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Reliability and minimum detectable change of the gait profile score for post-stroke patients

Gisele Francini Devetak[a], Suzane Ketlyn Martello[a], Juliana Carla de Almeida[a], Katren Pedroso Correa[a], Dielise Debona Iucksch[b], Elisangela Ferretti Manffra[a,*]

[a] Pontifícia Universidade Católica do Paraná, Health Technology Graduation Programm, Curitiba, Brazil
[b] Centro Hospitalar de Reabilitação Ana Carolina Moura Xavier, Curitiba, Brazil

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ABSTRACT

The objectives of this work were (i) to determine Gait Profile Score (GPS) for hemiparetic stroke patients, (ii) to evaluate its reliability within and between sessions, and (iii) to establish its minimal detectable change (MDC). Seventeen hemiparetic patients (mean age 54.9 ± 10.5 years; 9 men and 8 women; 6 hemiparetic on the left side and 11 on the right side; mean time after stroke 6.1 ± 3.5 months) participated in 2 gait assessment sessions within an interval of 2–7 days. Intra-session reliability was obtained from the intraclass correlation coefficient (ICC) between the three strides of each session. Inter-session reliability was estimated by the ICC from the averages of that three strides. GPS value of non paretic lower limb (NPLL) (13.9 ± 2.4°) was greater than that of paretic lower limb (PLL) (12.0 ± 2.8°) and overall GPS (GPS_O) was 13.7 ± 2.5°. The Gait Variable Scores (GVS), GPS and GPS_O exhibited intra-session ICC values between 0.70 and 0.99, suggesting high intra-day stability. Most of GVS exhibited excellent inter-session reliability (ICC between 0.81 and 0.93). Only hip rotation, hip abduction of PLL exhibited moderate reliability with ICC/MDC values of 0.57/10.0° and 0.71/3.1°, respectively. ICC/MDC values of GPS were 0.92/2.3° and 0.93/1.9° for PLL and NPLL, respectively. GPS_O exhibited excellent test-retest reliability (ICC = 0.95) and MDC of 1.7°. Given its reliability, the GPS has proven to be a suitable tool for therapeutic assessment of hemiparetic patients after stroke.

1. Introduction

The gait of hemiparetic stroke patients is characterized by changes in range of motion of the lower limbs, reduction of speed, stride length, and cadence [1] along with presence of asymmetry, which affects dynamic balance control for these subjects [2].

Gait impairments after stroke are highly correlated with personal perception of handicap [3] and responsible for reduction in functionality and increased social isolation as they interfere directly with an individual's ability to access and move around places where most basic activities of daily living occur [4].

Gait kinematic analysis allows for the discrimination between normal and abnormal walking, and also allows for the evaluation of changes over time [5]. Repeated measurements can be used to evaluate response to therapeutic or surgical interventions, and the use of ortheses and prostheses [6].

However, the relative complexity and the great amount of data from kinematic gait analysis prevent this procedure to spread among clinicians. For these reasons, some researchers have been compelled to develop summary measures that would allow to quantify and compare kinematic gait characteristics in a more direct and simple way.

Among the most reliable and clinically accepted summary measures are the gait normal index or Gillette Gait Index (GGI) [7], Gait Deviation Index (GDI) [8], and the Gait Profile Score (GPS) [9].

The GPS is a raw score based on the root mean square distances between angular trajectories of a subject and their averages on a reference sample with no gait pathology. The GPS has a simpler and more direct clinical interpretation than the GDI for three reasons: it is not based on decomposition of eigengait vectors, its value is

* Corresponding author at: Pontifícia Universidade Católica do Paraná—PUCPR, R. Imaculada Conceição, 1155, Curitiba, PR 80215-901, Brazil.
E-mail addresses: gidevetak@hotmail.com, elisangelaferretti@gmail.com (G.F. Devetak), susiketlyn@hotmail.com (S.K. Martello), julicarla.almeida@hotmail.com (J.C. de Almeida), katren.correa@gmail.com (K.P. Correa), dielise@gmail.com (D.D. Iucksch), elisangela.manffra@pucpr.br, elisangelaferretti@gmail.com (E.F. Manffra).

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given in degrees, and it is related to the movement analysis profile, which provides data for each joint [9,10]. The GPS decomposition is precisely the advantage of this index compared to other similar summary measures, such as the GGI and GDI [11]. The ability to analyze and classify the joints/segments individually and in each plane of the gait makes the GPS an advantageous measure.

Originally, the GPS was created to assess the gait of children with cerebral palsy [9,10,12]. However, recent studies have included populations with other conditions, namely lower limb amputation [13], Parkinson's disease [14], and multiple sclerosis [15]. Some studies have evaluated the GPS of mixed samples: adults with various orthopedic and neurological disorders [16] and children with multiple clinical conditions [17]. To our knowledge, the GPS has not been applied to stroke patients. Given the frequency and relevance of gait impairments in stroke patients, we believe that this index might provide an useful means of assessing gait of these population for clinical purposes.

The presentation of GPS values, without its reliability, would not suffice for stablish its clinical usefulness. Moreover, when it comes to the reliability of kinematic gait data, it is recommended to include absolute measures of measurement error [6] and the minimum detectable change (MDC), or minimal clinically important differences (MCID) [18] of the measures in question. Test-retest reliability allows to differentiate real clinical changes from biological variability and experimental error [19]. Therefore, a measure cannot be properly applied to evaluate a treatment if its reliability is not known.

