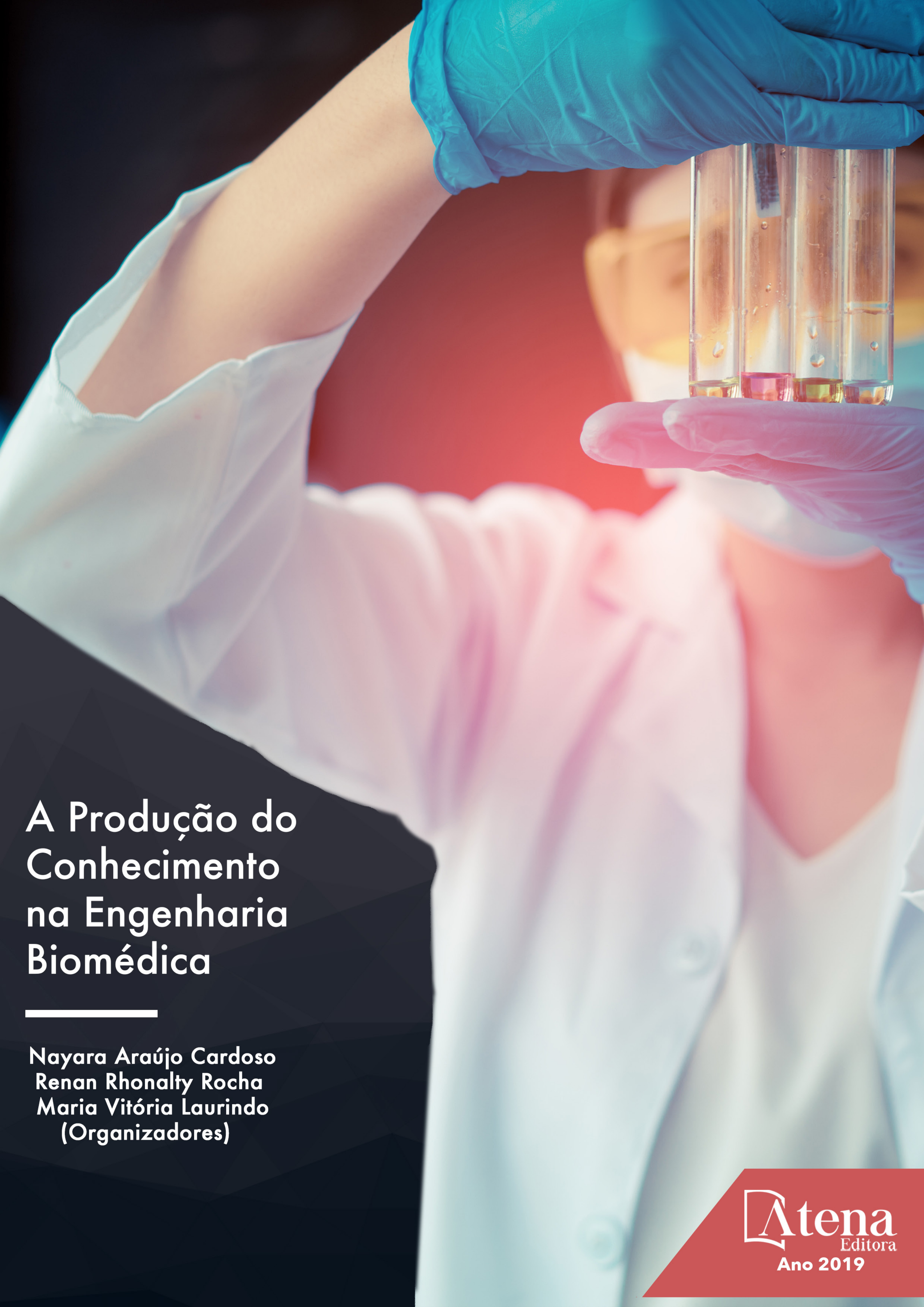

A Produção do Conhecimento na Engenharia Biomédica

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(Organizadores)

Atena Editora
Ano 2019

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APRESENTAÇÃO

A obra “A Produção do Conhecimento na Engenharia Biomédica” consiste em um livro de publicação da Atena Editora, com 21 capítulos em volume único, nos quais apresentam estratégias para as técnicas e tecnologias na produção de trabalho em saúde.

