Table 1
Monte Carlo simulations on normalcy gait index: healthy children and cerebral palsy patients

	Type of walk	Normalcy index	2 S.D. (Monte Carlo simulations)
Asymptomatics			
56 Subjects	Normal	15.4 (5–30)	6
Diplegics			
Patient 1	Normal	38	9
Patient 3	Key-walker	670	40
	Canes	795	53
Patient 4	Key-walker	870	34
Patient 5	Normal	800	56
	Orthosis	603	52
Quadriplegics			
Patient 6	Normal	389	39
	Key-walker	385	34
Patient 7	Normal	1137	65
	Orthosis	496	42
	Shoes	482	36
Patient 8	Normal	2000	98

and NI contain sources of errors due to intrinsic system's error, marker placement, relative movement between skin and markers, and sensitivity of biomechanical model to these errors. These values should be taken into account during comparison between patient and normal subject, and between pre- and post-treatment for a patient.

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Gillette Gait Index is consistent with qualitative visual assessments of gait

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1. Summary/conclusions

The Gillette Gait Index (GGI) provides quantitative scores that are consistent with qualitative assessments of overall gait for individual patients with cerebral palsy (CP). This supports the validity of GGI as a useful summary measure for gait analysis.

2. Introduction

Modern gait analysis produces a large volume of data. While these data are highly informative for specific aspects of gait such as velocity or peak dorsiflexion in stance, a quantitative measure describing a patient's overall gait is not usually reported. The Gillette Gait Index (GGI), formerly called the Normalcy Index, has been proposed as a summary measure that takes into account 16 clinically important kinematic and temporal parameters [1]. Previous studies have shown that the GGI can detect differences in groups of subjects who either have different diagnoses or have undergone surgery [2,3]. However, to fully validate this measure for use in individual patients, studies are needed to evaluate the validity of the GGI on an individual level. The purpose of this study was to compare GGI scores with qualitative assessments of gait in individual patients. This is needed to determine if the GGI provides a reasonable summary score that clinicians and researchers can use as a global measure of gait in individual patients.

3. Statement of clinical significance

By demonstrating that the GGI is consistent with qualitative assessments of overall gait for individual patients, this study helps to establish validity of this measure for quantifying patient status and clinical outcomes.

4. Methods

Pre- and 1-year postoperative gait analysis and video data were examined for 25 children with CP who underwent multilevel lower extremity orthopaedic surgery to correct gait problems. The gait analysis data were used to calculate the GGI [1]. 12 raters, including 3 experienced gait laboratory physical therapists (PTs), provided qualitative scores for each subject's gait based on the videotape recordings. While there was no set time period for watching the videos, most raters completed the study in a single session.

First, the raters watched the 25 pre- and 25 post-operative videos mixed together in random order, along with six repeats (56 videos total). Each video was rated as 1 = minimal impairment, 2 = moderate impairment, 3 = substantial impairment, 4 = severe impairment. Results are presented for overall walking ability; similar results were obtained for walking efficiency and for stability and balance. Next, the raters watched each patient's pre-operative video followed immediately by the post-operative video. The pre- to post-operative change was rated as 3 = significantly improved, 2 = moderately improved, 1 = slightly improved, 0 = not much better or worse, −1 = slightly worse, −2 = moderately worse, −3 = much worse.

Kappa statistics were used to evaluate intra- and inter-rater reliability of the video ratings. The Kruskal–Wallis test was used to compare the raters' assessments of change when viewing the pre- and post-operative videos separately versus together. Scores between −1 and −3 were combined in the Kruskal–Wallis analysis since only a few scores fell in this range. Linear regression was used to compare the GGI scores with the mean video ratings.

5. Results

There was moderate agreement between the raters' first and second assessments of the six repeated videos (Weighted Kappa = 0.52). Of 72 pairs of ratings, 42 (58%) were exactly the same, 29 (42%) differed by ±1, and only 1 (1%) differed by ±2. Agreement among the 12 raters was fair for assessment of the individual videos (Kappa = 0.25). Agreement was higher among the gait laboratory PTs (Kappa = 0.31) compared with the other raters (Kappa = 0.22) and for scores at the ends of the scale (Kappa 0.32–0.52 for scores 1 and 4) than for intermediate scores (Kappa 0.09–0.23 for scores 2 and 3). Agreement among the raters was lower for pre- to post-operative change (Kappa = 0.11). Agreement was highest for scores of −1 (Kappa = 0.37) and 3 (Kappa = 0.53) among the gait laboratory PTs although even the PTs had only slight agreement in the intermediate scores (Kappa < 0.08).

Raters tended to score patients as having greater improvement when the pre- and post-operative videos were viewed together compared with when the videos were viewed separately. 270 (73%) of the scores given when viewing the videos together indicated improvement, but only 138 (37%) of the pre-operative scores improved post operatively, with 192 (52%) remaining unchanged. Using the mean pre-operative, post-operative, and change scores from all raters, there was a highly significant relationship in the assessment of improvement between viewing the videos separately versus together ($P = 0.0001$).