Previous studies already investigated validity, reliability, MCID and MDC of GPS for different populations. The concurrent validity and intra-session variability of the GPS was determined for children with cerebral palsy [9]. It has been demonstrated that the GPS and movement analysis profile (MAP) are highly correlated to clinical judgments of experts in kinematic gait analysis [12]. Subsequently, a study with children with cerebral palsy, determined the MCID of GPS using the Functional Assessment Questionnaire (FAQ) as a reference measure [10]. More recently, intra-session and inter-session reliability as well as MDC of GPS were estimated in a sample of subjects with spinal cord injury [20]. The aforementioned studies revealed that GPS is a reliable measure for those populations, compelling us to investigate its behavior for post stroke patients. This is necessary, because the reliability depends on the population being investigated and estimates from one population cannot be transferred to another [22,21].

The reliability of many other gait kinematic variables of post stroke patients has been analyzed by various researchers [2,23–25]. However, to our knowledge, no published studies have investigated the reliability and MDC of the GPS in this population. Given this scenario, the objectives of this paper are to present GPS values, their reliability (intra session and inter sessions) and the MDC values for post stroke patients.

2. Materials and methods

This study was approved by the Research Ethics Committee of the University (n. 256,523). All participants provided written informed consent.

2.1. Sample

The sample included 17 hemiparetic participants (mean age 54.9 ± 10.5 years; 9 men and 8 women; hemiparesis: 6 left and 11 right) all with confirmed stroke diagnosis by neuroimaging (6 hemorrhagic, 11 ischemic; mean time after stroke 6.1 ± 3.5 months). All participants received physical therapy treatment at a rehabilitation hospital. Other characteristics are given on Table 1.

Table 1
Sample Characteristics (n = 17).

Characteristics	Values		
	Mean (SD)	Median (IQR)	min–max
Age (years)	54.9 (10.5)	53.0 (12)	33.0–78.0
Weight (kg)	68.1 (9.0)	67.8 (15.5)	56.8–88.8
Height (cm)	163 (8)	162 (16)	150–177
Body Mass Index (kg/m^2)	25.7 (2.1)	25.4 (3.1)	21.3–28.4
Time since stroke (months)	6.1 (3.5)	6.0 (8)	1–11
Berg Balance Scale	37 (12)	37 (19)	19–56
Barthel Index	81 (15)	80 (33)	65–100

Abbreviations: SD, standard deviation; IQR, interquartile range; min, minimum; max, maximum; kg, kilogram; cm, centimeters; kg/m^2, kilogram/square meters.

Inclusion criteria were as follows: age ≥18 years, presence of paresis in one lower limb, ability to understand the instructions for performing the gait analysis, and ability to walk 10 m without assistance of another person. The study excluded participants with bilateral stroke and those with a history or presence of other neurological or musculoskeletal disorders unrelated to stroke.

The clinical features of the patients were collected before the test session. The Functional Ambulation Category [26] was used to characterize the walking function. It classifies the walking ability according to six levels on the basis of the amount of the physical support required. The spasticity of plantarflexors of the paretic lower limb (PLL) was assessed using the Modified Ashworth Scale [27] . Proprioception was tested on big toe and ankle joint in both limbs. Without looking at the limbs, the subjects were asked to answer about the joint position (flexion or extension). Performance was graded as normal (accurate and prompt answer), impaired (accurate but delayed answer) or absent (wrong answer). The plantar cutaneous sensation was measured using the Semmes Weinstein monofilaments applied to 3 sites per foot (1th metatarsal head, 5th metatarsal head and base of the heel). Plantar sensation was graded as normal, hypoesthesia or absent relative to age-matched normative threshold values for protective sensation [28]. These features are detailed in Table 2.

2.2. Procedure

All participants underwent gait assessment in the hospital's gait laboratory at 2 different sessions (test and re-test) with an interval of 2 to 7 days between sessions. Reflective markers were placed on the skin of the participants, according to the Helen Hayes Marker Set recommended by the software user's manual (Cortex Version 1.1.4.368—User's Manual; Motion Analysis Corporation, Santa Rosa, CA, USA). Markers were placed by the same person in both sessions, a physical therapist with experience in gait assessment. Participants were instructed to walk barefoot at a self-selected speed, on a 10 m path for 6 times (trials). Kinematic data were collected from the 3 m in the middle of the path, with the help of 6 infrared cameras and a motion capture system (infrared digital Hawk; Motion Analysis Corporation, Santa Rosa, CA). The data were sampled at 60 Hz and low-pass filtered with a cut-off frequency of 6 Hz using a fourth-order digital Butterworth filter.

2.3. GPS and MAP calculation

Data from the first and second trials of each session were discarded, to avoid the effect of adaptation, and the first valid strides of the next three trials were used for analysis. The same procedure was applied to data from the test and re-test sessions.

The calculation of GPS requires the Gait Variable Score (GVS), which refers to the root mean square difference between joint angles of each subject and the average of healthy subjects during a gait cycle. There are 15 GVS values, one for each degree of freedom: