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RESEARCH

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Psychometric properties of the Edinburgh Visual Gait Score in children with spastic cerebral palsy

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Abstract

Background To our knowledge, no other studies investigated the internal consistency of the Edinburgh Visual Gait Score (EVGS). The aim of our study was to determine the reliability and construct validity of the EVGS in children with cerebral palsy (CP).

Results A total of fifty children with CP were enrolled in the study. Participants were evaluated with Gross Motor Function Classification System (GMFCS), Wisconsin Gait Scale (WGS), Gillette Functional Assessment Questionnaire (Gillette FAQ), Timed Up and Go Test (TUG), and EVGS (Rater-A and Rater-B). Slow-motion video analysis was used for the visual gait analysis. The inter-rater reliability, internal consistency, and construct validity of the EVGS were analyzed. The intraclass correlation coefficient (ICC) of the EVGS total score was 0.947 (CI: 0.90–0.97). Inter-rater reliability was excellent (ICC>0.80). The Cronbach's alpha value was 0.936, within the acceptable range (0.70<α<0.95). In addition, the standard error of measurement (SEM_{95}) and minimal detectable change (MDC_{95}) scores of EVGS were 1.72 and 4.78, respectively. The correlation values of EVGS (Rater-A) and GMFCS, TUG, GFAQ, and WGS were 0.494, 0.661, −0.663, and 0.611, respectively. On the other hand, the correlation values of EVGS (Rater-B) and GMFCS, TUG, GFAQ, and WGS were 0.492, 0.664, −0.714, and 0.757, respectively. Except for comparison with GMFC, EVGS was highly valid in all other correlational analyzes (r>0.50). EVGS had moderate validity with GMFCS for both raters.

Conclusion The EVGS was reliable and valid. Internal consistency of the EVGS is high, indicating a consistent structure to assess gait in children with CP.

Keywords Cerebral palsy, Edinburgh score, Gait assessment, Video analysis

Background

Cerebral palsy (CP) is a non-progressive loss of motor function, posture, and movement that restricts the movement due to fetal or perinatal damage to the developing brain [1]. The prevalence of CP in the world has been reported as 2–3 per 1000 live births [2, 3]. In Turkey, the prevalence has been reported as 4.4 per 1000 live births [4]. Permanent brain damage may develop with the emergence of risk factors in the etiology of CP in the prenatal, perinatal, and postnatal periods. The clinical progression may change over time depending on the child's development and other factors. Motor and sensory dysfunctions are common symptoms in children with CP [5]. As a result, the walking function is restricted to varying degrees. In a study by Shahid et al. on 96 children, it was stated that gait abnormalities vary according to the type of cerebral palsy and the condition of the child [6]. One of the essential physiotherapy and rehabilitation

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program goals in children with CP is to gain walking function. Therefore, visual gait analysis is crucial in the rehabilitation process. The visual gait analysis could be conducted by taking video-based recordings. Recordings taken from different angles such as sagittal, coronal, and vertical planes present detailed data on gait pathologies and provide more advantages than routine observation, owing to its features such as replaying in slow motion [7, 8]. The evaluation of gait function could be conducted with tools such as "Gross Motor Function Classification System (GMFCS), Timed Up and Go Test (TUG), Gillette Functional Gait Assessment Questionnaire (Gillette FAQ) and Wisconsin Gait Scale (WGS)" [9]. However, no gait assessment tools are available in the clinical practice to provide satisfactory reliability in various gait problems and patterns in children with CP. "Edinburgh Visual Gait Score (EVGS)" is one of the most comprehensive gait analysis scoring systems used in children [10]. It is a proven method in clinical follow-up because it is cost-effective, easily accessible, and applicable in the clinical setting and allows repetitive recordings [7, 11, 12]. Studies have also found that EVGS is reliable and valid for use in children with CP [11, 13, 14]. EVGS was found to be valid and reliable in different case groups and studies. [15]. To our knowledge, no other studies investigated the internal consistency of EVGS. The present study aimed to evaluate the validity and reliability of the EVGS in children with CP.

