemiparesis. Physical inactivity after stroke may contribute to cardiovascular and metabolic deconditioning, muscle weakness, and associated declines in physical and social functioning. The purpose in this study was to compare the gait velocity and gait energy cost on floor walking with and without a plastic AFO, and to investigate the cardiovascular and metabolic fitness variables in chronic stroke patients with hemiparesis.

Patients/ Material and methods: Participants were 12 hemiparetic patients with a stroke at least 6 months earlier (10 male and 2 female: 47±8 years old). An ambulatory activity test was performed which involved walking for a total of 6 minutes at a self-selected speed with or without AFO. Before walking, each subject was fitted with a portable gas analyzer (VE2000 System :Medical Graphics Co.Ltd, USA) programmed for metabolic analysis through indirect calorimetry. The rate of oxygen consumption (VO_2 in $mL \cdot min^{-1}$), minute ventilation ($L \cdot min^{-1}$), metabolic equivalent (METS), and heart rate (HR) in beats per minute (bpm) were continuously monitored during the 6-minute walking trial. The Physiological cost index: PCI ($beats \cdot m^{-1}$) was calculated by dividing the difference between the steady-state walking and resting heart.

Results: Walking speed: with and without AFO 27±11 vs 23±11m/min, difference 20% ($p<0.05$). Oxygen consumption: with and without AFO 11.8±2.0 vs 12.0±1.9ml/kg/min. Physiological cost index (PCI): with and without AFO 1.2±0.5 vs 1.6±0.8 beats/m ($p<0.05$). Energy expenditure cost: with and without AFO 0.6±0.3 vs 0.4±0.2 ml/kg/m ($p<0.05$). Conclusion: Use of AFO in patients with post-stroke may increase walking velocity and decrease energy cost during walking.

Discussion & Conclusion: AFO may decrease energy demands and have physiologically energy efficiency in walking-in stroke patients and these obtained results in this study suggest that a stroke hemiplegia patient with motor disorder can improve gait ability by wearing AFO and also lower the energy consumption while waking.

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Disclosure: No significant relationships.

P52

THE MOVEMENT ANALYSIS PROFILE AND GAIT PROFILE SCORE IN PATIENTS WITH PARKINSON'S DISEASE DURING DUAL TASK.

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Introduction: The Movement Analysis Profile (MAP) and the Gait Profile Score (GPS) have been used that summarizes the overall deviation of kinematic gait data relative to normative data. The MAP describes the magnitude of deviation of the nine individual variables averaged over the gait cycle.This study considered the suitability of the MAP/GPS for use in patients with PD during DT. The study investigated the use of MAP/GPS in patients with Parkinsonâ€™s disease (PD) during the dual task (DT).

Patients/ Material and methods: Fourteen patients with diagnosis of idiopathic PD (PDG) and nine healthy subjects (CG) participated in the study. All the subjects walked at comfortable speed under two baseline conditions: walking free (WF) and walking with dual task (WDT) (arithmetic subtraction regressive test). The kinematics data were collected using 3DGA VICON MX 40 system (Oxford Metrics Group; UK) from a minimum of six trials per subject. The MAP was calculated for the pelvis, hip, knee and ankle in the sagittal plane, pelvis and hip in the frontal plane and pelvis and foot in the transverse plane. For the statistical analysis, the wilcoxon matched-pairs signed test was used to compare WF and WDT in PDG and CG. The probability (p) smaller than 0.05 was considered to indicate statistical significance.

Results: The mean MAP/GPS scores for each variable are summarized in Table 1. GPS show differences in both groups. Concerning the MAP, there were significant differences in PDG (WF x WDT) on hip flexion/extension, adduction/abduction only left side and rotation only right side, knee flexion/extension in both side and foot progression in the left side. In the CG (WF x WDT) we observed statistical significance on hip adduction/abduction in right side, knee flexion/extension, ankle dorsi/plantar flexion right and foot progression in the left side. The largest deviations were seen at the hip and knee in the sagittal plane.

Table 1 – The MAP/GPS score in CG and PDG during WDT

Group	Tilt pelvic	Hip flex		Knee flex		Ankle flex		Obli pelv	Abd hip		Rot pelv	Rot hip		Prog foot		GPS		GPS
	ALL	L	R	L	R	L	R	ALL	L	R	ALL	L	R	L	R	L	R	ALL
CG (9)	0.5703	0.7962	0.8633	0.0039	0.008	0.055	0.0039	0.0547	0.5703	0.0391	0.4258	0.3594	0.0742	0.0195	0.9102	0.0039	0.0039	0.0039
p	ns	ns	ns	**	*	ns	**	ns	ns	*	ns	ns	ns	*	ns	**	**	**
PDG(14)	0.6257	0.0009	0.0001	0.0067	0.007	0.058	0.058	0.1726	0.0085	0.8077	0.6257	0.2958	0.0107	0.0166	0.4631	0.0001	0.0012	0.0002
p	ns	**	***	*	*	ns	ns	ns	*	ns	ns	ns	*	*	ns	***	**	**

*Abbreviations: CG = control group; PDG = Parkinson's disease group; ALL = Overall; L = left; R = right; *p≤0.05; **p≤0.005; ***p ≤0.0001; ns = not significant.*

Discussion & Conclusion: Using this approach it has been possible to verify different compensation strategies adopted by PD and health subjects during DT interference. Our results showed that the GPS/MAP were effective not only to give a global overview of the gait deviation respect to normality, but also to illustrate quantitatively the overall changes in pathological walking as a result of a particular DT interference. Elements of the MAP differentiated during gait with cognitive task. We propose that the GPS and particularly its MAP decomposition may be useful for clinical practice and provide information about the changes in movement pattern. The MAP demonstrated change in hip flexion/extension and knee flexion/extension during the DT.

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Disclosure: No significant relationships.

P53

CHANGES IN CONFIGURATION OF FOOT JOINTS DURING ANKLE DYNAMOMETRY OF CHILDREN WITH SPASTIC CEREBRAL PALSY: A PILOT STUDY

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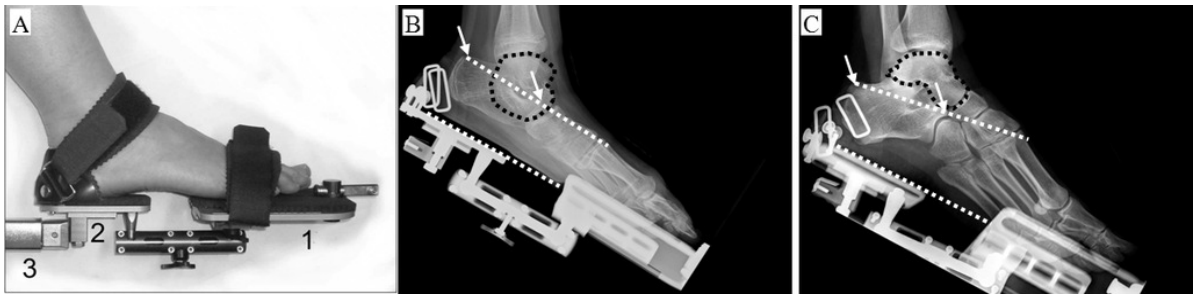
Introduction: Children with spastic cerebral palsy (SCP) are often impaired by a reduced range of motion (ROM) of the ankle joint [1]. Studying variables related to passive ankle ROM in these children can be done by ankle dynamometry [1,2]. This allows for estimating ankle angle and moment, and for relating these estimates to muscle length of the triceps surae (TS). This is likewise for active TS function using gait analysis. However, such relations will only be valid when, movement of the calcaneus (TS insertion) is fully prescribed by movement of the foot. As it has been suggested that this is not always true [2], we aimed to study foot joints for various ankle joint angles under passive loading in SCP children.

Patients/ Material and methods: One child with bilateral SCP (13 y, 60 kg, tibia length: 38 cm) and one typically developed (TD) adult (28 y, 65 kg, tibia length: 37cm) participated. Two lateral X-ray images were made of the foot with subjects lying on the side. A foot-fixation (used for dynamometry [1], Fig. A) was attached to the foot and images were made at footplate angles corresponding to those measured in prone position at 0 Nm (neutral) and +4 Nm (dorsal flexion). The angle between calcaneus and footplate was measured in these images. The orientation of the calcaneus was taken as a line between the most craniodorsal point of the calcaneus and the most cranial point of the anterior articular surface of the subtalar joint [2].

Results: The X-ray images show three important results: 1) within the subtalar joint of the SCP child, the talus was rotated medially with respect to the calcaneus (Fig. B, black dotted line), instead of its normal cranial position found in the TD adult (Fig. C), 2) for the footplate held at neutral, the talo-calcaneus complex was oriented such that the calcaneus was almost parallel to the footplate (i.e. the angle between calcaneus and footplate being -2°), compared to the inclined position in the TD adult (i.e. +9° Fig. C), 3) in the SCP child, when the footplate was dorsal flexed by 19°, the angle between footplate and talo-calcaneus complex decreased by 7.5° (not shown). This relative plantar flexion of talo-calcaneus complex constitutes 39% of dorsal rotation of the footplate. For comparison, in the TD adult, when the footplate was dorsal flexed by 23°, the angle between footplate and talo-calcaneus complex decreased by 2° (i.e. 9% of dorsal rotation of the footplate, not shown).



Discussion & Conclusion: X-ray imaging shows that during dynamometry measurements of foot and ankle of a child with SCP, compared to a TD adult, foot deformities, and especially the orientation of the calcaneus within the sagittal plane, gives a biased view on the relation between footsole and the TS length. In loaded conditions this foot deformity gets even more pronounced. These results are important to consider when TS function is concluded from footsole orientation, like in common gait analysis and physical examination.

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Disclosure: No significant relationships.

P54

ACTIVITY OF MUSCULUS TRICEPS BRACHII WITHIN POSTERIOR PLATFORM TRANSLATION IN HEALTHY SUBJECTS

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Introduction: Protective automatic reactions to unexpected displacements are multi-segmental [1]. One of the mechanisms to avoid falling on uneven surfaces is the involvement of the upper extremities [2]. The purpose of our study was to assess postural strategies in healthy subjects within unexcepted posterior platform translation in the standing position. The association between upper limb muscle activity (m. triceps brachii - TB) and center of pressure positioning (COP) in the mediolateral direction was evaluated.

Patients/ Material and methods: Postural reactivity to backward translation was assessed in eleven healthy subjects (age 50.9 ± 7.2 years, height 183.2 ± 6.3 cm, weight 84.8 ± 12.1 kg). Within the postural reaction to the translation simultaneously were measured both the position of COP (NeuroCom) of the whole body as well as the activity of TB by surface electromyography (Delsys). The relation between COP excursion in the mediolateral direction, and the difference in activity of the left and right TB was assessed by applying the Spearman rank correlation coefficient (Statistica, version 9.0).

Results: There is a correlation between the excursion of COP to the right or left side, and higher activity of TB on the homolateral side, within unexpected posterior platform translation (r=0.76).

