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Research article

Title: Evaluation of the feasibility of the use of the Edinburgh Visual Gait Score (EVGS) for the assessment of gait in children with cerebral palsy.

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Abstract

Background/Aims: The aim of this study was to investigate the use and scope of observational gait analysis in every-day physiotherapy practice. The Edinburgh Visual Gait Score (EVGS) is proposed as a simple and cost-effective tool for use in every-day practice, when instrumented gait analysis (IGA) is not available. The primary goal was the evaluation of the feasibility of the use of the EVGS in the assessment of the gait of children with cerebral palsy (CP) and the second was to assess whether the EVGS was sensitive enough to note changes following intervention. Finally, the relationship between the EVGS scores and the 10m walk-test performance was examined.

Methods: A feasibility study was conducted using the EVGS, the 10m walk-test and simplified video analysis software. Ten children with CP were recruited from two private physiotherapy practices in Greece.

Findings: The EVGS was a quick and easy to use tool when assessing the gait pattern of children with CP. A Wilcoxon test showed a statistically significant improvement in the total EVGS score (left side: $z= -2.395$, $p=0.017$, right side: $z=-2.392$, $p=0.017$) following a two-month course of physiotherapy treatment. The Spearman's correlation test showed no statistically significant correlation between the EVGS scores and the walking speed.

Conclusions: It was feasible to use the EVGS in children with CP to assess the treatment outcome on gait parameters after intervention. It may be sensitive enough to note changes after two months of physiotherapy intervention. Our results indicate that the difference in movement quality does not always relate to walking speed. Future researchers should investigate the relationship between the two.

Key words: observational gait analysis, cerebral palsy, Edinburgh Visual Gait Score, children

Introduction

There are limited published studies of the use of simple gait assessment tools in clinical practice. Instrumented gait analysis (IGA), using three-dimensional motion analyses systems, is extensively used to objectively assess gait abnormalities of children with cerebral palsy (CP) in a laboratory environment. IGA is reported to be the most accurate, valid and reliable measurement system (Bella et al 2012). Nevertheless, IGA is an expensive, time consuming technique and requires a high level of interpretation. Thus, every-day clinical practice needs a simpler and cost-effective alternative to assess the gait of children (Harvey and Gorter 2011, Bella et al 2012, Rathinam et al 2014).

Observational gait analysis is more feasible to implement as it has low cost and does not require high technology equipment (Bella et al 2012). In observational gait analysis, the clinician assesses the gait cycle visually by using video recordings to facilitate the analysis of the gait cycle (Whittle 2007, Pountney 2007, Kawamura et al 2007). Visual observation allows the assessment of movement in two planes, the sagittal and the coronal. The videotaping technology gives the ability of slow motion or freezing image that facilitates the analysis of actions that happen at the same time. It allows the therapist to repeatedly watch the video to observe each part of the body independently so reducing the actual number of walks required of a subject (Grunt et al 2010, Borel et al 2011).

Several observational scales have been developed to standardize, systematize and quantify observational gait analysis aiming to further the evaluation of treatment and the decision making. Some of the main scales used are the Physicians Rating Scale (PRS), the Visual Gait Assessment Scale (VGAS), the Observational Gait Scale (OGS) and the Edinburg Visual Gait Scale (EVGS) (Dickens and Smith 2006, Bella et al 2012, Rathinam et al 2014). According to Rathinam et al (2014) systematic review, five observational tools for children with CP were found but their reliability and validity compared with IGA varied.

The EVGS is a complete video assessment scale created for the assessment of gait of children with cerebral palsy. EVGS consists of 17 gait parameters that represent key features of pathological gait in all three planes in children with CP. These include the foot, knee, hip, pelvis and trunk in both stance and swing phase. It uses a three-point ordinal scale to specify the normal, moderate and marked deviation from normal movement range which was estimated from IGA. The maximum total score is 34 where 0 indicates normal and >0 abnormal gait. It was suggested that it is more important to use the total score for the evaluation of the outcome rather than the individual joint scores. Also, a minimum difference of 3 in the score is required for each limb of an individual child to be clinically significant (Read et al 2003, Gupta et al 2012, Rathinam et al 2014). It has acceptable intra-observer and inter-observer reliability in both experienced and inexperienced observers (Read et al 2003, Rathinam et al 2014, pp. 283, Gupta et al 2012).

Physical rehabilitation is part of usual care for children with CP and physiotherapy forms an important part of this. A frequent goal of treatment is to improve walking quality and function. However, most clinicians will not have access to gait laboratories, so it is useful for clinicians to use measurement tools that can show changes that may occur with typical rehabilitation programs. The EVGS is proposed as a simple and cost-effective tool for use in every-day clinical practice, when Instrumented gait analysis (IGA) is not available (Read et al 2003, Harvey and Gorter 2011, Rathinam et al 2014, Robinson et al 2015). The EVGS appears to have higher reliability and validity compared with the other tools, it has a strong agreement with the kinetic evaluation methods and it seems to be sensitive enough to note changes following intervention (Read et al 2003, Ong et al 2008, Bella et al 2012). However, there has been little exploration of the implementation and practicality of its use in day to day practice.

This study reflects a real-life treatment situation for many children with CP. If the EVGS and 10m walk test can demonstrate changes after a typical period of treatment, this will be useful for clinicians. The aim of this study was to investigate the use and scope of observational gait analysis in every-day physiotherapy practice, as its use in clinical practice was poorly supported due to limited published studies. The primary aim was the evaluation of the feasibility of the use of the Edinburgh Visual Gait Score (EVGS) in clinical practice, to assess the treatment outcome on gait parameters of children with CP. The secondary aim was to assess whether the EVGS was sensitive enough to note changes after usual care of two months of physiotherapy intervention. We aimed to see whether there was a significant difference between the total EVGS scores of the first session and the total EVGS scores of the second session for the left and right sides. The third aim was to examine if there was a relationship between the EVGS scores and the 10m walk-test performance.

The research objectives derived from our aims and created the research hypothesis:

Feasibility hypothesis 1: The EVGS will be a quick and easy to use tool when assessing the gait pattern of children with CP.

Experimental hypothesis 1: The EVGS will be sensitive to change following usual treatment and will show a statistically significant difference between the total EVGS scores of the first session and the total EVGS scores of the second session for the left and right sides.

Experimental hypothesis 2: There will be a statistically significant correlation between the average walking speed and the EVGS scores.

Methods

Study Design

A feasibility study was conducted to evaluate the ease of the use of the EVGS when assessing the gait of children with CP. The gait pattern of ten children with CP was assessed, using the EVGS, the 10m walk-test and simplified video analysis software. The study was approved by the research ethics committee of ATEI Thessaloniki in Greece on 21/5/2015 under the protocol number of ΔΦ 31.5/1951/21-5-2015 and received a favorable ethical opinion from the Faculty Research Ethics Committee (FREC) of St George's University of London. The parents of each child were informed about the purpose of the study and Information sheets and Informed Consent Forms were administered to everyone. The consent was voluntary. The need, the value and the risks and benefits of the study were explained in writing and verbally, with simple meanings so that they could understand the process. All information gathered was maintained in a strictly confidential manner. The only people who had access to the information were the researchers. In the reporting of the project, no information was released which would enable the reader to identify who the respondent was.

Participants

For the implementation of the research study, ten children diagnosed with CP were recruited from two private physiotherapy practices in Greece. A convenience sample of children was identified by the treating physiotherapists. Six females and four males participated, between 5 and 13 years old. Five of them had spastic diplegia, three of them had spastic hemiplegia and the other two had other types of CP. The children that were included could walk independently without the use of assistive devices or orthoses and there was no age or sex limitation. Also, the children were capable to comprehend and perform simple commands. The exclusion criteria included lower limb orthopedic surgery within the past 6 months and botulinum toxin injections into the leg muscles within the past three months.