As Tecnologias em Saúde é um processo abrangente, por meio do qual são avaliados os impactos clínicos, sociais e econômicos das tecnologias em saúde, levando-se em consideração aspectos como eficácia, efetividade, segurança, custos, custo-efetividade, entre outros, a mesma deve ser compreendida como conjunto de ferramentas, entre elas as ações de trabalho, que põem em movimento uma ação transformadora da natureza. Desse modo, além dos equipamentos, devem ser incluídos os conhecimentos e ações necessárias para operá-los: o saber e seus procedimentos.

Entretanto, o sentido contemporâneo de tecnologia, portanto, diz respeito aos recursos materiais e imateriais dos atos técnicos e dos processos de trabalho, sem, contudo, fundir estas duas dimensões. Além disso, dado o grande desenvolvimento do saber técnico-científico dos dias atuais, este componente saber da tecnologia ganha qualidade estatuto social adicionais. Assim, novas tecnologias são lançadas no mercado todos os dias e com isso as demandas pela incorporação pelo sistema de saúde geradas pelas indústrias, pacientes e profissionais de saúde, têm crescido e continuará crescendo.

Com o intuito de colaborar com os dados já existentes na literatura, este volume traz atualizações sobre novas tecnologias que implementam melhores estratégias terapêuticas, que podem inovar o tratamento dos pacientes de um modo mais prático e resolutivo, assim esta obra é dedicada tanto à população de forma geral, quanto aos profissionais e estudantes da área da saúde. Dessa forma, os artigos apresentados neste volume abordam: aplicabilidade da robótica em terapia para reabilitação de pacientes com perdas de membros; jogo educativo para avaliação cognitivo-motor de deficientes intelectuais, avaliação da resposta da frequência cardíaca de adultos durante teste cardiopulmonar; tecnologias aplicadas à oftálmica como forma de melhorar a qualidade de vida; exposição á radiação ionizante em cirurgias ortopédicas; considerações sobre o espectro luminoso da descarga eletrocirúrgica; desenvolvimento de hidrogéis de quitosana associados a Ibuprofeno para liberação controlada; sistema de identificação de alimentos baseado em imagens de porções alimentares; a hemólise como fator interferente em parâmetros bioquímicos; planejamento em área estética de implante instalado tardiamente pós exodontia - relato de caso clinico e epidemiologia do Alzheimer.

Sendo assim, almejamos que este livro possa colaborar com informações relevantes aos estudantes e profissionais de saúde sobre diferentes tecnologias e técnicas aplicada á saúde, que podem ser usadas para aprimorar a prática profissional, e também para a população de forma geral, apresentando informações atuais sobre técnicas e tecnologias aplicadas á saúde.

Nayara Araújo Cardoso
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SUMÁRIO

SUMÁRIO

CAPÍTULO 10

REPEATABILITY OF GAIT RANGES OF MOTION IN THE PRESENCE OF STROKE

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RESUMO: Encontrar medidas quantitativas para avaliar a marcha é um desafio, especialmente na presença de acidente vascular cerebral (AVC). Tais medidas podem ser clinicamente úteis somente se sua repetibilidade for conhecida, assim como o valor da mínima mudança detectável (MMD). As amplitudes de movimento (ADM) dos ângulos articulares durante a marcha pós-AVC são possíveis medidas de desfecho para avaliação do efeito de tecnologias de reabilitação, porém sua confiabilidade não é conhecida. O objetivo desse estudo é determinar a repetibilidade e MMD dessas amplitudes para as diferentes fases da marcha e para os membros parético e não parético. Para tanto, foi realizada a coleta de ângulos articulares de 17 voluntários hemiparéticos com AVC (8 mulheres, 11 hemiparéticos à direita, idade de 54,9±10,5 anos) em um laboratório de marcha, utilizando o sistema Motion Analysis. A repetibilidade das ADM dos ângulos de obliquidade pélvica, flexão de joelho, tornozelo e quadril foi determinada utilizando-se o coeficiente de correlação intra-classe (CCI). A repetibilidade entre dias pode ser excelente, com valores de ICC acima de 0,86 para todas as ADM, em ambas as fases da marcha e para os membros parético e não parético. Porém, os valores de MMD variam desde 0,41º até 7,0º e, para uma mesma articulação, apresentam diferenças entre membros. Conclui-se, portanto, que as ADM analisados apresentam confiabilidade suficiente para serem ser adotadas como medidas de desfecho, na avaliação de procedimentos clínicos, desde que sejam observados os valores de MMD ao analisar as mudanças entre os momentos pré e pós terapia.

PALAVRAS-CHAVE: Acidente vascular cerebral; marcha; biomecânica; repetibilidade.