Discussion & Conclusion: Movements of the upper limbs during bipedal locomotion are induced by the pripriospinal neuronal linkage of the cervical and thoracolumbar spinal cord [3]. TB is active during a fast gait and is manifested through the extension of the upper limb within the swing phase of ipsilateral lower limb [4]. To follow our results, TB is also active during postural reactions to prevent falls. Supposedly, the propriospinal circuits of the upper and lower limbs are also active in situations requiring balance. The findings showed postural asymmetries in healthy subjects during balance reactions due to the preferential positioning of their COP to the left or right side (independent of lower limb dominance). We conclude that the excursion of COP in the mediolateral direction during the translation of the platform is related to increased activity of homolateral TB. These results may assist in further understanding motor control mechanisms.

Aknowledgements
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P55

PATHOLOGICAL GAIT OF PATIENTS WITH MUSCULOSKELETAL INJURIES AFTER POLYTRAUMA

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Introduction: The functional result of polytrauma patients is important long term process. To assess the functional result of polytrauma patients with musculoskeletal injuries we used instrumented gait analysis. We analysed the gait changes of these patients in order of New Injury Severity Score (NISS).

Patients/ Material and methods: Retrospective analysis of 154 polytrauma patients with musculoskeletal injuries treated in two Riga hospitals during 2008 – 2010 year period was made. The New Injury Severity Score and Injury Severity Score values for these patients were calculated. The evaluation of functional recovery of 16 polytrauma patients with musculoskeletal injuries was performed in 4 – 13 months after polytrauma using instrumented gait analysis. We evaluated kinematic parameters (motions in pelvis and lower extremities joints in sagittal plane) of gait cycle.

Results: 12 patients had increased anterior pelvic tilt, 3 patients had increased posterior pelvic tilt, 1 patient had asymmetric pelvic motion during gait cycle. 7 patients had limited extension in both hip joints, 3 patients had limited extension in hip joint of most seriously injured side, 1 patient had excessive extension in both hip joints, 5 patients had normal hip joint motion during gait cycle. 8 patients had persistent flexion in both knee joints, 3 patients had persistent flexion in knee joint of most seriously injured side, 2 patients had excessive extension of most seriously injured side, 3 patients had normal knee joint motion during gait cycle. 5 patients had limited dorsiflexion in ankle joint of most seriously injured side, 2 patients had limited plantar flexion in both ankle joints, 3 patients had limited plantar flexion of most seriously injured side, 6 patients had normal ankle joint motion during gait cycle. 13 patients had correlation of pathological changes of gait with NISS, 3 patients had not correlation between pathological changes of gait and NISS.

Discussion & Conclusion: Our study gives preliminary indication that the pathological changes of gait correlates with NISS in polytrauma patients with musculoskeletal injuries and possibility to identify primary and secondary functional changes which can not be diagnosed with clinical examination methods.

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Disclosure: No significant relationships.

P56

RECTUS FEMORIS SPASTICITY IN PATIENTS WITH CEREBRAL PALSY

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Introduction: Foot clearance in swing phase is one of the basic prerequisites of normal gait. Aim of the study is the objective and dynamic documentation of the knee kinematics in ambulatory children with spastic cerebral palsy and the examination of possible causes of differences when compared to normals.

Patients/ Material and methods: 23 ambulatory patients with an average age of 10,8 years (6-17 years) with cerebral palsy, spastic diplegia where examined clinically including Duncan-Ely test. They were also examined with 3-D instrumented gait analysis. The Elite system with six cameras was used and the knee kinematics in the sagittal plane was recorded.

Results: Almost all patients (21/23) had a positive Duncan-Ely test during clinical examination. The knee kinematics in the sagittal plane showed that in 28/46 knees the range of motion was decreased compared to normal values. In 41/46 knees there was a delayed maximum knee flexion in swing phase and in 22/46 knees the amplitude of the maximum knee flexion was decreased compared to normals. Patients with severe crouch or mild rectus spasticity had almost normal knee flexion.

Discussion & Conclusion: Patients with spastic cerebral palsy who are able to walk have an impaired foot clearance because of the pathological action of the rectus femoris. In our study the majority of the patients with clinically confirmed rectus spasticity had decreased timing and amplitude of max. knee flexion in swing. In patients with severe co-contraction of the knee flexors and extensors the max. knee flexion was within normal range. Therefore max. knee flexion in swing should not be considered as a specific evaluation parameter in rectus femoris spasticity.

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Disclosure: No significant relationships.

P57

SPASTICITY CAN BE QUANTIFIED DURING PASSIVE MUSCLE STRETCH IN AN OBJECTIVE AND REPEATABLE WAY BY INTEGRATING ELECTROPHYSIOLOGICAL AND BIOMECHANICAL SIGNALS.

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Introduction: Current clinical measures of spasticity lack the accuracy and sensitivity that is needed to provide clinicians with quantitative data[1]. The aim of this study was to investigate the repeatability of a non-invasive, portable muscle tone measurement device which integrates signals to measure spasticity in the med. hamstrings (MEH) and gastrocnemius (GAS) in children with spastic cerebral palsy (CP).

Patients/ Material and methods: Nine children with spastic type of CP (age 5.3-16.1yrs, GMFCS I-III, 6 hemi-, 3 di, 1 quadraplegia) were tested on two occasions within a four week period. The MEH and GAS were tested in supine position by passively moving the knee or ankle joint through the full ROM during five seconds (V0), one second (V1) and as fast as possible (V2). Three repetitions were performed at each velocity with 7 seconds of rest between repetitions.
Joint angles, angular velocity and acceleration were measured using inertial measurement units (IMUs). Reactive resistance was measured using a 6 DoF force transducer and muscle activity of the agonistic and antagonistic muscles using surface EMG (sEMG). Data was recorded with a custom-made Labview application (National instruments). EMG parameters were calculated at each velocity during a zone starting 200ms prior to the time of maximum velocity and ending when 90% of the ROM was reached (Zmaxvel). To calculate the normalized average, the amount of sEMG (area under the rms EMG-time curve) was divided by the time and expressed as a percentage of maximum voluntary contraction (MVC). The following parameters were calculated (custom-made software Matlab®): the average amount of sEMG, torque at pre-defined angles (10° dorsiflexion and 70° knee flexion) at each velocity, the difference in the average amounts of sEMG and in torque between V2 and V0. Within session repeatability was calculated with ICCw(1,1), based on single data; between session repeatability with ICCb(1,k), using averaged data[3]. The standard errors of measures and smallest detectible differences were calculated from one way ANOVA.

Results: All parameters explored had moderate to high repeatability between and high repeatability within sessions[2] (Table 1). In general, EMG parameters are more repeatable than torque parameters. The MEH has more repeatable results for change parameters than the GAS. Table 1: Between- and within-session ICC in CP group (n=9)

	Between/Within Session					
	MEH			GAS		
Velocity	**V0**	**V1**	**V2**	**V0**	**V1**	**V2**
sEMG Zmaxvel	0.8/0.95	0.9/0.98	0.8/0.99	0.97/0.96	0.9/0.9	0.9/0.9
Torque	0.6/0.93	0.7/0.98	0.7/0.96	0.57/0.98	0.68/0.9	0.5/0.97
sEMG Zmaxvel (V2-V0)	0.77			0.5		
Torque (V2-V0)	0.86			0.49		

Discussion & Conclusion: In conclusion, this study showed that electrophysiological and biomechanical parameters can objectively and repeatedly quantify spasticity in the MEH and GAS in children with spastic CP. Methodological improvements to the torque measurements may further increase repeatability and assessments of inter-rater repeatability is needed to further verify these initial findings.

References: 1. Fleuren et al. (2010), Journal of Neurology, Neurosurgery and Psychiatry, 81(1):46-52. 2. Katz et al. (1992), Med Care, 30: 917-925

Disclosure: No significant relationships.

P58

THE RELATION BETWEEN GAIT STABILITY AND ECONOMY IN HEMIPARETIC GAIT.

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Introduction: Stroke patients frequently suffer from a unilateral paresis which impairs their walking ability. It has been established that hemiparetic gait is less economic compared to normal gait [1]. Additionally, balance control is affected after stroke, which affects gait stability and increases fall risk [2,3]. Although these gait impairments are often considered independently, both could well be inter-related [4]. To test this we investigated the effect of balance support on metabolic energy cost and step parameters related to gait stability in hemiparetic gait.

Patients/ Material and methods: Fifteen stroke patients (age 58±12 y, time since injury 1-115 months, FAC 3-5) and thirteen age-matched control subjects performed two four-minute walking trials at comfortable walking speed on a motorized instrumented treadmill (Forcelink, the Netherlands). In one trial they walked unsupported. In the other trial they were allowed to use the handrail of the treadmill for support without excessive weight bearing. During both walking trials metabolic energy cost ($J \cdot kg^{-1} \cdot m^{-1}$) was derived from open circuit respirometry (Oxycon Delta, Jaeger, Germany). Step characteristics were derived from the center of pressure profiles recorded with a forceplate embedded in the treadmill.

Results: Comfortable walking speed was significantly lower in stroke patients compared to controls (0.59±0.30 vs. 1.2±0.19 $m \cdot s^{-1}$). Energy cost of walking was two-fold higher in stroke patients compared to controls (Fig. 1). Providing support had a significantly larger effect on stroke patients. Stroke patients experienced a 15.6% reduction in energy cost against 3.9% for controls. The reduced energy cost during the support condition in the stroke group, coincided with a significant decrease in cadence, step width and step length asymmetry and an increase in stride length.

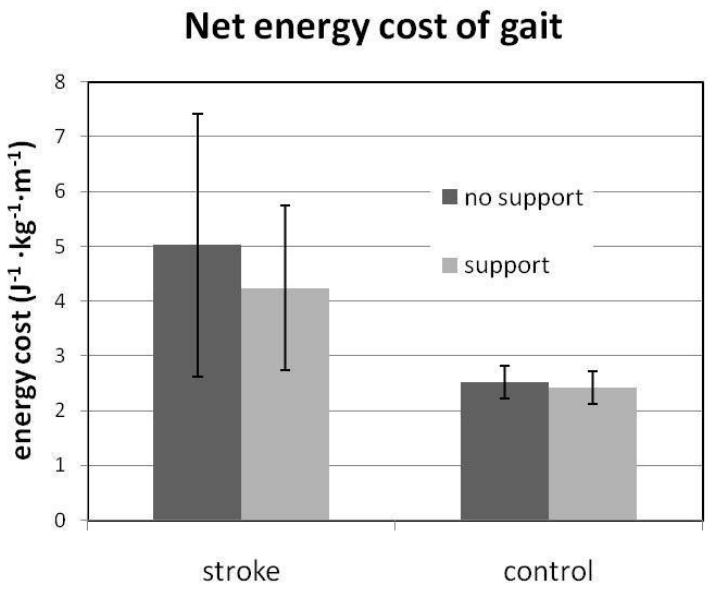

Fig 1: metabolic cost during supported and unsupported walking in stroke patients and controls

Discussion & Conclusion: Despite large heterogeneity in the stroke group, providing tactile support significantly reduced energy cost of walking in stroke patients. On average this reduction amounts to one third of the increase in energy cost in stroke patients relative to healthy control subjects. Hence, the effort for balance control seems to explain a substantial part of the reduced economy of hemiparetic gait. Providing handrail support increased stride length and reduced cadence, step length asymmetry and step width. These adaptations are all associated with improved gait stability [5]. Apparently, providing handrail support reduces the demands imposed on these step characteristics to control stability and allows stroke patients to adopt a step pattern closer to the energetic optimum. It is concluded that the increased energy cost of hemiparetic gait can be partly attributed to the increased effort for balance control. Providing manual external support (and possibly also other ways of balance training or support) not only enhances gait stability and reduces fall risk but can also improve walking economy and reduce fatigue.

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P59

THE BIOMECHANICS OF THE REACHING MOVEMENT IN FRIEDREICH AND STROKE PATIENTS.

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Introduction: Friedreich patients (FPs) present impaired coordination ability and muscle weakness. Upper-extremity movements against gravity are soon compromised and, consequently, the patient's autonomy is significantly reduced. Impaired joint torque production is reported in the literature both in cerebellar and stroke patients (SPs) and is considered a prominent cause of inability to perform activities of daily living [1, 2]. In this study the biomechanics of the reaching movement against gravity is analyzed and the different motor control and compensatory strategies of FPs and SPs are compared.

Patients/ Material and methods: Participants. A group of 8 FPs (42±15 years, 3 males), a group of 8 high functioning SPs (49±12 years, 4 males, 3 left hemiparesis) and an age-matched group of 8 healthy control subjects (HCs) (42±15 years, 3 males).
Equipment. A 8 TVC optoelectronic 3D system (Elite, BTS, Italy).
Study Design. Patients seated on a stool or on their wheelchair performed 12 reaching movements at self selected speed. The upper-extremity kinematics was calculated using a five markers setup [3]. Joint torques and powers were calculated through inverse dynamics.
Dependent measures.
Movement duration, joint angles and torques, a coefficient of movement repeatability, normalized jerk (an indirect measure of inter-limb coordination) [3] and the shoulder equivalent angular impulse (a quantity derived from classical mechanics and here used to evaluate the global subject effort).
Statistics. Mann-Whitney U test.

Results: All patients but one were able to perform 12 complete movements (full elbow extension and shoulder flexion), 1 FP completed 5 movements only due to fatigue.
Movements performed by FPs and SPs were statistically significant slower than those of HCs. Both FPs and SPs compared to HCs showed a statistically significant reduction in inter-joint coordination and repeatability. Both groups also presented a statistically significant increase in the mean and maximum shoulder torque and in the shoulder equivalent angular impulse. With regard to the comparison between the two patients' groups, as FPs anticipated the elbow extension, a statistically significant difference in the elbow angle at 75% of the reaching movement was found. Even if SPs generally performed better than FPs no other statistically significant difference was found probably due to the heterogeneity of the two groups.

Discussion & Conclusion: It is well known that slower movements are more fatiguing than the faster ones as they are less efficient [4]. Both FPs and SPs are unable to efficiently convert the rotational kinetic energy into the potential one thus reducing the maximum shoulder torque. SPs partially reduce the global effort by postponing the elbow extension (and reducing the extension at the end of movement) while, on the contrary, FPs increase the global effort by anticipating the elbow extension.
On the basis of these results it seems that patients with an involvement of the extrapyramidal system have more difficulties than SPs in controlling joint torque. More studies should be done to confirm these findings and try to gain insight the different motor control mechanisms.

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P60

ARMSWING DURING WALKING IN PERSONS WITH STROKE: A PILOT STUDY

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Introduction: Three-dimensional (3-D) motion analysis provides complex kinematic data of gait that may be summarized by different indexes [1, 2]. The so-called Arm Posture Score (APS) has recently been developed and implemented to quantify arm movements during walking in spastic hemiplegic cerebral palsy [3]. The aim of our pilot study was to investigate if the APS is applicable to persons with stroke and to explore further methodological development such as implementing rotation variables.

Patients/ Material and methods: The gait pattern of two persons (49 y and 51 y) with chronic left hemiparesis following stroke and healthy controls was assessed with an 8-camera 3-D motion capture system (240 Hz, Oqus®, Qualisys Gothenburg, Sweden). Thirty-two spherical reflective markers were placed on the following anatomical landmarks: the spinal processes of C7; the jugular notch of sternum, the midpoint of the clavicles; and bilaterally on acromions; upper arms (cluster with four markers), lateral and medial epicondyle of humerus; styloideus radius; styloideus ulna, distal dorsal part of the forearm; heads of the second and the fifth metarcarpales; and on the anterior and posterior iliacal spines. Segments included the thorax, upper and lower arms, and the hands. Participants walked 10 m at a self selected speed four times. Calculations of four variables (shoulder flexion/extension, shoulder abduction/adduction, elbow flexion/extension, and wrist flexion/extension) were performed [3]. A higher APS score indicates a larger deviation from normal. In addition, two rotation variables of the arm (internal/external rotation and pronation/supination) were calculated. All data was filtered at 15Hz with a critically damped digital filter and processed in the software Visual 3D (C-motion Inc., Germantown, MD, USA).

Results: The APS, based on four variables, were calculated for each participant. Preliminary data indicate markedly higher APS values and deviations in the rotation variables in the involved arm of the persons with stroke compared to the non-involved arm and in comparison to healthy persons.

Discussion & Conclusion: Clinical observation tests are often lacking in quantifying upper extremity abnormality during gait in stroke rehabilitation. However, the 3D gait analysis has made it possible to develop comprehensive objective measures of arm swing during gait. The present results verify the earlier proposed use of APS to discriminate between an impaired gait pattern with regard to arm movements for subjects with neurological involvement of the upper extremity compared to healthy controls [3]. Thus, the APS may be used to target the deviation in arm swing after stroke and the additional quantification of rotation component seems valuable but needs to be verified in larger populations.

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Disclosure: No significant relationships.

P61

EVALUATION OF POSTURAL STABILITY AFTER RECONSTRUCTION OF ANTERIOR CRUCIATE LIGAMENT (ACL) IN JUVENILES USING BIODEX BALANCE SYSTEM

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Introduction: The number of ruptures of ACL in adolescents is increasing during the last years[1]. The management of tearing out of the ligament at the point of insertion is standardized. Compared to this operative treatment of intraligamentous ruptures is a controversial issue. Cases with damaged epiphyseal cartilage and consecutive disturbance of growth were described. Neither conservative treatment showed satisfying results.
Containing a lot of receptors rupture of ACL causes both a mechanical and functional instability. These changes are expressed in an alteration of sensorimotor function. There are several studies concerning recovery of sensorimotor function in adults after ACL-reconstruction[2] but no one dealing with juvenile ACL-reconstruction. Therefore in our study was evaluated if juvenile ACL-reconstruction causes restitution of proprioceptive and neuromuscular control of the knee joint. As basis for comparison the contralateral leg and a control group were examined.

Patients/ Material and methods: The patient group consisted of 18 patients (8 female, 10 male); average age 17.44years, average height 1.71m, average weight 66.27kg. Mean follow-up was at 44 months.
The control group consisted of 18 adolescents (8/10), (17.39years, 1.73m, 65.65kg). Patients completed the IKDC-score and the KOOS-score and underwent clinical examination. Postural stability was measured by Biodex Balance System. The patient had to balance on one leg on the circular platform for 3x30 seconds in two different levels. Simultaneously EMG was recorded.
The obtained data were fed into SPSS. Due to missing normal distribution non-parametric tests were used (Wilcoxon-test for paired, Mann-Whitney-U-Test for unpaired samples). For comparing different mean values the Friedmann-Test was used. Mean scores were treated as statistic significant if $p \leq 0,05$.

Results: Patients achieved excellent results in both scores compared to reference date of general population and other studies[3]. Using the Biodex-Stability-System neither in bilateral comparison nor in comparison between patients and probands significant differences could be detected. There was only little correlation between Biodex-indeces and muscle activity in both groups proofing that deficient postural stability can't be improved by additional muscle activation.We could proof a more of muscle activity in healthy probands when performing the test at the most instable level due to experiences about proprioceptive training of ACL-patients during postoperative rehabilitation.

Discussion & Conclusion: In our study we could proof, that adolescents after ACL-reconstruction neither bilateral nor in comparison with probands show any statistic significant differences in postural stability and neuromuscular activity. Sensorimotor function at the knee joint as measured in our trial was completely working. This allows the conclusion of a reinnervation of the transplant. Result of our study is, that -beside of the aspect of mechanical stability-sensomotoric control is recovered. Due to the good results of ACL-Reconstruction in juveniles this operation should be recogneized as standard treatment performed by an experienced surgeon.

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P62

CHANGES IN GAIT KINEMATICS AND KINETICS ASSOCIATED WITH STRUCTURAL JOINT DEGENERATION IN KNEE OSTEOARTHRITIS

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Introduction: The pathomechanics of knee osteoarthritis (OA) are still not well understood, but it has been suggested that mechanical factors are implicated in the progression of knee OA. Several studies of knee OA have characterized changes in joint kinematics and kinetics during gait. However, only a few studies have attempted to capture how these gait changes relate to disease progression. These studies focused primarily on the knee adduction moment. It is still not clear which other gait kinematics and kinetics are related to structural joint degeneration.
In this cross-sectional study we studied the kinematic and kinetic changes around hip, knee and ankle during gait for subjects with different levels of structural severity of knee OA.

Patients/ Material and methods: Nineteen persons with moderate knee OA (Kellgren-Lawrence (K/L) grade 1 or 2) and nine persons with severe knee OA (K/L grade 3 or 4) participated. Seventeen persons without knee pain and radiographic evidence of knee OA (K/L grade 0) comprised a healthy control group. Hip, knee and ankle kinematics and kinetics during gait were calculated from three-dimensional motion analysis and were assessed in the moderate group (N=26 knees), severe group (N=12 knees) and control group (N=28 knees). Differences in kinematics and kinetics were examined using ANOVA.

Results: The results show that the severe knee OA group has less hip extension during late stance compared to the control and moderate group. There is a trend of a decrease in hip adduction during stance in patients with severe OA compared to those with moderate knee OA and in patients with moderate knee OA compared to controls. Patients with severe OA exhibited significantly less peak hip adduction during stance compared to controls. There is a trend of decreased peak hip adduction moments during stance in patients with severe OA compared to controls.
No significant differences in knee kinematics and kinetics were found between severe OA and controls during stance, except for an increase in knee flexion during late stance. Patients with moderate OA, however, showed more knee adduction and an increase in peak knee adduction during stance compared to controls. The peak knee adduction moments during stance were also significantly increased in patients with moderate OA compared to controls.
Around the ankle joint, there is a trend of decreased peak ankle dorsiflexion during stance with progressive structural joint degeneration. Patients with severe OA have a significant decreased dorsiflexion moment compared to patients with moderate OA.

Discussion & Conclusion: Individuals with severe structural joint degeneration demonstrate mainly differences in hip kinematics and ankle kinetics compared to asymptomatic individuals with no structural joint damage and/or compared to patients with less structural joint degeneration. Except for knee flexion, no differences were found in knee kinematics and kinetics in patients with severe joint damage compared to those with less or no joint damage. Patients with moderate joint degeneration however do show significant changes in knee kinematics and kinetics compared to those with no joint damage.
In this pilot trial, more structural joint degeneration appears thus to affect hip and ankle kinematics and kinetics more than kinematics and kinetics of the knee.