Procedure

To evaluate the feasibility of the use of the EVGS and to examine if the EVGS was sensitive to change, the gait pattern of each child was video recorded before and after 2 months of physiotherapy intervention (June 2015 to August 2015). The video recordings for each child were observed after the first and the second measurement, by using the video analysis software and were scored with the EVGS. Each limb was scored separately and the total scores were calculated independently. The data were collected and scored by the researcher, who is a professional paediatric physiotherapist with two years of working experience with children with CP and a particular interest in gait analysis methods. As a result, the scorer was not blinded to when the videos were recorded. The average time taken to score with the EVGS and the time spent to complete the video recordings were counted by the observer. The physiotherapy program was provided by two different experienced physiotherapists and they were asked to focus on gait during the intervention. The intervention consisted of balance exercises, strengthening and training in activities of daily living and gait re education. Each child was expected to attend approximately 16 sessions (twice per week) within two-month period.

Video recording

During the procedure, the children were asked to walk a marked distance of 10m at their self-selected speed. To record the sagittal plane, the camera was placed on a 3m distance and the video was captured from both sides. The children were asked to walk 4 times from one direction to another trying to capture the whole body and zoom in from the pelvis and downwards. For the frontal plane, two different cameras were placed on the two sides (at the front and back of the walkway) to catch the movement from both sides at the same time. The cameras focused at the level of the sacrum and remained fixed during the procedure. They were requested to walk across the marked pathway twice and were given 1-3 minutes of rest when necessary. The younger children were recorded wearing only their underwear. The older children were asked to bring shorts so that the greater part of the leg was visible. All children walked barefoot. Additionally, anatomical landmarks such as the patellar, the knee caps, anterior superior iliac spines and the calcaneum were marked using colorful markers or shiny stickers to help with the visibility of the recordings.

The analysis was performed by using the Kinovea 0.8.15 software (Figure 1)

(Figure 1 here)

10m walk-test

To explore if the difference in movement quality relates to function, we used the 10m walk-test to assess the functional mobility of the children and examine if there was a relationship between the EVGS scores and the average walking speed (Graham et al 2008).

The 10m walk-test provides important clinical information regarding walking abilities and outcomes in these children. It is considered safe, easy to implement and inexpensive. It has excellent test-retest and interrater reliability in adults with traumatic brain injury and has a potential applicability for children with CP (Thomson et al 2008, Clark et al 2013).

A different trial to the EVGS recording was given for the 10m walk test. A ten-meter distance was defined and marked on the floor. The children were instructed to walk fast until they were told to stop. The time taken to walk 10m was recorded by using a digital stopwatch. Also, the assessor demonstrated prior to the measurement what fast walk looks like in comparison with the running. The test was repeated three times and the average score was calculated. A practice trial was given.

Equipment

A video camera and a mobile phone camera of high quality were used for the recording. The video recordings were transferred to a computer and the Kinovea 0.8.15 software was downloaded to facilitate the analysis. The mobile phone's stopwatch was used for the 10m walk test. Also, a measure tape was needed to measure the 10m distance and a colorful scorer and stickers to mark the bony landmarks.

Statistical Analysis

SPSS statistics software (Version 20) and the Microsoft Office Excel 2007 were used for the data entry and analysis. Descriptive statistics were used to analyze the data: the median difference of the total EVGS scores and the mean difference of the average walking speed, before and after the intervention, were calculated. Furthermore, the Wilcoxon test was used for two related samples to examine if there was a statistically significant difference between the total EVGS scores of the first measurement and the total EVGS scores of the second measurement for both sides of the body separately. Also, paired sample T-test was used to identify if there was a significant difference between the average walking speed before and the average walking speed after the intervention. Finally, the Spearman's correlation test was used to examine if there was a correlation between the total scores of the EVGS and the walking speed and reach a conclusion. $P<0.05$ was considered statistically significant.