ABSTRACT: Finding quantitative measures to evaluate gait is a challenge, especially in the presence of stroke. Such measures might be clinically useful only if their repeatability is known, as well as the minimum detectable change (MDC) value. The range of motion (ROM) of the joint angles during gait after stroke are possible outcome measures to evaluate the effect of rehabilitation technologies, but their reliability is not known. The purpose of this study is to determine the repeatability and MDC of these ROM for the different gait phases and for the paretic and non-paretic limbs. To do this, the articular kinematic data was collected from 17 hemiparetic volunteers with stroke (8 females, 11 hemiparetic on the right, age 54.9 ± 10.5 years) in a gait laboratory using the Motion Analysis system. The repeatability of the ROM of the pelvic angles, knee, ankle and hip flexion was determined using the intra-class correlation coefficient (ICC). Repeatability between days can be considered excellent, with ICC values above 0.86 for all ROM, in both phases of gait and for the paretic and non-paretic limbs. However, the MDC values range from 0.41 to 7.0 and, for the same joint, have differences between limbs. We conclude, therefore, that the ROMs analyzed here exhibit sufficient reliability to be adopted as outcome measures, for assessing clinical interventions, provided that the MMD values are observed when analyzing the changes between moments pre and post therapy.

KEYWORDS: Stroke; gait; biomechanics; repeatability.

1 I INTRODUCTION

The hemiparetic gait pattern is commonly adopted after a stroke (KIM et al., 2016; SCHMID et al., 2013)secondary mechanisms are required. The aims of this systematic review were (1, and is associated with reduced gait velocity (YAVUZER et al., 2008; CARMO et al., 2012) and increased risk of falls (WEERDESTEYN et al., 2008). According to (AWAD et al., 2015)42 individuals with chronic hemiparesis (>6 months poststroke, the synergy pattern exhibited by post-stroke individuals affects the gait in a way that the more asymmetrical the gait, the slower the speed and the higher the energy expenditure. Furthermore, the gait after stroke exhibits reduced range of motion (ROM) of hip, knee flexion and ankle joints on the paretic side (MACLELLAN et al., 2013;SHEFFLER AND CHAE, 2015), in comparison to normal. The cadence, stride length (CHEN et al., 2005)healthy controls at matched speeds. The hemiparetic subjects walked on the treadmill at their comfortable speeds, while each control walked at the same speed as the hemiparetic subject with whom he or she was matched. Kinematic and insole pressure data were collected from multiple, steady-state gait cycles. A large set of gait differences found between hemiparetic and non-disabled subjects was consistent with impaired swing initiation in the paretic limb (i.e., inadequate propulsion of the leg during pre-swing, increased percentage swing time, and reduced knee flexion at toe-off and mid-swing in the paretic limb, step length and single support are reduced (CARMO et al., 2012), while the swing phase (CARMO et al., 2012;AWAD et al., 201542 individuals with chronic hemiparesis (>6 months poststroke,RINALDI AND MONACO, 2013)while homologous participants walked at two fixed speeds.\\n\\

nMETHODS: Five patients with left and five with right chronic hemiparesis, characterized by similar level of motor functioning, were enrolled. Ten non-disabled volunteers were recruited as matched control group. Spatio-temporal parameters, and intralimb thigh-leg and leg-foot coordination patterns were used to compare groups while walking on a treadmill at 0.4 and 0.6 m/s. The likelihood of Continuous Relative Phase patterns between healthy and hemiparetic subjects was evaluated by means of the root mean square of the difference and the cross correlation coefficient. The effects of the group (i.e., healthy vs. hemiparetics is increased on the paretic side.

Many of the abovementioned gait characteristics were observed using the kinematic gait analysis, which allows obtaining angular and linear data to characterize gait impairment with relatively good precision and objectivity. However, the analysis is complex since there is a large number of joints and segments in several planes (BAKER, 2013). In order to produce simple measures that can be useful for clinical assessment, one can extract parameters from the trajectories of kinematic and of kinetic variables (BAKER, 2007).

As a matter of fact, such parameters have been defined and studied in the literature to describe the characteristics of the hemiparetic gait (CARMO et al., 2012; LUCARELI AND GREVE, 2006; CHEN et al., 2003). The peak values of angular trajectories of stroke subjects walking at self-selected speed have been analyzed and it has been found that faster walkers compensated for poor knee flexion and ankle dorsiflexion with larger amounts of circumduction (STANHOPE et al., 2015).