The GGI scores reflected the mean video ratings pre-operatively ($P = .003$), post-operatively ($P = .005$), and in pre- to post-operative change ($P = .006$ for absolute change; $P = .02$ for %change). One subject was a clear outlier and was excluded from the analyses. This subject demonstrated substantial improvements in dorsiflexion which led to a mean score of 1.5 from the raters, but had a worsening in GGI due to deterioration of less visual variables such as range of pelvic tilt and time to peak knee flexion in swing.

6. Discussion

The raters differed in some individual ratings and tended to note more improvement when viewing the pre- and post-operative videos together. However, using mean scores from the group as a whole, there was good correlation between viewing the videos separately versus together. The mean scores therefore provide a reasonable basis for comparing the GGI scores. The GGI scores were consistent with these mean scores in 24 of 25 patients.

The one outlier demonstrates the difference between the visual and quantitative assessments of gait. While the visual ratings were primarily influenced by the patient's obvious improvement in dorsiflexion, this improvement was outweighed by worsening of several less visual variables in calculation of the GGI. Both assessments are "true"; the difference lies in the relative weight given to different variables. The quantitative assessment is able to account for more variables. Other variables and different weightings could be implemented if desired.

A previous study performed detailed visual analysis of specific gait variables by persons experienced in gait analysis to calculate the Edinburgh Gait Score (EGS) [4]. This study found high correlations between EGS and GGI. Our study differs by assessing gait globally rather than in terms of specific gait variables. Taken together, the two studies suggest that the GGI is a valid measure for assessing overall gait in individual patients.

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Gaitabase: New approach to clinical gait analysis

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1. Summary/conclusions

A web interfaced repository for gait analysis data, the GAITABASE, has been established. It allows users anywhere in the world to contribute data and to view all the data selected for specific groups of subjects and specific conditions of data capture. Its use has been illustrated in the context of a mock cohort study of children with CP who have undergone single-event multi-level surgery which includes data from two centres in USA, one in Europe and one in Australia.

2. Introduction

Decision-making in clinical gait often relies on comparing gait patterns from populations with and without gait pathology. Such comparison, however, requires dataset from large sample size population differed by age and gender, which in most cases does not exist [1–4]. The objectives of a valid international gait analysis repository will be to allow orthopaedic surgeons, physiotherapists, biomechanical engineers, and human movement specialists to share data from large population, create and select large normative dataset, and to give a valuable insight into how effective specific interventions have been for others. Lately, researches began to build gait analysis repository in their own local laboratories [5,6]. Unfortunately, these repository systems did not provide the capability of sharing gait patterns between national and international clinics and research groups. Moreover, they were still limited by the small patients sample size.

We present here the GAITABASE, a web interface database for gait analysis, that in the future will provide ways of collecting and collating, and accessing data from all participating clinical and research centres around the world. Four main concepts are implemented to ensure that the system is flexible: (1) secure archiving of processed gait data, (2) flexible personalised filter mechanism that allow users to create criteria for querying gait data, (3) visualising the results in appropriate tables and graphs, (4) export query results for statistical analysis.

To illustrate the benefits of GAITABASE we will present a case study of Cerebral Palsy patients where gait analysis was performed before and after an intervention.

3. Statement of clinical significance

GAITABASE is a valuable resource and tool for the international clinical and research community. It provide ways of sharing data from all participating centres to establish normative and pathology datasets of much larger numbers of patients than could be achieved by any single centre. The accumulated stored data will facilitate clinicians in comparing their own gait data with others, and will give a valuable insight into how effective specific interventions have been for others.

4. Methods

GAITABASE is web-based interface utilising MySQL database, HTML, CSS, JavaScript, PHP, and Fusebox 3.0, which is hosted by the Royal Children Hospital and accessed through the Murdoch Children's Research Institute web site. Stored data include: (1) patient's data such as code, pathology, gender, (2) temporal-spatial parameters such as walking speed, stride length and cadence (as measured by GaitRite system), and (3) time-normalized 3D kinematic and kinetic data (joint angles, moments, powers) which are uploaded from c3d files. Ethical approval has been obtained to receive, store and publish de-identified gait data. Contributors of data will have to obtain ethical approval from their own institutions to contribute data.

To illustrate the potential of the GAITABASE and to test whether users in different countries would be able to contribute data, a mock cohort study of progress of children following single event multi-level surgery for children with diplegic cerebral palsy was set up. Users in USA, Europe, Australia and New Zealand were approached to contribute pre-operative and 1 year follow-up data.

5. Results

The GAITABASE web interface allowed the user to add, view, edit, import, and export patient's gait data. Users from two centres in the USA, one in Europe and one in Australia contributed data of five CP children to the mock cohort study. Fig. 1 shows pre-operative and follow-up data of one CP child with mean ±1 S.D. of 10 children without pathology.

6. Discussion

This exercise proved that the concept of the GAITABASE can work. Several of the users approached for gait data envis-