Findings

Feasibility of using the EVGS

The study was successfully executed from the beginning to the end without significant difficulties and took approximately 60 minutes in total per child. The researcher was able to conduct the measurements within the limited space of two different private practices with minimal use of equipment and help of colleagues. It also required minimal preparation to set up the space and follow the instructions to conduct the measurements.

Only simple instructions were required to videotape the walking of the children following the instructions and scoring the EVGS was straightforward using the appropriate video analysis software and documentation. It took less than 10 minutes to video-record each child. Initially it took 1 hour to observe and score the 17 items for each child but the average observation time decreased as the observer became familiarized with the process. After the first 4 patients, the researcher was able to score a child in 40 minutes. An average of 3 repeats of the videos was needed, using the ability of slow-motion, zooming, freezing screen and measuring the ankle of the joints, to score the items. Some were easier to observe requiring less time and fewer repeats to score them.

Ankle dorsiflexion at initial contact was the most straightforward event to observe and knee flexion during swing phase and the peak hip flexion were the most challenging events to observe. It was more difficult to score the knee items, such as the peak extension in stance and terminal swing position, compared to foot and hip items. Moreover, most of the changes in the scores occurred at the knee, the obliquity of the pelvis and the peak hip flexion during swing. It was harder to compare the two sides of the pelvis in relation to the hip placement. Also, the observation of the lateral displacement of the trunk was evaluated as challenging as it was not feasible to put markers.

Comparison before and after physiotherapy treatment

In order to analyze the existing data we used descriptive statistics for all of the variables. The statistic box that appears (Table 1) includes the mean, median, standard deviation, range, minimum and maximum. We notice that there was a 3.5 point improvement of the median EVGS scores of the left side (median EVGS_1 (left)=14.5 and median EVGS_2 (left)=11) and a 2 point improvement of the median EVGS scores of the right side (median EVGS_1(right)=13.5 and median EVGS_2(right)=11.5). Also, the mean average gait speed before and after intervention was increased by 0.01 m/s (mean average walking speed 1=1.30m/s and mean average walking speed 2=1.31m/s) (Table 1).

(Table 1 here)

Additionally, the total EVGS scores before and after the intervention and the average walking speed were presented for each child separately (Table 2). We noticed that the C4, C5 and C10 had a clinically significant change of the total score of the left side ≥3 points (Gupta et al 2012). Also, the C1, C3, C4 and the C5 had a clinically significant change of the total score of the right side too (Figure 2).

(Table 2 here)

(Figure 2 here)

Inferential statistics

The Wilcoxon test was used for two related samples and showed that the improvements observed after therapy in the total EVGS score were statistically significant on the left ($z= -2.395$, $p=0.017$) and on the right side ($z=-2.392$, $p=0.017$). The EVGS picked up a significant change between the two-time points and as a result the null hypothesis was rejected.

The paired sample T-test, however, demonstrated that there was no statistically significant difference between the average walking speed before after the physiotherapy intervention ($t=0.079$, $p=0.9$).

Relationship between the EVGS and 10m walk test

Finally, the Spearman's correlation test was performed between the baseline total EVGS scores and the walking speed plus between the difference in the EVGS scores and the difference in the average walking speed to examine if there was a relationship between them. The tests demonstrated that the EVGS scores and the walking speed were not significantly correlated (Table 3).