A previous study (KERRIGANet al., 2000) defined twelve peak parameters to characterize circumduction and hip hiking by comparing them to those of healthy subjects. It has been found that hemiparetic subjects had smaller range of motion (ROM) of hip, knee and ankle angles than healthy subjects, while the range of motion of the pelvic angle was larger (CHEN et al., 2003). More recently (CARMO et al., 2012) assessed the ROM of upper and lower limb joint angles in the sagittal, frontal and transverse planes during de hemiparetic gait.

The aforementioned studies have parametrized the gait angle curves using peak values, time to peak values, or/and excursions. Such parameters might be relevant in clinical practice, if their repeatability and minimal detectable change (MDC) are known. Measures with high repeatability are more suitable for clinical assessments as their changes will be less sensitive to measurement error or natural variability (WEIR, 2005). In the study of (YAVUZER et al., 2008) the authors found high repeatability of some kinematic parameters, that include hip and knee flexion in the swing phase and ankle flexion in both phases. However, they focused only in the paretic limb and performed the two measurements in the same day. Previous studies that investigated the repeatability of the summary measures from kinematic angles of stroke patients (DEVETAK et al., 2016;CORREA et al., 2017) found out that there are differences between repeatability of the paretic (P) and non-paretic (NP) limbs and different. Moreover, the repeatability between days is more clinically relevant as, when assessing the effects of an intervention, the therapists must take the patients to the lab in different days. The repeatability of other kinematic parameters (CATY et al., 2009;KESAR et al., 2011) have also been investigated but assessed walking on a treadmill. Given the differences between gait patterns on ground and on treadmill (YANG et al., 2015), the repeatability obtained observing the gait on a treadmill, cannot be assumed to be the same over ground.

In summary, even though the ROM of lower limb joints are parameters with potential clinical interest, as they are influenced by strength training and interventions for spasticity, their repeatability and minimal detectable change (MDC) are not known for gait after stroke.In this context, the main aim of this study was to determine the repeatability and to estimate the MDC of the ROM of pelvic angle in the frontal plane, and hip, knee and ankle in the sagittal plane for paretic and non-paretic limb during the gait of post-stroke subjects. We also addressed the differences in the amplitudes of the paretic and the non-paretic lower limbs.

2 I METHOD

Gait data was collected at Ana Carolina Moura Xavier Rehabilitation Center (CHR) after approval by the Ethics and Research Committee of the Pontifical Catholic University of Paraná.

The sample consisted of 17 subjects diagnosed with unilateral stroke, confirmed by computed tomography or magnetic resonance imaging. Inclusion criteria were: age above than 18 years old; understand the instructions for accomplishing gait analysis; and to have the ability to walk 10 m without assistance from another person. Exclusion criteria were: bilateral stroke; other neurological disease; severe musculoskeletal disorders; and orthopedic surgery in the last 6 months. The following clinical characteristics were assessed by a physiotherapist: spasticity of the plantar flexors of the paretic limb, according to the modified Ashworth Scale [26]; degree of independency during gait, evaluated with the Functional Ambulation Category (FAC) (MEHRHOLZ et al., 2007); and functional postural control, evaluated with the Berg Balance Scale (MIYAMOTO et al., 2004). The clinical e demographic characteristics of the sample are detailed in Table 1.

Gender (F/M)	8/9
Age (years)	54.9 ± 10.5
Paretic side (L/R)	11/6
Stroke Etiology (I/H)	11/6
Time after stroke (months)	6.1 ± 3.5
Body mass (kg)	68.1 ± 9.0
Body height (cm)	163.0 ± 8.0
FAC Level (3/4/5)	6/6/5

Score of Berg Balance Scale	36.6 ± 11.6
Aswhorth (0/1/2/3/4)	3/6/2/5/1
Proprioception P limb (Normal/Absent)	1/13/3
Proprioception NP limb (Normal/Absent)	1/13/3

TABLE 1. Characteristics of the sample (n=17). Continuous values are expressed as mean ± standard deviation.

Note: M. male; F. female; R. rigth; L. Left; H. hemorrhagic; I. ischemic.

Participants underwent two sessions of 3D gait analysis (test and retest), 2 to 7 days apart from each other. In each session, the same experienced rater placed reflective markers on the anatomical landmarks of the participants, according to the Helen Hayes marker set. The participants were, then, instructed to walk on a 10 m walkway for six times (trials), barefoot at a self-paced speed. A rest between trials was allowed if necessary.