References:

Disclosure: No significant relationships.

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PLANTAR ROLL-OVER PATTERNS OF OBESE AND DIABETICS – A MULTIVARIATE APPROACH

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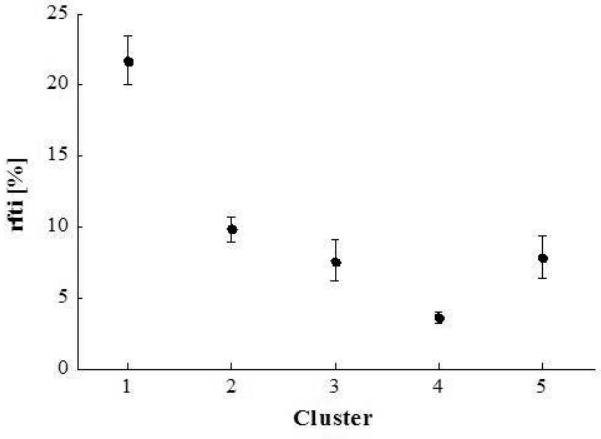
Introduction: SUMMARY The purpose of this study was to clarify whether patients with diabetes mellitus and/or obesity people have characteristic multivariate roll-over patterns (ROP) quantified by plantar pressure distribution. Results of a cluster analysis using relative loads (rfti) of 6 anatomical plantar areas showed specific ROP for class III obese people (BMI > 40kg/m²). INTRODUCTION Analysis of plantar pressure parameters between healthy subjects and patients with diabetes and/or obesity carried out by univariate approaches often suggest differences in discrete plantar loading variables between these groups[1,2]. However, it is sparsely examined if multivariate ROP of patients with diabetes and/or obesity differ from those of healthy subjects. Several studies demonstrated successful multivariate approaches to classify pressure distribution data into ROP during barefoot walking[3] and running[4].

Patients/ Material and methods: 328 subjects (f=170, m=158; 38yrs ±16) participated in this study. A BMI of greater than or equal to 30kg/mÂ² classified 108 individuals as obese (O). 75 subjects were diagnosed with type 1 or type 2 diabetes (D). 25 subjects had an abnormal perception (P) of vibration and touch (128Hz Rydel-Seiffer, 5.07 Semmes-Weinstein). Plantar pressure data were captured by a capacitive pressure distribution platform during walking (Zebris FDM, Isny, Germany). Anatomical sub-areas were identified as described by Maiwald et al. (2008)[5]. Peak pressure (pmax) and rfti were calculated for 6 sub-areas (heel, midfoot, lateral-, middle-, medial-forefoot, hallux). An agglomerative hierarchical clustering analysis was applied based on rfti data of the sub-areas to classify ROP. The distribution of healthy, D, O, and P across clusters was evaluated by a chi²-test. Differences in pmax and rfti values of the sub-areas between clusters were verified by ANOVA.

cluster	healthy	D	DP	O	OD	ODP	BMI[kg/m²]
1	1	0	0	6	8	5	49.1 ±11.40
2	42	5	1	19	9	6	32.1 ±10.70
3	27	1	1	11	8	2	29.7 ±8.90
4	100	4	2	9	6	3	24.6 ±4.40
5	32	3	1	6	6	4	29.5 ±10.58



Results: A 5 Cluster (C1-C5) solution was selected considering the increase in variance for the clusters being merged. Clusters had distinctive ROP and differed largely in rfti and pmax of forefoot, lateral/ medial midfoot and heel. 90% of subjects in C1 had a BMI > 40kg/m². C1 differed substantially from other clusters, e.g. in midfoot rfti (Figure 1). In contrast, C4 included 80% healthy individuals and none with a BMI>40kg/m². The distribution of healthy, D, O, and P across clusters (Table 1) was not uniform ($p<0.01$). No aggregation for P and D was evident in any cluster.

Discussion & Conclusion: DISCUSSION BMI seems to have a major influence on ROP. Apparently, patients with morbid obesity (BMI > 40kg/m²) change their unroll performance to a more midfoot loaded footstrike and takeoff, presumably to avoid plantar overloading. Furthermore, changes in foot morphology can result in higher rfti and pmax in midfoot areas[2]. No effect of P and D on the ROP was found, probably due to small sample size of P and D subgroups. CONCLUSIONS Different ROP of the plantar foot during gait could be determined by a multivariate approach of a cluster analysis. BMI seems to have an influence on the total ROP of the foot during gait.

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P64

THE RELATION BETWEEN PASSIVE ANKLE DORSIFLEXION AND ANKLE AND KNEE JOINT ANGLES DURING BAREFOOT GAIT IN CHILDREN WITH SPASTIC CEREBRAL PALSY

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Introduction: Range of motion deficits, for example reduced ankle dorsiflexion and knee extension, are present in about the half of the children with spastic Cerebral Palsy (CP)[1]. In clinical practice, it is assumed that reducing passive ankle dorsiflexion, measured with extended knees, causes a reduced ankle dorsiflexion and knee extension during gait. In studies with large sample sizes, it has been shown that passive ankle dorsiflexion, measured in clinical examination, is associated with ankle dorsiflexion during gait, but not with knee extension[2,3]. Although the associations were significant, the calculated correlation coefficients were classified as poor and fair. Possibly, the lack of standardisation in physical examination weakens the relation. The aim of this study was to investigate whether there is an association between passive ankle dorsiflexion, measured with an ankle dynamometer at a standardized ankle moment, and ankle and knee angles during gait in ambulant children with CP, walking with extensive knee flexion in stance.

Patients/ Material and methods: Passive ankle dorsiflexion and ankle dorsiflexion and knee extension during gait were obtained from 8 children with spastic CP who participated in the Splint study[4]. Passive ankle dorsiflexion was measured using a hand held ankle dynamometer[5] applying an ankle moment of 4Nm dorsiflexion. Also, sagittal video recordings of 50Hz were made of the participant's gait pattern. Children were asked to walk barefoot and at the same speed during all recordings. Linear regression techniques were used to analyse associations between the ankle and knee angle in gait (dependent variables) and passive ankle dorsiflexion (independent variable). R^2 was calculated as well. Furthermore, the mean and standard deviation of the difference between the passive ankle dorsiflexion and ankle dorsiflexion in gait were determined.

Results: Significant associations with passive ankle dorsiflexion (PADF) were found for ankle dorsiflexion during Terminal Swing, Mid Stance and Toe Off. The explained variance was about 70 % (Table 1).

Table 1: Results of linear regression. Independent variable: PADF	Regression			Difference
	B (se)	*p*	R^2	Mean (sd)
Knee extension in Terminal Swing	-0.100 (0.708)	0.892	0.003	
Ankle dorsiflexion in Terminal Swing	0.734 (0.215)	0.014*	0.661	-19.2 (4.2)
Knee extension in Mid Stance (KMS)	-0.172 (0.616)	0.790	0.013	
Ankle dorsiflexion in Mid Stance (AMS)	0.971 (0.525)	0.008*	0.712	-11.9 (4.4)
Maximal Knee extension in Stance (KMAX)	-0.414 (0.784)	0.616	0.044	
Ankle dorsiflexion at Toe Off (ATO)	0.914 (0.226)	0.007*	0.732	-27.7 (4.9)
Difference between KMS and KMAX	0.242 (0.279)	0.418	0.112	
Difference between AMS and ATO	0.058 (0.443)	0.900	0.003	

Discussion & Conclusion: Despites the low sample size (n=8), significant associations were found between passive ankle dorsiflexion and ankle joint angles during gait in children with CP, but not for knee joint angles. Less passive ankle dorsiflexion was associated with less ankle dorsiflexion during gait. For example, a 1^{o} reduction in passive ankle dorsiflexion could lead to almost a 1^{o} reduction in ankle dorsiflexion during the Mid Stance phase of gait. Furthermore it could be seen that the mean ankle dorsiflexion angle in Mid Stance is about 12^{o} smaller than the mean passive ankle dorsiflexion angle. Results show that a reduced passive ankle dorsiflexion does influence gait in children with CP walking with extensive knee flexion in stance. Further research has to be performed to find out whether a within subject change of passive ankle dorsiflexion is significantly associated with a change in ankle dorsiflexion during gait.

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P65

KINEMATIC CHARACTERISTICS DURING WALKING IN PATIENTS WITH PROGRESSIVE PSEUDORHEUMATOID ARTHROPATHY OF CHILDHOOD

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Introduction: Progressive pseudorheumatoid arthropathy of childhood (PPAC) is a specific autosomal recessive subtype of spondyloepiphyseal dysplasie (SED) tarda. PPAC is a skeletal disorder and is characterized by polyarthropathy of large and small joints. Typical signs are very prominent epiphysis, progressive joint stiffness, muscle weakness and inclination to early fatigue [1]. These processes lead to malpositions and compensatory movements, therefore most patients have great difficulties in walking and will need a wheelchair starting within the first or second life decade. 3d-gaitanalysis is used for PPAC patients to quantify their gait patterns in order to individualize and optimize their physical therapy. In the context of PPAC therapy, preservation of physiological movements is an important issue. Therefore the aim of this study is to quantify the movement restrictions and gait abnormalities in PPAC to use this information particularly with regard to physiotherapy.

Patients/ Material and methods: In a retrospective investigation eight adolescents were included, which suffer from PPAC (sex: female=1; male=7; age:14.6y; weight:50.0kg; size:1.42m; BMI:25)). For comparison there were a healthy control group (cg) of 20 young persons (sex: female=17, male=3; age:17.9y; weight:53.8kg; size:1.59m; BMI:21). Gait analysis was performed with eight infrared cameras (Vicon, 200Hz). For investigation the participants were marked in accordance to the Plug-in-Gait Model for the lower limbs. The walking speed was individually selected and should represent a pleasant and normal speed. For the evaluation 6 left and right strides were used and due to symmetrical joint infestation of the PPAC and on the assumption of a symmetrical gait of the cg the results were averaged between left and right. Further analysis focused on spatio-temporal and kinematic parameters in sagittal plane. Mann-Whitney-U-Tests were used for statistical analysis. Statistical significance was determined at the level of $p<.05$. Additionally the pearson product-moment correlation coefficients were analyzed in the PPAC group.

Results: The PPAC show a very slow walking velocity ($p<0.001$) with extreme short step length ($p<0.001$) and broadened step width ($p<0.001$). The foot off occurs noticeable late ($p<0.001$). The kinematic data appear very heterogeneously to the cg with highly significant differences in pelvis, hip, knee and ankle motions. Especially the range of motion (ROM) in the hip flexion/extension, in the knee flexion while loading response and extension in mid/terminal stance as well as the ROM of the ankle plantar flexion while push off are decreased ($p<0.001$). Within the PPAC-group high negative correlations were calculated between BMI and ROM of the ankle plantar flexion (push off) ($r=-.860$).