(Table 3 Here)

Discussion

The aim of this study was to investigate the use and scope of observational gait analysis in every-day physiotherapy practice, as its use in clinical practice was poorly supported due to limited published studies. A feasibility study was conducted aiming to support clinicians by presenting in-depth research that leads to relevant intervention in every-day practice (Bowen et al 2010). We examined the feasibility of the use of the Edinburgh Visual Gait Score (EVGS) to assess the treatment outcome on gait parameters of children with CP. Bowen et al 2010 has proposed several areas of focus for feasibility studies. The feasibility analysis focused on the exploration of the implementation and practicality of the use of the EVGS and its expansion and efficacy in clinical practice. To accomplish this, we examined the possibility and method of implementation while time and resources available were limited (Bowen et al 2010). We found that the EVGS was a quick and easy to use tool when assessing the gait pattern of children with CP. The study was successfully implemented without major difficulties. It did practically work as it required simple equipment that was already available to the researchers and a marked distance of 10m in both private practices. It did not take long to prepare for the implementation of the measurements by simply reading the instructions provided. The time needed to analyze and score the videos for each child was less than an hour and it required only video-recording and simplified video analysis software to be able to observe and score the gait of children with CP. The reasonable time needed for the analysis and the simple and low cost equipment makes it feasible for the clinicians who do not have access to gait laboratories to use the EVGS in every-day practice and gives value to this study which reflects a real life treatment situation for many children with CP.

Secondly, part of the feasibility analysis was the examination of the use of the EVGS in everyday practice by clinicians to assess possible changes of the gait pattern in children with CP. The comparison before and after physiotherapy treatment showed that it is worth using the EVGS to assess gait in children with CP and that it is feasible to implement in day to day practice. The EVGS identified changes in the gait of children with CP after two months of physiotherapy intervention and showed a statistically significant difference between the total EVGS scores before and after the intervention for both sides. The current findings agreed with the previous studies of Read et al (2003),Bella et al (2012), Rathinam et al (2014)and Robinson et al (2015), who supported the use of the EVGS as a worthwhile measurement tool to assess gait in children with CP, when 3D gait analysis is not available, in order to evaluate the treatment outcome.

The total scores of each individual child were observed. Previous studies supported that it was meaningful to evaluate the total scores of the EVGS and that a minimum change of 3 points was considered significant (Read et al 2003, Gupta et al 2012). Despite the variability in the number of treatments, significant changes were recorded in the total score after the intervention (Figure 2). These changes could have arisen due to the physiotherapy intervention but it may have also occurred because of the nature of the disease and development of the child. Moreover, the fact that the observer was not blinded may have influenced the results. The improvement in gait assessment may have also made changes more apparent. For example, the participant C5, who had 4-point improvement of the total scores for both sides, had athetosis which presented a great variety of gait patterns and could confuse the observer. However, the video recordings allowed the observer to repeatedly assess the gait pattern several times before scoring with the EVGS and the most usual gait pattern was counted. Also, the difficulty in observing some of these items could explain the changes in the scores. For example, most of the changes in the scores were occurred for the knee, the obliquity of the pelvis and the peak hip flexion during swing which were some of the most difficult events to observe. In particular, it was harder to compare the two sides of the pelvis in relation to the hip placement. Children with CP usually have rotational abnormalities in their gait pattern in combination with the problems in the sagittal plane and the clothing that makes it difficult to visually observe the hip angle (Brown et al 2008). Besides the difficulties, the pelvic obliquity could be reliably evaluated visually and there was an agreement with Kawamura et al 2007. Negative change of score seemed to occur for the children with fewer treatments. These findings were consistent with earlier studies (Read et al 2003, Kawamura et al 2007, Ong et al 2008, Viehweger et al 2010).

The third goal was to assess if there was a relationship between the EVGS scores and the 10m walk-test performance. It was found that the EVGS scores and the walking speed were not significantly correlated. This was contrary to the expectation of the research team due to the assumption that improved gait quality would lead to better functional gait. It is possible that the sample was too small to identify a statistically significant relationship. The number of treatments was not equal for all the children (Table 2) and that could affect the overall results. Also, a two-month period might not be long enough to note changes in overall gait speed and functional mobility.

Another influencing factor may be that the children were instructed to walk fast during the 10m walk-test, per standard guidelines, in contrast with the EVGS video-recordings which were performed in their self-selected speed. These differing instructions could have affected the relationship between the two variables as the tasks will have been subtly different. In a recent study, Graser et al 2016 examined the test-retest reliability of the 10m walk-test performed at preferred speed and maximum speed (10MWTmax) and found low relative and absolute reliability of the 10MWTmax. It seems that the difference in movement quality does not always relate to function. Future researchers should investigate the relationship between the two.

Limitations of the Study

The results of the study may not be generalized to a larger population but could be applied to every day physiotherapist practice. The data were collected and analyzed by the researcher and as a result it was not possible to be blinded and the results may be biased. With a longer recruitment period, a larger sample could have been recruited and this should be considered for future work. Also, a longer period should be given within the two measurements to increase the possibility of measurable change occurring due to the intervention, rather than the risk of differences due to chance or type 1 error.

Another limitation was the time and the conditions under which the study was conducted. The summer period was not very convenient for the measurements as some of the participants decided to interrupt the physiotherapy program for personal reasons. Also, technical difficulties during videotaping may have influenced the quality of the videos and may have affected the accuracy of the observations.

Conclusions

This study has demonstrated that it was feasible to use the Edinburgh Visual Gait Score (EVGS) in children with CP to assess the treatment outcome on gait parameters after a period of physiotherapy intervention. The EVGS is a quick and easy to use tool for the assessment of the gait of children with CP. It has the potential for utility for clinicians who do not have access to gait laboratories to use the EVGS in every-day practice and gives value to this study as it reflects a real-life treatment situation for many children with CP.

It appears sensitive enough to note changes after two months of physiotherapy intervention and showed a statistically significant difference between the total EVGS scores of the first and the second session. However, no statistically significant correlation was found between the EVGS scores and the walking speed. It seems that the difference in movement quality does not always relate to function. Future researchers should investigate the relationship between the two. Moreover, future follow up study with more than one observer should be conducted to instigate blinding, explore inter and intra-rater differences.

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Conflict of interest: None

KEY POINTS

- The primary goal was the evaluation of the feasibility of the use of the Edinburgh Visual Gait Score (EVGS) to assess the treatment outcome on gait parameters of children with CP.
- Ten children diagnosed with CP were recruited, six females and four males, between 5 and 13 years old.

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Tables

Table 1. Descriptive statistics for the group values.

		Age of participant	**Number of treatments**	**EVGS_1 session total score(left side)**	**EVGS_2 session total score(left side)**	**EVGS_1 session total score(right side)**	**EVGS_2 session total score(right side)**	**average walking speed 1^{st} session**	**average walking speed 2^{nd} session**
N	Valid	10	10	10	10	10	10	10	10
	Missing	0	0	0	0	0	0	0	0
Mean		8	8.7	15.3	13.2	14.9	12.9	1.30*	1.31*
Median		8	9	14.5*	11*	13.5*	11.5*	1.25	1.29
Std.Deviation		3.09	5.5	6.7	7.52	7.09	6.96	0.36	0.23
Range		8	14	23	23	20	21	0.97	0.77
Minimum		5	2	7	6	8	5	0.86	1.03
Maximum		13	16	30	29	28	26	1.83	1.8

*median EVGS_1 session total score (left side)=14.5>median EVGS_2 session total score (left side)=11, median EVGS_1 session total score (right side)=13.5>median EVGS_2 session total score (right side)=11.5, mean average gait speed 1^{st} session=1.30m/s>mean average gait speed 2^{nd} session=1.31m/s.

Table 2. Representation of the total EVGS scores and the average walking speed before and after the intervention for each child

	NT	EVGS_1L	EVGS_2L	EVGS_1R	EVGS_2R	avspeed_1	avspeed_2
C1	16	7	6	8	5	1.07	1,1
C2	16	30	29	28	26	0.86	1.27
C3	14	11	9	11	8	0.92	1.17
C4	10	15	8	15	11	1	1.06
C5	4	17	13	25	21	1.18	1.03
C6	11	10	8	8	6	1.77	1.8
C7	2	17	18	8	8	1.72	1.46
C8	3	22	21	19	19	1.37	1.49
C9	3	14	14	13	13	1.83	1.41
C10	8	10	6	14	12	1.33	1.32

*NT=Number of treatments; EVGS_1L=the total score of the EVGS of the 1st session for the left side; EVGS_2L=the total score of the EVGS of the 2nd session for the left side; EVGS_1R=the total score of the EVGS of the 1st session for the right side; EVGS_2R=the total score of the EVGS of the 2nd session for the right side; avspeed_1=the average walking speed of the 1st session(m/s); avspeed_2=the average walking speed of the 2nd session(m/s).

Table 3. Correlation of EVGS scores and average walking speed (m/s)

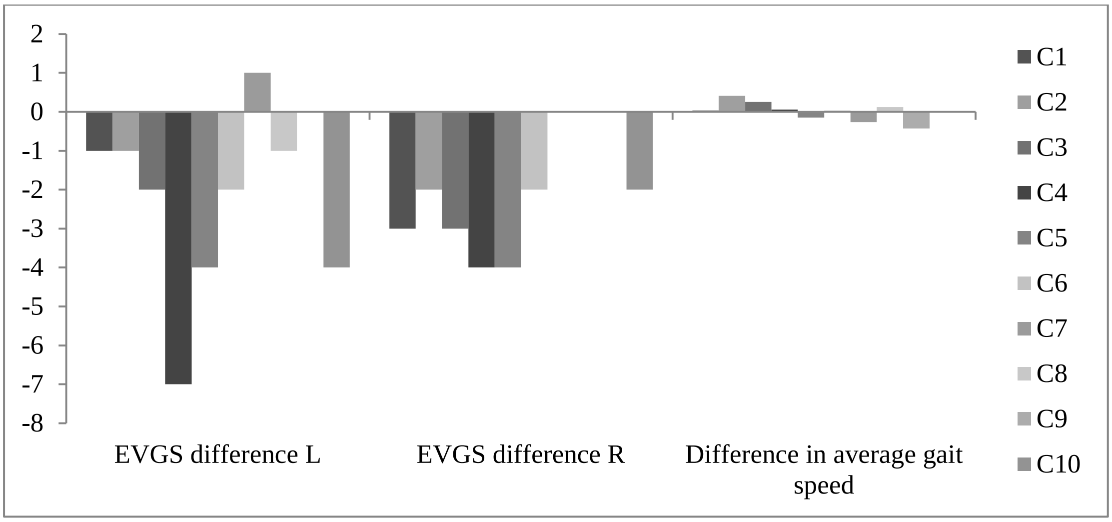
Spearman Correlation	**R**	**P value**
EVGS_1L versus Avspeed_1	-0.17	0.62
EVGS_1R versus Avspeed_1	-0.42	0.22
EVGS_2L versus Avspeed_2	-0.28	0.43
EVGS_2R versus Avspeed_2	-0.14	0.70
EVGS_diff L versus difference in Avspeed	-0.23	0.50
EVGS_diffR versus difference in Avspeed	-0.26	0.46

* EVGS_1L=the total score of the EVGS of the 1st session for the left side; EVGS_1R= the total score of the EVGS of the 1st session for the right side; EVGS_2L= the total score of the EVGS of the 2nd session for the left side; EVGS_2R= the total score of the EVGS of the 2nd session for the right side; Avspeed_1=the average walking speed of the 1st session(m/s); avspeed_2=the average walking speed of the 2nd session(m/s); EVGS_diffL=the difference in the scores of the EVGS of the left side; EVGS_diffR=the difference in the scores of the EVGS of the right side; difference in Avspeed= the difference in the average walking speed.

Figures

Figure 1.Measuring the ankle of the joints with Kinovea software.

Figure2.Representation of the difference in the EVGS scores of the left side, the difference in the EVGS scores of the right side and the difference in the average walking speed (m/s).



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