Methods

Study design

The research was carried out in the Özel Son Atılım Special Education and Rehabilitation Center prospectively. Fifty children with cerebral palsy were enrolled. Children diagnosed with cerebral palsy and able to walk independently without an assistive device and orthosis were included in the study. Children who had undergone lower extremity orthopedic surgery in the last six months, who received botulinum toxin injection into the leg muscles in the last three months, and whose parents did not want to be included in the study without their consent, were not included in the study. The local ethics committee approved the study protocol (No: 210084-116). International adaptation stages were preferred for the translation of the EVGS [16, 17].

Sample size estimation

Considering the analysis results in a similar study, we calculated that at least 47 patients were required. "Gpower" program, was used with the effect size=0.40, type 1 error 0.05, power 0.90 [18]. The methods and recommendations of Read et al. were used in the investigation of inter-rater reliability and validity.

Study design

The children included in the study and their parents were given detailed information about the study and video recording, and their consent was obtained. Evaluation forms were filled under the supervision of the researcher. The physical and socio-demographical information (e.g., age, gender, height, weight, birth history, dystocia, walking time, and cerebral palsy type) were filled. The participants were evaluated with "Gross Motor Function Classification System (GMFCS), Wisconsin Gait Scale (WGS), Gillette Functional Assessment Questionnaire (Gillette FAQ), Timed Up and Go Test (TUG), and EVGS (Rater-A and Rater-B)". Video recording was conducted in a large treatment room using three video cameras. A flat 10-m pathway was determined as the patient's walking line. The patients' gait was recorded from 3 different angles (anterior, lateral, posterior). 2 physiotherapists watched the video recordings of 50 patients obtained from 3 different angles in slow motion with the Kinovea (open source) software and performed the scoring independently of each other [11, 19]. In this way, it was aimed to observe inter-rater reliability. In addition, EVGS was compared with GMFCS, WGS, Gillette FAQ, and TUG to evaluate the construct validity by comparing it with other clinical evaluations.

Edinburgh Visual Gait Score (EVGS)

EVGS evaluates different stages of the gait with video and analyzes the gait parameters quantitatively. It consists of 17 parameters and evaluates gait in three different planes. Six anatomical regions in each lower extremity are evaluated separately. In our study, the gait of all children was recorded with video from the lateral, anterior, and posterior directions. Then recordings were monitored in slow motion video technology. EVGS was measured by Rater A and Rater B (Both of the researchers were physiotherapists) independently in a computer environment. In scoring, a value of 0 indicates natural, 1 (or −1) and 2 (or −2) indicates moderate and severe deviation from normal, respectively [11].

Gross Motor Function Classification System (GMFCS)

GMFCS evaluates child's movements based on sitting, displacement, and mobility. Gross motor functionality was defined for each level in the "0–2 years, 2–4 years, 4–6 years, 6–12 years, 12–18 years" ranges [20].

Timed Up and Go Test (TUG)

TUG is a performance test that evaluates functional mobility, dynamic balance, and postural stability applied to different ages and individual groups. The activities in the test evaluate the transition from sitting to standing position, walking, turning, and sitting again, which are necessary for functional movements and the presence of dynamic balance. Timed stand up and walk test; evaluates different elements such as walking speed, postural control and functional mobility. In TUG, the individual was asked to get up from a chair with a backrest but no arm support, walk 3 meters at a safe and normal speed, turn, walk backwards, and sit on the chair [21].

Gillette Functional Assessment Questionnaire (Gillette FAQ)

Gillette FAQ is a walking scale with scores of "0" indicating that the child cannot take a step and cannot walk; "10" means that the child can walk, run, and go up and down stairs without assistance on all surfaces. Previously, Günel et al. adapted the scale in Turkish [22].

Wisconsin gait scale

The Wisconsin Gait Scale (WGS) can be used to evaluate the gait problems experienced by a patient with post-stroke hemiplegia. The minimum and maximum scores are 13.35–42, respectively. The higher the score, the more severely the gait is affected. Yalıman et al. (2014) conducted the Turkish version in patients with stroke [23]. This scale has recently been shown to be reliable in children as well [24].

Statistical analysis

"IBM SPSS Statistics Version 25 (SPSS Inc, Chicago, IL, USA)" computer package program was used for all statistical analyses. Descriptive statistical information was given as mean ± standard deviation (x±SD) or %. Cronbach's alpha of ≥0.70 and <0.95 shows excellent internal consistency [25]. The intraclass correlation coefficient (ICC) was used for inter-rater reliability. ICC greater than 0.80 indicates excellent reliability [26]. The minimal detectable change (MDC_{95}) and the standard error of measurement (SEM_{95}) were calculated regarding the following equations (1) and (2), respectively [27]:

$$MDC_{95} = 1.96 * SEM * \sqrt{2} \tag{1}$$

$$SEM_{95} = SD * \sqrt{(1 - ICC)} \tag{2}$$

The construct validity was calculated for the EVGS by comparing it with the GMFCS, WGS, Gillette FAQ, and TUG. The correlation between the questionnaire score was considered strong if the coefficient was greater than 0.5 [28].

Results

Fifty children with cerebral palsy (60% female, 40% male) with a mean age of 11.7±4.6 were included in the study. The children's body mass index and the age of gaining walking ability were 19.6±5.8 kg/m^2 and 13.6±3.3 months, respectively. Half of the participants (50%) had monoplegia-type cerebral palsy. Detailed information about the individual characteristics of children is given in Table 1. Table 2 shows the clinical measurement results. The mean EVGS of the two raters (Rater-A, Rater-B) were 9.8±7.5 and 5.9±8.4, respectively. The scores of both raters were between 0 and 31. In Table 3, the results of the reliability analysis are presented. The ICC value of the EVGS total score was 0.947 (CI: 0.90–0.97). Inter-rater reliability was excellent (ICC>0.80). The ICC value of EVGS items varied between 0.42 and 0.89. The Cronbach's alpha value, which indicates the internal consistency of the EGVS, was 0.936, that is, within the acceptable range (0.70< α <0.95). The alpha values of the items ranged from 0.929

Table 1 The individual characteristics of the participants

n:50	Total
Age (years, mean±SD)	11.7±4.6
Height (m)	1.3±0.1
Weight (kg)	39.8±19.1
Body mass index (kg/m^2)	19.6±5.8
Gender (*n*, %)	
Female	20 (60.0)
Male	30 (40.0)
Walking age (months, mean±SD)	13.6±3.3
Cerebral palsy type (*n*, %)	
Diplegia	12 (24.0)
Hemiplegia	13 (26.0)
Monoplegia	25 (50.0)
Dystocia (*n*, %)	
Yes	24 (48.0)
No	26 (52.0)
Birth history (*n*, %)	
Natural birth	26 (52.0)
Cesarean section	24 (48.0)

SD Standard deviation, *n* Number of patients

Table 2 The mean values of the clinical evaluations

n: 50	Mean±SD	Range
GMFCS	15.19±7.23	(1–2)
TUG	11.42±7.28	(8–33)
GFAQ	11.42±7.28	(5–10)
WGS	11.42±7.28	(11.3–29.8)
EVGS		
Rater-A	64.70±23.67	(0–31)
Rater-B	49.75±38.13	(0–31)

SD Standard deviation, *n* Number of patients

Table 3 The reliability of the EVGS

n: 50	Rater-A (Mean±SD)	Rater-B (Mean±SD)	ICC (95% CI)	α	SEM_{95}	MDC_{95}
Item 1	0.78±0.64	0.54±0.70	0.859 (0.75–0.92)	0.931	0.24	0.66
Item 2	0.40±0.60	0.54±0.64	0.850 (0.73–0.91)	0.930	0.23	0.64
Item 3	0.38±0.63	0.52±0.70	0.812 (0.66–0.89)	0.930	0.27	0.75
Item 4	0.68±0.58	0.32±0.62	0.676 (0.42–0.81)	0.934	0.38	1.07
Item 5	0.84±0.61	0.36±0.66	0.742 (0.54–0.85)	0.933	0.42	1.18
Item 6	0.80±0.60	0.48±0.64	0.719 (0.50–0.84)	0.932	0.31	0.88
Item 7	0.42±0.67	0.48±0.70	0.896 (0.81–0.94)	0.929	0.21	0.59
Item 8	1.00±0.70	0.18±0.48	0.567 (0.23–0.75)	0.934	0.46	1.27
Item 9	0.40±0.70	0.40±0.70	0.884 (0.79–0.93)	0.930	0.23	0.66
Item 10	0.40±0.67	0.44±0.78	0.895 (0.81–0.94)	0.930	0.21	0.60
Item 11	0.50±0.61	0.32±0.65	0.757 (0.57–0.86)	0.933	0.30	0.83
Item 12	0.60±0.63	0.34±0.55	0.428 (−0.07–0.67)	0.940	0.47	1.32
Item 13	0.30±0.50	0.26±0.48	0.594 (0.28–0.77)	0.933	0.31	0.88
Item 14	0.54±0.61	0.16±0.42	0.590 (0.27–0.76)	0.931	0.39	1.08
Item 15	0.60±0.63	0.18±0.43	0.477 (0.07–0.70)	0.931	0.45	1.26
Item 16	0.52±0.58	0.26±0.52	0.586 (0.27–0.76)	0.935	0.37	1.03
Item 17	0.64±0.63	0.12±0.48	0.571 (0.24–0.75)	0.932	0.41	1.14
EVGS	9.8±7.5	5.9±8.4	0.947 (0.90–0.97)	0.936	1.72	4.78

n Number of patients, *ICC* Intra-class correlation coefficient, *CI* Confidence interval, *α* Cronbach's alpha, *SEM* Standard error of measurement, *MDC* Minimal detectable change

Table 4 The results of the construct validity

n: 50	EVGS (Rater-A)	EVGS (Rater-B)
GMFCS	0.494**	0.492**
TUG	0.661**	0.664**
GFAQ	−0.663**	−0.714**
WGS	0.611**	0.575**

** $p<0.01$

to 0.940. In addition, the SEM_{95} and MDC_{95} scores of EVGS were 1.72 and 4.78, respectively.

Table 4 shows the construct validity results of the EVGS. EVGS values of Rater-A and Rater-B were compared with GMFCS, TUG, GFAQ, and WGS. The correlation values of EVGS (Rater-A) and GMFCS, TUG, GFAQ, and WGS were 0.494, 0.661, −0.663, and 0.611, respectively. On the other hand, the correlation values of EVGS (Rater-B) and GMFCS, TUG, GFAQ, and WGS were 0.492, 0.664, −0.714, and 0.757, respectively. Except for comparison with GMFC, EVGS was highly valid in all other correlational analyzes ($r>0.50$). EVGS had moderate validity with GMFCS for both raters.

Discussion

The present study aimed to demonstrate the reliability and validity of the EVGS. No other studies investigated the internal consistency of EVGS. EVGS was found to be reliable and valid. So far, several studies have focused on the psychometric properties of the EVGS, demonstrating the validity and reliability of this standardized tool. However, internal consistency of the EVGS had analyzed first time in our study regarding the guidelines of the COSMIN [29].

Some EVGS studies in the literature should be briefly mentioned. Read et al. in the development study and Ong et al. in another study emphasized that EVGS was reliable with kappa analysis and Bland-Altman plot analysis, respectively [11, 14]. Hillman et al. emphasized that EVGS is a valid tool with a correlation of 05 to 0.8 with other clinical measurements [30]. Another study stated that EVGS could be used in longitudinal measurements with a single evaluator evaluation [31]. Viehweger et al. claimed that EVGS could provide an alternative to laboratory measurements [32]. The MCID value and responsiveness analysis of EVGS have also been recently presented [33, 34]. In a pilot study, the usability and reliability of the EVGS in Children with CP by slow-motion video technology were presented in detail [35]. Therefore, we pragmatically preferred to analyze with slow-motion video technique in our study.

The 50 children with cerebral palsy included in our study consisted of diplegic, hemiplegic and monoplegic individuals. Studying with a sample including the hemiplegic or diplegic group alone could have produced more homogeneous results. However, our focus was to obtain a valid and reliable psychometric analysis study in all children with cerebral palsy, appealing to a broader audience. In this respect, we retained the sample and inclusion criteria a bit wide. Half of the participants (50%) had monoplegic-type cerebral palsy. In this respect, it should be noted that the children in our sample are a group with relatively moderate gait disturbance.

The ICC analysis performed by comparing the measurements of the two raters (Rater-A, Rater-B) was 0.947 (CI: 0.90–0.97) for the total EVGS score. Inter-rater reliability was excellent (ICC>0.80). In other words, there was a high level of reliability in that different evaluators gave similar results for the same clinical case. The ICC scores of the items showed variation. The ICC value of EVGS items varied between 0.42 and 0.89. According to the guidelines, ICC values between 0.4 and 0.6 indicate moderate reliability [26]. Items 8, 12, 13, 14, 15, 16, and 17 had moderate reliability, while other items had high and excellent reliability. Item 8 represents the knee progression angle. The difficulty for clinicians to interpret the kneecap position with slowed video may have caused the situation. Although the validity and reliability of the analysis with slowed video for EVGS had been demonstrated, we interpreted that this situation may create a handicap. It should be noted that items 12-17 include the analysis of the hip-pelvis-trunk girdle, and its reliability can be more difficult to interpret than other limb regions (foot, knee) [11].

The Cronbach's alpha value showing the internal consistency of the EGVS was 0.936, that is, within the acceptable range (0.70< α <0.95). The alpha values of the items ranged from 0.929 to 0.940. Edinburgh has high internal consistency both in terms of total score and items. Considering that this tool was developed only to evaluate gait evaluation, high alpha scores are expected. However, especially items 12–17. has a low ICC value. The high internal consistency of the items enabled us to obtain a result that clarifies the reliability a little more [27]. In addition, the SEM95 and MDC95 scores of EVGS were 1.72 and 4.78, respectively. MDC value can be beneficial for physiotherapists, especially in the rehabilitation process of cerebral palsy. It is thought that the changes in scores of "4" and above to be obtained from EVGS with the different treatment modalities given may be a clinically significant change. On the other hand, it should be noted that this measurement may vary according to the sample standard deviation value, and this value may vary for cases with a relatively severe clinical presentation [27].

The construct validity results of the EVGS revealed a high degree of validity. The correlation values of EVGS (Rater-A) and GMFCS, TUG, GFAQ, and WGS were 0.494, 0.661, −0.663, and 0.611, respectively. On the other hand, the correlation values of EVGS (Rater-B) and GMFCS, TUG, GFAQ, and WGS were 0.492, 0.664, −0.714, and 0.757, respectively. Except for comparison with GMFC, EVGS was highly valid in all other correlational analyzes (r>0.50). EVGS had moderate validity with GMFCS for both raters. These results are precious in that they are all clinician-based measurements. Correlation with GMFCS was relatively low. We thought that this situation might have arisen due to the classification with a single item. The correlation with WGS was invaluable. WGS, which was found to be valid and reliable in the CP group [23], is the most viable alternative to EVGS. Therefore, we added originality to the construct validity in our study.

By addressing some of the study's limitations, it is necessary to offer some hints to researchers who will study more EVGS from now on. First of all, we did not apply intra-rater reliability or responsiveness in our study. Especially since these methods require a follow-up process for children, we could not perform these analyzes. It may be necessary for the same evaluator to present similar results for the same case at different times to present the questionnaire's intra-rater reliability. Using the MDC value, we have calculated, it can be a valuable clinical outcome to follow the long-term treatment results of individuals and the clinical significance of the score change. Finally, we were unable to compare slowed visual video with a wearable sensor-based analysis. It should be noted that this situation may further strengthen our results.

Conclusion and recommendations

The EVGS was found to be reliable and valid. Internal consistency of the EVGS is high, indicating a consistent structure to assess gait in children with CP. EVGS should be pragmatically used in clinical practice, where gait analysis laboratory is not available.

Abbreviations

GMFCS	Gross Motor Function Classification System
WGS	Wisconsin Gait Scale
Gillette FAQ	Gillette Functional Assessment Questionnaire
TUG	Timed Up and Go Test
EVGS	Edinburgh Visual Gait Score

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None.

Authors' contributions

İU: Study conception and design, data collection, analysis and interpretation of results, draft manuscript preparation. FÖ: Study conception and design, data collection, analysis and interpretation of results, draft manuscript preparation. ST: Study conception and design, data collection, analysis, and interpretation of results. İT: Data collection, analysis, and interpretation of results. The author(s) read and approved the final manuscript.

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Availability of data and materials
Data will be made available by the corresponding author to the editor after a request email from the editor. The reason for sharing the data should be justified, and it will be shared after all the authors approve the same.

Declarations

Ethics approval and consent to participate
The study was carried out in accordance with the ethical principles and the Helsinki Declaration. Informed consents of the patients were obtained. The study protocol was approved by the ethics committee of Muğla Sıtkı Koçman University (No:210084-116).

Consent for publication
Not applicable.

Competing interests
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