Tab.1: Selection of kinematic results in pelvis, knee, and ankle joint

	PPAC (n=8)		control group (n=20)		M.-W.-U-Test
	Median	Q25 / Q75	Median	Q25 / Q75	Sign. (2-tailed)
Pelvic tilt [°]	19.4	(15.1 / 21.6)	11.2	(8.5 / 12.8)	p<0.01
Hip ROM (Flex/Ext) [°]	32.0	(28.3 / 34.6)	44.0	(42.0 / 46.4)	p<0.001
Knee ROM (Flex, loading response) [°]	5.3	(4.4 / 6.9)	11.6	(10.7 / 13.4)	p<0.001
Knee ROM (Ext, single-supportl) [°]	2.5	(1.1 / 4.7)	15.4	(13.6 / 17.8)	p<0.001
Ankle ROM (Plan-Flex, push off) [°]	12.8	(11.3 / 13.0)	29.7	(26.8 / 35.5)	p<0.001

Discussion & Conclusion: The results represent gait patterns that are determined by very small ROM in the lower extremities. Responsible are the distinctive joint stiffness and muscle weakness. The effect of weakness is intensified by the high body weight. Intensive functional practice including flexibility and strength as well as a reduction of body weight might be important to decelerate the progressive joint destruction in the lower extremities and enables to walk without orthopedic additive.

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GAIT MODIFICATIONS TO UNLOAD THE HIP IN CHILDREN WITH LEGG-CALVE-PERTHES DISEASE

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Introduction: Avascular necrosis of the femoral head in children with Legg-Calve-Perthes disease (LCP) severly limits the range of hip motion and hinders a normal gait. The aim of this study was to evaluate gait patterns in patients with LCP and identify modifications decreasing the load on the affected hip.

Patients/ Material and methods: Forty children with unilateral LCP were divided into three groups based on the time base integral of the hip abductor moments during single stance on the affected side aquired during the instrumented gait analysis. X-rays of the affected hip were classified according to Herring and Caterall (1, 2).

Results: The time base integral of the hip abductor moments during single stance correlated positively with the hip abduction angle and age but only a weak positive correlation was found with X-ray classifications of Herring and Caterall. Children who were able to unload the hip spontaneously adopted a Duchenne-like gait with hip abduction and external rotation during the single support phase. The patients who loaded their hips normally also showed a Duchenne-like pelvis elevation and the position of the hip in the frontal plane was neutral. In the group of children who over-loaded their hips, a pelvis drop to the swinging limb at the begining of stance (Trendelenburg sign) was accompanied by prolonged hip adduction during stance (Fig.1).

Discussion & Conclusion: Loading of the hip joint is a major consideration in the treatment of LCP disease. Hip joint loading depends on the extent of hip abductor moments occurring during the single support stance phase of the gait cycle. This study reports on the kinematic patterns of three groups of children with LCP disease. Groups were formed based on degree of hip joint loading during the single support phase. Correlations were found between the hip abduction angle in single stance, the age of the patients and the loading of the affected hip joint. These correlations indicate that older children tend to overload their hips, walk preferably with hip adduction during single stance, and have hips, which are more impaired. The hip overloading pattern should be avoided in children with LCP. As the hip unloading pattern (Hip abduction and a lean of the trunk to the stance limb) of gait has successfully been used to unload the hip and relieve the pain in adults suffering from hip problems (3), gait training might become an integral component of conservative treatment in children with Legg-Calve-Perthes disease.

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Disclosure: No significant relationships.

P67

KINEMATIC ANALYSIS OF GAIT IN SUBJECTS WITH LUMBAR DISC HERNIATION

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Introduction: Low back pain is a very common problem. Various studies have investigated the gait in subjects with low back pain, however there is a problem with homogenity of sample [1]. The aim of this study was to compare the gait of subjects with lumbar disk herniation who do not undergo surgical intervention with healthy population.

Patients/ Material and methods: The sample of 10 subjects with lumbar disk herniation participated in this study – mean age 41 ± 8 years, mean weight 79 ± 15 kg, mean height 177 ± 6 cm. These subjects have not had pain in lumbar area during experiment. The control group consisted of 12 subjects – mean age 47 ± 10 years, mean weight 67 ± 8 kg, mean height 169 ± 7 cm). Kinematic variables were evaluated by kinematic system Vicon Mx (7 cameras, frequency 200 Hz, Vicon Motion Systems, Oxford, UK). The basic kinematic variables of lower limbs and pelvis were evaluated during gait. Statistical processing was performed by Statistica programme (version 8.0, Stat-Soft, Inc., Tulsa, Oklahoma, USA) using Mann Whitney U test.

Results: Significant differences between the experimental and the control groups were found in movement of pelvis and hip. Gait of subjects with lumbar disc herniation is characterized by reduced pelvic obliquity and pelvic rotation and reduced range of hip movement in sagittal plane. Time variables showed greater duration of stance phase in the comparison with control subjects.

Discussion & Conclusion: Gait of subjects with lumbar disc herniation is characterized by reduced pelvic and hip movement. Similar results in subject with chronic low back found Lamoth et al. [2]. They presented that the coordination between transverse thoracic and pelvic rotations and lumbar and pelvic rotations was more rigid and less variable than in healthy controls. This information can be useful for physiotherapists. Da Fonseca et al. [3] suggested that patients with low back pain use strategies to attenuate the amount of force imposed on their body which can be change by some rehabilitation methods. The results of the study showed limitation of movement in pelvis and hip during gait in subjects with lumbar disc herniation which have already not pain in lumbar area. These findings can be useful for physiotherapists for subsequent care concerning these patients.

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Disclosure: No significant relationships.

P68

STEP WIDTH OF SIX-YEAR-OLD CHILDREN WITH RELATION TO CHOSEN FEATURES OF THEIR BODY BUILD

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Introduction: The aim of the study was to investigate the width of feet positioning of six-year-olds and to evaluate the correlation between step width, hip joint span, length of lower limbs and the positioning of the right and left knee joint assessed in the frontal plane during a single support phase of gait.

Patients/ Material and methods: In 380 children of six years of age the lower limb length, hip joint span, body height and weight were measured. The step width during a double support phase and the angle between the thigh and the tibia in the knee joint were calculated at gait in the frontal plane during the single support phase (separately for the right and left lower limb). The gait examinations were performed by means of video and computer [1] and the children's gait was recorded at a frequency of 50 Hz. Each child walked in a natural manner and barefoot in a straight line in front of the camera, perpendicularly and parallel to the lens axis.

Results: The results of the gait examinations showed that the step width with regards to the hip joint span was 122,2%, while to the lower limb length was 13,2%. No statistical significant differences were noted between the right and left lower limb with regards to the analyzed features. During the single support phase the thigh-tibia angle was 4.6° (±1.01) in the frontal plane. The physical development of children assessed upon their body weight and height, conformed to the age norms of their peers. A statistically significant correlation ($p<0.05$) was determined between the step width and the hip joint span, lower limb length and the thigh–tibia angle in the knee joint; all correlations besides the last had a positive value. Additionally, the hip joint span significantly correlated with the analyzed features of body build, i.e. body height, body weight and lower limb length (positive value of the coefficient of correlation).

Discussion & Conclusion: The percentage value of the step width to the lower limb length that was obtained by this study is comparable with the results presented by other authors [2,3], however slightly greater than in 7-year-olds [4] and smaller (with statistical difference) than in peers of genu valgum [1]. The reason for the step width being wider than the hip joint span in the double support phase of the examined six-year-olds, should been interpreted by the adapting changes that are forced by the subconscious need for improving the conditions of body balancing, which have a positive impact on body stability and the sense of security during gait. This is determined by an increased restriction of the pelvic mobility in the transverse plane, of body trunk inclination motion directed towards the loaded lower limb [2] and by a small lateral oscilation OSC [4].

References: [1] Pretkiewicz-Abacjew E., Journal Sports Medicine and Physical Fitness, 2003. [2] Sutherland D.H. and Coll. The Development of Mature walking. Mac. Keith Press, Oxford. 1988. [3] Stolze H., J.P. and Coll., Gait & Posture. 1998. [4] Basmajian J.V. The human bicykle. Univ. Park Press, Baltimore 1976.

Disclosure: No significant relationships.

P69

THE CLINICAL IMPACT OF APPLYING A CRITERION FOR PREDICTING RECTUS FEMORIS TRANSFER SURGERY OUTCOMES: EVALUATION VIA RETROSPECTIVE CASE-CONTROL DESIGN

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Introduction: Distal rectus femoris transfer (RFT) is widely considered an effective treatment for stiff knee gait (SKG) in ambulatory individuals with cerebral palsy (CP) [1]. However, controversy exists regarding the expected outcomes [2, 3]. Reinbolt et al. derived a score capable of correctly predicting outcomes after RFT 80% of the time [4]. No control group was tested in Reinbolt's study, thus it is unclear whether the score was specific to the RFT, or merely predicted subjects likely to benefit from single event multi-level surgery (SEMLS). The current study re-evaluates Reinbolt's criterion including a matched control group that also underwent SEMLS without RFT.

Patients/ Material and methods: This study examined 145 individual limbs from 112 children with CP and SKG who underwent SEMLS±RFT. Each subject had a pre-operative gait analysis <18 months prior to the SEMLS, and a post-operative gait analysis between 9-24 months after the SEMLS. All of the subjects were able to walk without the use of an assistive device. The definition of SKG was consistent with Reinbolt. The criterion developed by Reinbolt was used to retrospectively predict which limbs would benefit from including RFT as part of the SEMLS. The outcome of the intervention was considered good if the limb was not classified as walking in SKG after surgery. The benefit (percentage of good outcomes) that could be expected when following the criterion was also calculated. To analyze the benefit of following the current practice, all of the limbs that had SEMLS+RFT are considered in the 'met criterion' group and those that had SEMLS-RFT are considered in the 'did not meet criterion' group.

Results: The odds ratio was 2.34 for SEMLS±RFT regardless of the criterion. This increased slightly to 2.63 when only the group that met the criterion was analyzed [Table 1]. The results of the benefit analysis show that 49% of the limbs with SKG are expected to have good outcomes when following the recommendations of the criterion while 50% are expected to have good outcomes when following the current clinical practice.

Table 1.

	All Subjects		All Subjects who met criterion	
Outcome	+RFT	-RFT	+RFT	-RFT
Good Bad	52	21	33	17
	37	35	14	19
Odds ratio	2.34		2.63	
Chi-square test	p = 0.014		p = 0.034	

Discussion & Conclusion: This study shows that the criterion proposed by Reinbolt does no better at predicting the outcome of RFT surgery than current clinical practice. The current study adds a control group to show that the group that met Reinbolt's criterion did better overall (60% corrected SKG after SEMLS±RFT) and did better with an RFT (70% corrected SKG after SEMLS+RFT). However, the benefit is limited due to the fact that only 57% of the limbs with SKG met the criterion. The limited value of the criterion can only be seen when a control group is identified and analyzed.

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Disclosure: No significant relationships.

P70

OUTCOMES USING AMBULATORY ANKLE FOOT ORTHOSES IN DUCHENNE MUSCULAR DYSTROPHY

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Introduction: Progressive weakness in Duchenne Muscular Dystrophy (DMD) affects proximal extensor muscles. Toe walking, an early compensation, maintains knee extending moments; slightly later, lumbar lordosis maximises hip extending moments1. These compensations prolong walking, but calf and hip flexor contractures, the conflicting postures required, and progressive weakness cause the loss of independent walking2. Ankle Foot Orthoses (AFOs) have been recommended as a way of controlling hip and knee moments3 but previous investigations have not stated at what stage of DMD gait this has been attempted, or what design of AFO footwear combination (AFOFC) was used. Therefore, boys with DMD were asked to use AFOs and footwear that were "tuned" to optimise kinematics and kinetics4 and data collected on the efficacy and acceptability of this strategy.

Patients/ Material and methods: A case study design was used for 10 subjects, recording a range of DMD gait, and the effect of AFOFC. Each boy was examined for muscle strength and contractures, completed a functional questionnaire (the Activity Scale for Kids - ASK), was cast for AFOs, and issued with an activity logger (activPal). Boys were fitted approximately 6 weeks later with AFOs (with adjustable ankle hinges) and footwear, with video vector tuning, and were reissued with the activePAL. After another 6 weeks, boys returned for 3D gait analysis with and without AFOs, the ASK and a user satisfaction questionnaire.

Results: Preliminary results from 7 subjects have been collected: 3 subjects reported finding regular use of the AFOFC useful, one subject used the AFOFC intermittently, but did not find it useful, and 3 subjects did not use them. Of those who used them, positive effects included: reduced calf pain; improved walking distance; reduced plantarflexion contracture; increased walking speed and step length; reduced step width and double support time; decreased anterior pelvic tilt; near normal range of motion at the knee; knee valgus moments normalised to varus moments.

Discussion & Conclusion: The use of AFOFC in DMD can improve gait kinematics, kinetics and activity levels. However, 3 boys did not use the AFOFC: they found them too heavy, uncomfortable, cosmetically unacceptable or felt their walking was less stable. These boys were more affected by weakness and contractures, and walked less. For the AFOFC to be acceptable and assist in speed, stability and kinetics, boys must be able to walk community distances with assistance or be independent household walkers who are just starting to struggle to maintain their level of mobility. AFOFCs in DMD can better ambulation if used at the correct stage of disease progression.

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Disclosure: No significant relationships.

P71

REPEATABILITY OF THREE-DIMENSIONAL KNEE KINEMATICS FOR ELEVEN MOTOR TASKS

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Introduction: Numerous studies have demonstrated the role of gait analysis in the evaluation of the knee , but most confine their research to flexion-extension during typical walking. Furthermore, very little is known about three-dimensional kinematics of the knee during more complex motor tasks, inducing greater motion at the knee[1]. Also, repeatability data on 3D knee motions during these tasks are not widely available. Therefore, the present study describes the kinematics of the knee in healthy subjects for 11 daily motor tasks, in particular the repeatability both within and between subjects.

Patients/ Material and methods: Ten adult subjects (29±9years, BMI24±5) participated in this study. Kinematic data were obtained using a 14 camera motion capture system tracking the 3D positions of 23 retro-reflective markers (Plug-in-Gait, Vicon, Oxford). A knee alignment device was used to identify the knee flexion/extension axis. During 3 sessions, 11 motor tasks, 3 repetitions each were performed; gait tasks: walking, walk and crossover turn (WCO) and sidestep turn (WSS), ascent onto a step (SA), descent off a step (SD), descent with crossover turn (SDCO) and sidestep turn (SDSS); non-gait tasks: chair rise (CR), mild (MS) and deep squat (DS), lunge (L). Within and between repeatability, was quantified by means of coefficient-of-multiple-correlation (CMC), root-mean-squared difference (RMS) against the average. Inter-subject variability was characterized by the standard deviation (SD), coefficient of variation (CV), and the two-way-mixed-model intraclass-correlation coefficient (ICC). Measurements were considered to have “good” repeatability presenting a high ICC (0.8-1), low SD (<5°), low CV (<15%), or any combination of the three.

Results: Crossover turns (17º) and high-flexion tasks (17º-25º) showed the largest internal rotation, while WSS, SDSS (11.1º&12.0º) presented with the largest external rotation. Crossover turns also showed smaller adduction peaks (5.7º&6.4º), compared to typical walking (8.7º). Consistent coupling between flexion-extension and axial rotation curves were recognized in non-gait tasks. Other studies confirm internal rotation while flexing the knee[1]. Gait tasks showed repeatable kinematics among all anatomical planes, most clearly for flexion-extension (Table 1). Crossover and sidestep turns increased the range of axial rotation by factors of 1.5 and 2, respectively, compared to walking, resulting in higher relative repeatability. The large physiological axial rotation during turning tasks thereby increased the measurement-to-error ratio[2].

	Flexion/ Extension		Abduction/ Adduction		Endorotation/ Exorotation	
	Worst	**Best**	**Worst**	**Best**	**Worst**	**Best**
CMC_{intra}	0.93 (MS)	0.99 (W)	0.35 (L)	0.81 (W)	0.63 (SD)	0.92 (SDSS)
CMC_{inter}	0.84 (MS)	0.97 (W)	0.06 (L)	0.45 (SDCO)	0.35 (SA)	0.79 (SDSS)
RMS_{intra}	10.7° (DS)	2.8° (W)	3.7° (L)	1.4° (W)	4.9° (DS)	2.9° (W)
RMS_{inter}	18.3° (DS)	5.1° (W)	7.0° (L)	3.0° (WCO)	6.7° (DS)	4.5° (W)

Furthermore, the range of knee abduction-adduction for high-flexion tasks was small compared to the gait tasks. This was unexpected, since the larger flexion ranges of these tasks were hypothesized to lead to more crosstalk errors. Instead this may be attributed to the stabilization of the knee during these tasks. A number of parameters with good intra-subject repeatability were found for gait and non-gait tasks, with most tasks showing CV under 10% and ICCs above 0.90.

Discussion & Conclusion: The different motor tasks revealed a large spectrum of inter-subject repeatability and variability, and also different patterns and ranges of knee joint motion, in flexion-extension but also in out-of-sagittal plane rotations. The least constrained motor tasks, such as lunge and squat, were also the least repeatable. Finally, larger joint rotations were more repeatable.

References: [1]Moro-oka, et al., J Orthop Res., 26:428-434,2008 [2]Desloovere, et al., Gait & Posture, 32(4):597-60,2010

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P72

INTERSITE DISCREPANCIES IN CORRELATIONS AMONG GILLETTE GAIT INDEX VARIABLES

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Introduction: It is well known that different laboratories' normal reference samples are usually different. Previous studies have demonstrated univariate discrepancies. However, relationships among variables could be also different and they have been not explored yet. The aim of this study is to describe differences in these relationships between two different pediatric control data sets.

Patients/ Material and methods: 32 gait parameters (16 left and 16 right) used to calculate Gillette Gait Index (GGI) were acquired by means of instrumental gait analysis (Codamotion Charnwood Dynamics Ltd) in two different groups of children walking in two different places. Lab A control data set was formed by 27 children (6-13 yrs) and they walk in a 6-meter path. Lab B control data set was formed by 31 children (6-13 yrs) walking in this case in a 15-meter path. Two approaches were used. 1. Factor analysis using principal component analysis with varimax rotation (SPSS 17.0) was made in both labs control data set. An absolute correlation between a variable and a factor higher than 0.5 is considered as relevant. 2. For each lab's control data set a multiscale bootstrap resampling hierarchical clustering of the 32 variables was obtained (package pvclust in R language). Distance and clustering criteria were 1-(abs correlation) and average, respectively. Approximately unbiased p-value was used to interpret the results and clusters with a p-value higher than 95% were considered stable.

Results:

		F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11
Lab A	Left	4,7	**14,15**	**2,3**	**1,12**	9	10	5	16	**6**	13	11
	Right	4,7	**2,3**	**1,12**	14,15	11	**10**	**13**	16	6	5	9
Lab B	Left	4,7	**1,3**	11	5	16	**15**	10	**2**	13	9	**14**
	Right	14,15	4,7	**1,3**	**8**	11	9	16	**12**	5	**2**	6

Table 1. Factors in the two different laboratories and relevantly correlated variables. Variables number corresponds to the order defined by Shutte et al. Variables grouped in different ways in the two labs are in bold.

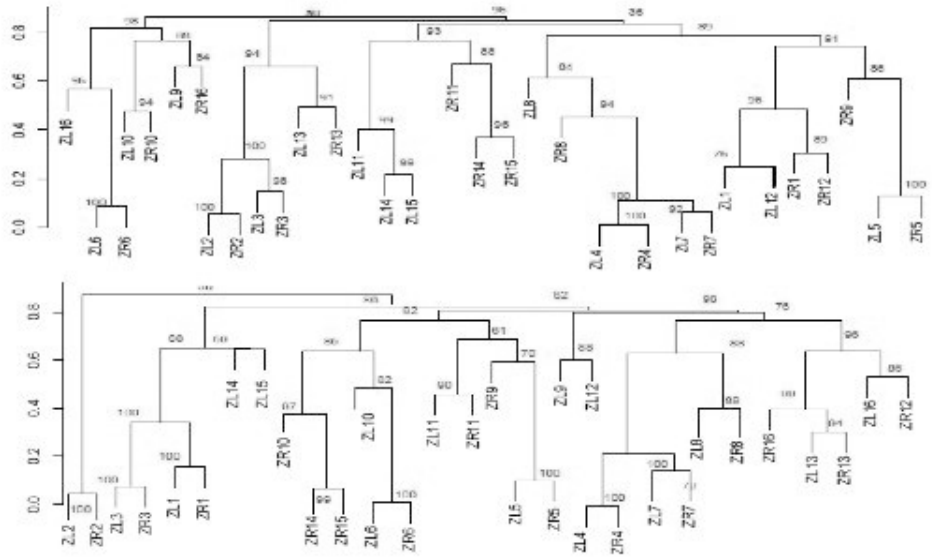

Figure 1. Hierarchical clustering in lab A and B. Vertical axis represents 1- absolute correlation. AU p-value is shown in red for each node. Notice completely different organization in variables.

Discussion & Conclusion: Lineal correlations among GGI variables are not consistent among normal reference samples. This could lead to differences in gait analysis interpretations and intersite variations in gait indices. This fact should be carefully studied when using external reference data sets.

References: 1. Schutte et al. An index for quantifying deviations from normal gait. Gait & Posture 2000;11:25–31.
2. McMulkin et al. Intersite variations of the Gillette Gait Index. Gait & Posture 2008;28(3):483-7.

Disclosure: No significant relationships.

P73

GAIT PATTERNS IN A REFERENCE DATASET OF HEALTHY CHILDREN

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Introduction: A relevant issue in reference gait datasets is to assess the nature of their disribution, that is, unimodal multivariate versus patterned and multimodal. No consistent data support either form. The aim of this study is to search for patterns in a normal pediatric reference dataset.

