Assessment of the Kinematic Variability between Twelve Shriners Motion Analysis Laboratories Part 2: Short term follow up

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Introduction

The field of motion analysis does not currently have any formal standards for data collection, communication of information, or quality assurance across multiple laboratories. Historically, laboratories have developed with little or no direct collaboration with other facilities. Efforts at multi-center research have been limited for many reasons, including inconsistent evaluation protocols and questionable data compatibility between laboratories using differing hardware and software [1]. For this field to produce effective collaborative research on a wide scale basis, standards need to be developed, reviewed and adopted in the areas of data collection, communication and quality assurance. Over the past several years, the Shriners Hospitals for Children have developed recommendations for standards for clinical examination, kinematic assessment and EMG technique. The goal of this project was to evaluate the change in between site variability following implementation of a standardized training program.

Statement of Clinical Significance

Variability of kinematic measurements between multiple sites participating in a collaborative research investigation is a primary factor in determining the number of test subjects and the level of detectable difference in a statistical analysis.

Methodology

Recommendations for a minimum standardized gait analysis protocol (MSGAP) were developed by task forces within the 12 Motion Analysis Laboratories in the Shriners Hospitals for Children system (SMALnet) [1]. Based on these recommendations, a standardized training program was developed and distributed for use in training staff. One review session was conducted with at least one representative from each SMALnet site attending to view and critique the training materials. A baseline assessment of between site variability of one test subject, collected prior to development of the training program, has been previously described [2]. Following 1 month using MSGAP for clinical studies, the same test subject visited each SMALnet lab within a 1 month period. At each lab the subject underwent a full kinematic assessment by at least one evaluation team. Ten of 12 labs utilized Vicon Motion Analysis data collection equipment (Oxford Metrics, Oxford, UK), the remaining 2 utilized Motion Analysis Corporation hardware and software (Motion Analysis Corporation, Santa Rosa, CA). Ten kinematic trials were collected and processed during each session using the protocol specified within the training materials. Cadence was controlled using a metronome. This resulted in 240 motion trials collected by 24 testing teams within the 12 hospitals.

Eight kinematic variables were analyzed for the subject's right side (Table 1). A predicted curve was created for each walk, clinician and site using multilevel modeling software. The mean predicted joint angles for each clinician were then analyzed using a general linear mixed effects model to investigate variability between sites, clinicians nested within site, and walks nested within clinician. Speed was analyzed as a covariate. Due to the large number of clinicians and sites, post hoc pair-wise comparisons were not performed.

Results

The mean predicted angles averaged over all 24 clinicians for the eight kinematic measures are shown in Table 1. There were significant differences between walks within a testing session for hip flexion and pelvic obliquity. All variables showed significant differences in the mean predicted angle between sites and between clinicians. Speed was a significant covariate for knee flexion, hip rotation and pelvic obliquity. Six of eight variables decreased in both standard deviation and range compared to the baseline assessment in 1999. On average there was a 14% decrease in the standard deviation, and 22% decrease in range of the mean predicted joint angle by clinician, averaged across all 24 clinicians.

Table 1 – Mean, standard deviation and range of the predicted angle for eight kinematic measures from one subject evaluated by 24 clinicians from 12 sites during 1999 and 2001. All measures are reported in degrees unless otherwise noted.

Parameter	Mean			StDev			Range		
	2001	1999	Change	2001	1999	% Change	2001	1999	% Change
Pelvic tilt	4.5	5.2	0.7	3.8	3.5	9%	13.9	14.8	-6%
Pelvic obliquity	0.3	0.3	0.0	1.1	1.3	-16%	3.6	6.0	-39%
Pelvic rotation	-2.0	-2.1	0.1	1.3	1.6	-18%	6.2	5.9	5%
Hip flexion	10.7	9.9	0.8	4.4	5	-11%	17.1	23.9	-28%
Hip rotation	-8.3	-5.0	3.3	7.6	7.3	4%	33.8	28.3	20%
Knee flexion*	24.4	20.0	4.4	3.0	4.6	-35%	9.3	17.3	-46%
Ankle dorsiflexion*	4.2	1.1	3.1	1.9	2.7	-29%	6.1	12.1	-50%
Foot progression	-14.0	-13.9	0.1	2.2	2.6	-14%	7.8	10.9	-28%
Average 24 clinicians			**1.6**	**3.2**	**3.6**	**-14%**	**12.2**	**14.9**	**-22%**

*Significant difference in the means from 2000 to 2001, pooled t-test, $p<0.05$

Discussion

Knee flexion and ankle dorsiflexion showed the greatest change in mean, standard deviation and range between the two assessments. This may be the result of a detailed discussion during the review session on understanding the relationship between the technical and anatomic coordinate systems, especially the location of the knee joint center, knee alignment device (KAD) and lateral femoral epicondyle marker. Hip rotation (defined by the position of the KAD) and pelvic tilt showed a mild increase in both range and standard deviation from 1999 to 2001. Concerns were raised at the training session that reliable placement of the KAD and the pelvic markers with respect to the underlying anatomic coordinate system were difficult to perform. These data suggest that additional training or alternative techniques for defining marker alignment goals should be explored.

In summary, there appears to be evidence that the standardized training program has resulted in moderately decreased variability among 24 clinicians at 12 sites. However, there continue to be significant differences that must be addressed before the data can be considered comparable.

References

[1] Davis RB, *et al.*, *A minimum standardized gait analysis protocol: Development and implementation by the Shriners Motion Analysis Laboratory Network (SMALnet)*, in *Pediatric Gait - A new millenium in clinical care and motion analysis technology.* Piscataway, NJ, 2000.

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Acknowledgments

This work was supported by funding from the Shriners Hospitals for Children, Tampa, FL. The authors would like to thank the staff of the Shriners Motion Analysis Laboratories in Springfield, MA; Philadelphia, PA; Erie, PA; Greenville, SC; Shreveport, LA; Houston, TX; Lexington, KY; Salt Lake City, UT; Chicago, IL; Spokane, WA; Portland, OR; and Sacramento, CA as well as Suzanne Doyle, Ph.D. for statistical support.