Patients/ Material and methods: 32 gait parameters (16 left and 16 right, frequently used to calculate Gillette Gait Index) were acquired by instrumental gait analysis (Codamotion Charnwood Dynamics Ltd) in 27 healthy children (6-13 yrs) walking through a 6-meter path. Growing Cell structure (GCS) neural networks were used to classify patterns of children gait. GCS main advantage is the ability to automatically find a suitable network structure and size. Topographic function and mean number of strong violations were used to select the most appropriate number of groups. MANOVA p-value was used to validate classification. Random forest graphs were used to estimate the importance of each variable in the classification.

Results: The trained network found three patterns of gait, which we named as alpha (12 children), beta (10 children) and gamma (5 children). These differed statistically with high signification ($p < 0,001$). Figure A shows topographic map obtained for the optimal GCS network with 3 clusters. Figure B shows a basiogram representing the median value of principal components for each group. Sagittal and spatiotemporal values are the most discriminating parameters amongst groups.

Discussion & Conclusion: Our pediatric reference gait dataset is multimodal. These three different groups could represent three gait different strategies. This fact is important when considering normal gait as gold-standard in clinical gait analysis. Closer neighbor-based strategies could be more adequate than whole population-based strategies because first ones do not assume unimodal distribution.

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Disclosure: No significant relationships.

P74

INTERACTION BETWEEN WALKING SPEED AND SPASTICITY IN CHILDREN WITH SPASTIC GASTROCNEMIUS

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Introduction: Spasticity as defined by Lance is a "velocity dependent increase in muscle tone"[1], leading to gait deviations. Studying the muscle lengthening velocity (MLV), the muscle activity and the relationship in between, at different walking velocities, gives us further insight in the effect of spasticity on gait[2]. To be able to compare data of children with cerebral palsy (CP) and typical developing (TD) children, they must be obtained from an equal walking speed.

Patients/ Material and methods: 25 Children with CP with a Modified Ashworth Score of ≥1.5 (10.4+-2.4years) and 14 TD children (10.4+-2.5years) received a 3D lower limb gait analysis, including kinematics, kinetics (8 camera Vicon system), EMG of 8 muscles bilateral (Aurion, ZeroWire) and a full clinical examination. They were asked to walk at self-selected speed, faster and as fast as possible without running. To compare the data of both groups, a linear regression model was created which resulted in two non-dimensional gait velocities of 0.3 and 0.6, used to compare a large set of parameters. To define the relation between muscle activity and MLV, the ratio of emg activity in swing versus maximum MLV in swing was calculated. Difference scores (DS) between both velocities were calculated for all parameters. Statistical analysis was done with the Mann-Whitney U test.

Results: At initial contact (IC), the TDgroup showed shortening of the gastrocnemius muscle, which became more pronounced with increasing velocity. The CPgroup on the other hand showed immediately lengthening of the gastrocnemius at IC. This lengthening velocity increased at higher walking velocity ($p=0.01$). At loading response (LR), power absorption increased significantly more with increasing walking speed for the CP compared to the TD group (DS:$p<0.01$), coupled with a higher muscle activity at both speeds and a significant DS ($p<0.001$). In the second rocker, the ROM of dorsiflexion was lower in the CPgroup at both speeds. With increasing speed, push-off appeared earlier in the CPgroup, coupled with an earlier timing of maximum gastrocnemius length. In swing, the total ROM of the ankle was lower in the CPgroup at both velocities (but no significant DS). The maximum MLV in swing showed similar results. The emg activity on the other hand, showed no significant difference at baseline, but significant higher activity at highest speed ($p<0.001$) and a significant DS ($p<0.005$). The emg activity in swing versus maximum MLV in swing ratio showed higher values at both speeds and a larger DS in the CPgroup.

Discussion & Conclusion: In this study, data of TD en CP children could be compared at the same non-dimensional velocity. The higher ratio of muscle activity versus muscle lengthening in the CPgroup confirms the contribution of spasticity in two major parts of the gait cycle: IC-LR and swing. Although many other parameters showed significant difference at the lowest or at both velocities, not all of them changed differently with increasing speed when comparing both groups.

References: (1)Lance, Spasticity: disordered motor control, Chicago; 485-495,1980 (2)Crenna, Neurosci Biobehav Rev; 22:571-578,1998

Disclosure: No significant relationships.

P75

EVALUATING GAIT ADAPTABILITY IN ADOLESCENTS WITH CP - A TREADMILL APPROACH

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Introduction: Next to efficiency, adolescents with CP are concerned about safe mobility [1]. To keep up with peers and navigate in complex environments of daily life, their gait needs to be adaptable. Muscle weakness, spasticity and a lack of selective motor control may affect their ability to execute gait adaptations, e.g. when stepping across obstacles. We investigated whether time constrained gait adaptability can be measured objectively using an instrumented treadmill with visual obstacles and which impairments interfere with gait adaptability.

Patients/ Material and methods: 12 adolescents with CP (15.6±1.7 years, 6 GMFCS I, 6 GMFCS II) and 12 age-matched healthy controls participated. They walked at comfortable speed on a treadmill (Forcelink, NL) while avoiding visual obstacles projected on the belt as bars of lights. Obstacles were presented randomly, appearing either 4 (anticipatory) or 2 steps (reactive) in advance of possible collision. The obstacle's location was timed according to the subjects' walking pattern such that it would coincide with foot placement when subjects did not react. Physical examination included manual spasticity assessment (adductor, hamstrings, soleus, gastrocnemius) [2], evaluation of lower limb selectivity [3] and measurement of isometric muscle strength (plantar flexors, knee extensors, hip abductors) by means of hand held dynamometry. Success of obstacle avoidance was scored by inspection of video recordings.

Results: In the reactive condition CP GMFCS I and II both had a significantly lower success rate than controls (p=.005 and p=.018), with no significant (p=.394) difference in between GMFCS levels (fig 1). In the anticipatory condition CP GMFCS II scored significantly lower than controls (p<.001) and GMFCS I (p=.019). Differences between CP GMFCS I and controls were significant (p=.041) but less pronounced. Pearson's r revealed that the success rate in the anticipatory condition significantly correlated with the overall level of spasticity (r=-.66, p=.02) and selectivity (r=.62, p=.03) in the lower limbs. No significant relations with physical impairments could be found during the reactive task. Strength measures did not correlate in either of both tasks.

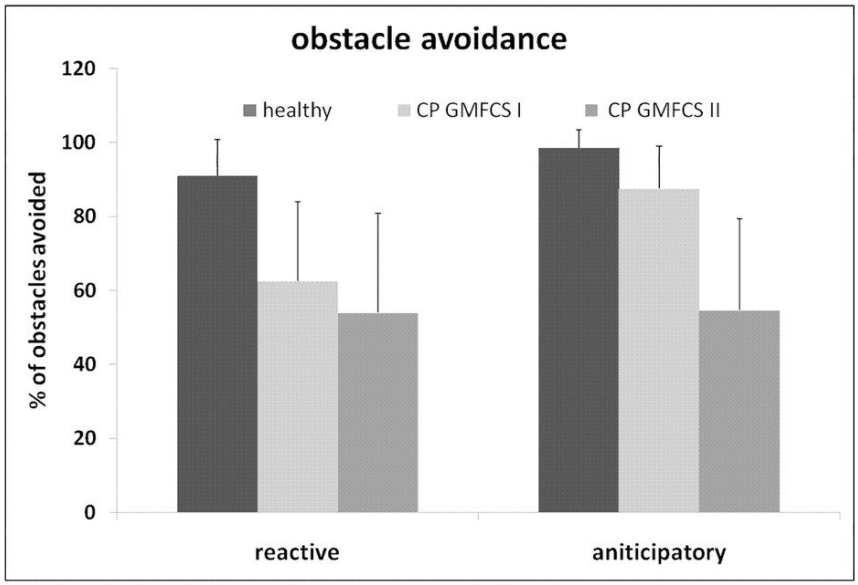

Figure 1 . Success of obstacle avoidance in controls, GMFCS I and GMFCS II.

Discussion & Conclusion: We showed that gait adaptability in adolescents with CP is reduced in comparison to healthy peers. In general, GMFCS II faced greater problems than GMFCS I. The significant correlations of selectivity and spasticity with the success rate in the anticipatory conditions indicate that decreased motor control limits adaptability, while strength seems to be of minor importance. Adolescents with CP were also more likely to fail in the reactive condition, but physical impairments were not significantly correlated. Slowed processing of visual information and attentional deficits [4] might have affected their performance. Whereas [5] showed that adolescents with CP are able to successfully clear an obstacle during overground walking, provided that they have sufficient time, our time constrained treadmill set-up accentuated coordinative problems and revealed reduced gait adaptability in CP.

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A MARKER BASED KINEMATIC METHOD OF IDENTIFYING INITIAL CONTACT DURING GAIT FOR USE IN REAL-TIME VISUAL FEEDBACK APPLICATIONS.

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Introduction: Ideally initial contact (IC) is identified using kinetic data from force platforms. When these data are not available then other methods of event definition using kinematic data are required. Accurate methods of identifying IC have been described based on marker accelerations but these require further processing of marker trajectories which is not appropriate for real-time applications [1,2]. The aim of this study was to identify a simple marker based method for determining gait events which could be used in real-time applications such as providing visual feedback in a virtual rehabilitation environment.

Patients/ Material and methods: Ten (5 male, 5 female) unimpaired subjects (mean ± SD age, height, mass, 25.1 ± 6.6 years, 1.76 ± 0.11 m, 71 ± 7.7 kg) were recorded completing a minimum of 25 overground gait cycles while walking at a self-selected speed along a 10 m walkway. A pelvis and lower limb model was used, captured by a Vicon system operating at 100 Hz. IC was defined at an ascending threshold of the vertical component of the ground reaction force (20 N). Contralateral peak hip extension was used to define IC kinematically i.e. right IC occurred at left hip peak extension (minimum flexion). In all a total of 566 kinetically and kinematically defined IC events were compared to determine the accuracy of match. A limits of agreement analysis (LOA) was conducted [3] and the 95% confidence intervals established in order to quantify agreement or otherwise between kinematic and kinetic events.

Results: The mean difference between the kinematically and kinetically defined events was + 0.003 ±0.009 s which is less than 1 frame when recorded at 100 Hz. The range was between 0.02 s before and 0.05 s after the force defined IC event and the 95% LOA was ±0.018 s. There was no statistically significant difference caused by sex or walking speed on the accuracy of this kinematic event with respect to the kinetic IC.

Discussion & Conclusion: The results of this study identified a new algorithm based upon the contralateral hip flexion-extension angle to identify IC. This method provides simple to implement and relatively accurate gait events for use when kinetic data are not available in both a clinical and research setting or possibly when kinetically defined gait events are inappropriate to use due to foot scuffing or dragging at the beginning and end of stance phases. It also lends itself to use within real-time biofeedback applications due to the small amount of processing time required.

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RECOGNITION OF PHYSICAL ACTIVITY ADAPTED TO REHABILITATION

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Introduction: New systems based on inertial sensors for ambulatory movement analysis are currently under development. This technique promising for rehabilitation purpose requires the development of algorithms for the recognition of the physical activities recommended by the clinical staff. The algorithms currently proposed are mainly consisting in decisional trees and neural networks having as inputs diverse acceleration frequency parameters defined by analyzing data of specific group of subjects [1,2]. The aim of the present study is to propose a method using biomechanical analysis of the activities to classify to perform activity recognition, whatever the subject characteristics are.

Patients/ Material and methods: For the European project Physical Activity Monitoring of Elderly People (www.pamap.org), the postures sitting/standing/lying are to be classified as well as the endurance activities walking/running/cycling. 16 subjects of different age and physical condition took part in this study. They had to take the different postures during period of 6*5s, to walk/run/cycle 6 times through a 10m-pathway at 3 different paces (slow/normal/fast) and they had to perform 2 daily activities also at 3 different paces. The motion capture was performed using an optoelectronical system (Vicon System). Markers were placed to track not only the body segments but also potential inertial sensor locations. The signals analysed to determine the “universal” characteristics of each activity were the accelerations deduced from the marker trajectories.

Results: Each body posture could easily be recognized based on the acceleration of the markers placed at the pelvis and at least one placed on the thigh. For the different activities, the markers placed at the pelvis and those placed at the both thighs were needed. The biomechanical analysis of the different activities enabled the detection of typical pattern of coordination of thigh acceleration, whatever the subjects as illustrated on the figure hereafter.

Discussion & Conclusion: The results of this study confirmed that the biomechanical approach enables the recognition of different physical activities. This approach has to be now implemented on ambulatory systems with inertial sensors.

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P78

THE ESTIMATION OF MUSCLE FATIGUE DURING RUNNING AT DIFFERENT INTENSITIES

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Introduction: Surface electromyography (sEMG) is one of methods which have been used to investigate mechanisms of neuromuscular fatigue [1]. The muscle fatigue is specific to contraction type, intensity and duration of activity therefore relationships seen e.g. in the isometric muscle contraction are not the same in the dynamic exercise. Therefore, based on previous experience in that evaluation the effectiveness of the estimation of fatigue for individual lower extremities muscles during the run at various intensity was the aim.

Patients/ Material and methods: Four athletes took part in this research. EMG measurements were recorded during the run on tartan athletic track. The athlete had to run 400m distance with a different intensity. The first distance of 400 m took 90s, the second one 70s, the third one 60s and the last one was performed with maximal intensity. Bipolar surface EMG recordings were obtained from the rectus femoris (RF) and biceps femoris – long head (BF) of right and left thigh were obtained. The raw SEMG signal was recorded at the sampling rate of 1000Hz using a device ME3000P4. Power spectral analysis were performed to calculate MPF on 1024-point (Hamming window processing) by fast Fourier transformation (FFT) technique. All participants signed written consent form and proper consent was obtained from Warsaw UPE Ethical Committee.

Results: Fatigue comparison for individual muscles depending on the intensity of run was described by slopes of regression lines estimated by method of least squares. The values of slope coefficients are presented in table 1. Significant differences between the slopes for muscles of left and right limbs were noticed. For both muscles slopes increased with increasing intensity of the race. That increase was, however, stronger for the left limb. It is worth noting that the differences between left and right limbs are more strongly marked for the RF muscle. Tab. 1. Average values and standard deviation (SD) of the regression line slopes computed on the value of MPF for the run at different intensities: 1 – the 90 s run, 2 – 70 s, 3 – 60 s, 4 – run with maximal intensity

Discussion & Conclusion: The biggest changes in MPF were observed for BF (23,6 %) and RF (19,5 %) muscles of the left leg and then for BF (17,5 %) and RF (12,5 %) of the right leg. Further research requires the phenomenon of the MPF local minimum observed between 18 to 22 seconds. This phenomenon is probably related to the collapse of energy associated with the ATP-PC resynthesis. Because sEMG allows to investigate activation of a single muscle separately during performance, we know that the changes are different in BF and RF of right and left limb. We suppose that those differences (between right and left leg) were mainly due to the curve of the track where those muscles were differently loaded. Acknowledgements This study was supported by the grant from the Polish Ministry of Science and Higher Education - grant no. Ds-137 of the University of Physical Education in Warsaw.

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P79

DAILY USAGE OF COMPUTED GAIT ANALYSIS IN CLINICAL REHABILITATION OF MOTOR DISABLED PATIENTS

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Introduction: Computed gait analysis is a well-known and powerful tool for evaluation and documentation of the rehabilitation progress of motor-disabled patients [1]. It is widely utilized in research laboratories worldwide, thereby enriching the literature with insights to the gait characteristics of different pathologies. In the clinical setting, however, the complexity of the custom gait analysis systems prevents its accessibility to the physicians and physiotherapists who treat the patients in the rehabilitation daycare department. Our aim was therefore to create simple test protocols for acquiring spatio-temporal data, muscle activity and joint angles. These protocols will be useful for daily evaluation of the disability and the effect of different treatments, e.g. orthosis, muscle or nerve anesthetic injections, and orthopaedic surgery, on the gait characteristics of patients who visit the rehabilitation department.

Patients/ Material and methods: Our gait analysis tools comprise of a motion capture system (Simi Motion, Germany) and a telemetric electromyography (EMG) device (Zebris, Germany). Custom-made protocols were designed according to the clinicians' requirements. Several different test protocols can be chosen to evaluate a patient and produce reports (Figure 1).

Results: Our custom-made test protocols, fitted to the clinical settings needs, have been used in our department to evaluate gait disorders in patients suffering from stroke, poliomyelitis, amputations, cerebral palsy, multiple sclerosis, traumatic brain injury and more. The patients underwent functional disability evaluation and specific rehabilitation protocol, which includes treatment according to gait laboratory evaluations. The functional outcomes of these cases will be presented.

Discussion & Conclusion: We conclude that utilization of custom-made test protocols of gait analysis can be regarded as a standard clinical tool for the evaluation of patients during the rehabilitation period. Using these protocols, the maximal potential of gait rehabilitation can be achieved.

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P80

MOVEMENT VARIABILITY IN VIRTUAL-REALITY WELDING

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Introduction: Investigations of occupational disabilities show that welders are prone to work related disorders (Burdorf, Naaktge-boren, & Post 1998). Apart from neurological disorders and disorder of the respiratory system (Bowler et al. 2006) in particular disorders of the musculoskeletal system show a large prevalence in this population (Alexopoulos, Konstanti-nou, Bakoyannis, Tanagra, & Burdorf 2008). To gain a better understanding of the risk factors leading to these disor-ders further research seems warranted as currently only very limited knowledge is available. Usually, welding is per-formed under specific spatial constraints as the welding joint determines the welding process. Thus, the welder has to adjust his posture and movements according to these constraints, which sometimes yield to the acquisition of awkward postures. As biomechanical and physiological conditions vary widely between individual welders one can expect large inter-individual differences in acquired postures for a given spatial set-up. Therefore it seems unlikely that there is a universal optimal movement pattern for successful welding rather that individual solutions will vary in accordance with spatial, biomechanical and physiological constraints (Rein, Davids, & Button, 2010).

Patients/ Material and methods: In total six professional welders and seven novice welders were studied. Professional welders were instructors at a welding training facility whereas the novices were trainees at the same institution. Three different welding positions were investigated (PA, PF hip high, and PF head high). Anatomical landmarks were identifed using passive reflective markers and movements were recorded using six high-speed infrared video cameras (Qualisys©, Oqus 100) set at 120Hz. In addition muscle activation was recorded using surface-electromyography (Noraxon U.S.A. Inc©). All trials were performed using a virtual-reality welding simulator (Lincoln Electric©, VRTEX 360). Virtual-reality welding simulators are becoming more common during welding training as they are time efficient and allow the trainer to di-rectly observe the trainee whilst welding (Porter et al., 2006). All participants used the virtual-reality welding simulator for the first time. Based on the 3D trajectories of the markers a biomechanical full-body model was calculated using OpenSim 2.2.1 and Matlab software to obtain joint angle trajectories were obtained.

Results: Results show large inter-individual differences in welding movements between both experts and novices. Thereby, no clear trend between welding positions and posture was identifiable and individuals used different strategies to satisfy the spatial constraints. Experts in general welded much faster with greater precision as displayed by smaller movement variability thereby obtaining better results compared to the novices. Experts also better controlled the angle of the weld-ing gun with respect to the work piece.

Discussion & Conclusion: As the results show welders use rather individual solutions according to their own set of constraints. More successful welding is characterized by smaller movement variability of the end-point. Adopting a constrained-led perspective and based on the present research it seems therefore advantageous to adapt training strategies, which allow learners to find their own individual optimal solutions for a given welding situation (Button, Chow, & Rein, 2008). Thus, welding train-ing should include more variable training, which allows the learners to search the perceptual-motor workspace.

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RESEARCH INTO KINEMATICS OF MOTION OF PEOPLE AFTER STROKE

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Introduction: People, who survived a stroke, need a special, long lasting rehabilitation [5]. Whereas in many countries, with developed healthcare system, about 80% patients after stroke can start working again, in Poland this percentage is much more smaller. Plenty of people have problems with walking and executing simple daily activities. For this reason, a group of scientists and physicians from the Department of Applied Mechanics of Silesian University of Technology and the Upper Silesian Rehabilitation Center in Tarnowskie Gory works on the system, which is to enable objective estimation of condition of patients locomotion system and assessment how the rehabilitation progress run. This system will join standard examinations carried out by doctors, which are based on some medical tests, with motion analysis and mathematical modeling [1, 2].

Patients/ Material and methods: There are three groups of analyses of the patientâ€™s locomotion system carried out within the framework of this system: â€¢examinations carried out by doctors, based on Beck Depression Inventory, Barthel Index, Ashworth Scale, Brunnstrom Scale or Mini-Mental State Examination â€¢measurements of kinematic quantities, ground reactions and calculations of kinematic quantities as well as balance analysis. â€¢estimation of muscle forces and joint reactions. Kinematic quantities muscle forces and joint reactions are determined by means of mathematical models prepared by authors of this article [3, 4]. This paper concerns mainly the kinematic and ground reactions analyses. Examinations are conducted at the beginning of the rehabilitation process and after every three weeks of patient treatment (generally there are three measurements because six week treatment is the most common one in the Rehabilitation Centre). Measurements of kinematic and dynamic quantities are carried out for three tasks: walk along a measurement path, stand up from a chair and go up the step. Balance measurements are conducted as well. Measurements and analyses are carried out by means of Kistler platform, Zebris platform, set of camcorders, APAS System and mathematical models, prepared by authors of this article which enable determination of kinematic quantities such as joint angles or moments of muscle forces. All measurements were performed in the Upper Silesian Rehabilitation Centre â€œReptyâ€ in Tarnowskie Gory, Poland. There were 25 patients examined until now.

Results: Gait and going up the step analyses were carried out on the basis of such quantities as: courses of joint angles, ground reactions, time of gait cycle, duration of stance phase. Gait Gilette Index (GGI) parameters were used to conduct quantitative analyses. Analysis of standing up exercise was based only on ground reaction and force distribution carried out on the Zebris platform.

Discussion & Conclusion: Applied methodology enables objective analysis based on kinematic quantities and ground reactions. Such approach to the problem of estimation of rehabilitation progress broaden doctors knowledge and enables more individual patient treatment. The study was supported by research grant no. NN504083438 of the Ministry of Science and Higher Education in Poland.

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