Kinematic data were collected with the help of a motion capture system (Motion Analysis Corporation, Santa Rosa, CA), with 6 infrared digital cameras at a sampling frequency of 60Hz. Data was low-pass filtered with a cut-off frequency of 6 Hz using a fourth-order digital Butterworth filter. All data were processed using Cortex® and OrthoTrak® softwares.

A skilled engineer identified the instants when each foot touched and set off the ground, by inspecting the motion of the stick figure frame by frame. Data from two consecutive strides of the first four trials were used in the analysis.

We calculated the ranges of motion of the following angles: pelvic obliquity (in the frontal plane), hip flexion/extension, knee flexion/extension, and ankle dorsi/plantarflexion. Angular ROM or amplitude during each gait phase was defined as the difference between the maximum and minimum angle values reached during that phase. Calculations were performed using a routine written in Matlab®.

Statistical analysis was performed using the SPSS statistical package, version 21.0 (SPSS Inc., Armonk, NY), with significance level of 0.05. Normality of data and homogeneity of variances were verified using the Shapiro-Wilk and Lèvene tests, respectively. The amplitudes obtained in each phase for paretic limb (PL) and for non-paretic limb (NPL) sides were compared using the T-Student or Wilcoxon test, according to data normality.

The repeatability was estimated using the two-way mixed intra-class correlation coefficient (ICC), according to (WEIR, 2005)J.P. Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. J. Strength Cond. Res. 19(1, with a confidence interval of 95%. The ICC was calculated for data collected on the same day (intraday) and for data collected on different days (inter-days).

Eight strides were used for calculating de intraday ICC both for the test and for retest session. For calculating the inter-days repeatability, we averaged the values of the 8 strides of each day and used the averages to calculate the ICC.

The presence of systematic error was investigated using ANOVA or Kruskall-Wallis test, depending on the normality of data, as recommended by (WEIR, 2005).

The standard error of measurement (SEM) was estimated from the inter-day ICC, according to expression 1 (WEIR, 2005).

$$SEM = SD * \sqrt{1 - ICC} \qquad (1)$$

Where SD is the standard deviation of the all 16 values: 8 from the test and 8 from the retest session.

Finally, the Minimal Detectable Change (MDC) was obtained from the SEM, according to equation 2 from (WEIR, 2005)J.P. Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. J. Strength Cond. Res. 19(1.

$$MDC = SEM * 2{,}11 * \sqrt{2} \qquad (2)$$

3 I RESULTS

The ROM obtained during test and retest sessions are reported in table 2. It is possible to observe that hip flexion/extension for PL and NPL differed only during the support phase, while those of the knee differed in both phases and those of the ankle exhibited no difference between limbs.

ROM	Limb	Test				Retest			
		Support		Swing		Support		Swing	
		Mean (SD)	p-value	Mean (SD)	p-value	Mean (SD)	p-value	Mean (SD)	p-value
Pelvic Obliquity (°)	P	5. 64 (0.61)	0.035	0.81 (0.31)	0.092	5.64 (0.31)	0.019	0.92 (0.36)	0.070
	NP	6.63 (0.46)		0.58 (0.26)		6.17 (0.51)		0.62 (0.21)	
Hip flexion (°)	P	18.85 (0.83)	0.000	19.18 (1.25)	0.230	19.34 (0.70)	0.000	20.05 (0.83)	0.218
	NP	32.58 (1.21)		24.45 (0.90)		33.74 (0.57)		25.17 (0.91)	
Knee flexion (°)	P	29.52 (1.34)	0.000	30.29 (3.19)	0.000	30.29 (3.19)	0.000	31.12 (3.13)	0.000
	NP	38.86 (0.83)		43.53 (4.60)		43.53 (4.60)		44.37 (5.12)	
Ankle flexion (°)	P	19.60 (1.25)	0.726	9.12 (1.27)	0.068*	20.31 (1.37)	0.381	9.26 (2.24)	0.066
	NP	20.28 (0.93)		12.23 (0.94)		22.11 (1.21)		13.36 (1.39)	

Table 2: Values of the ROM for test and retest sessions.

Note: SD means standard deviation, P means paretic, NP means nonparetic. The p-values were calculated with the Student´s t-test or the Wilcoxon test (*).

Systematic error was detected in the retest session, when three of the volunteers had values of knee flexion/extension ROM markedly different among the strides, as depicted in Figure 1.

The values of ICC corresponding to intraday repeatability from test and retest sessions are in Table 3 and those corresponding to the inter-days, in Table 4. It is possible to see the effect of the systematic error on the value of the ICC of the knee angle, of the NP limb, during the swing phase.

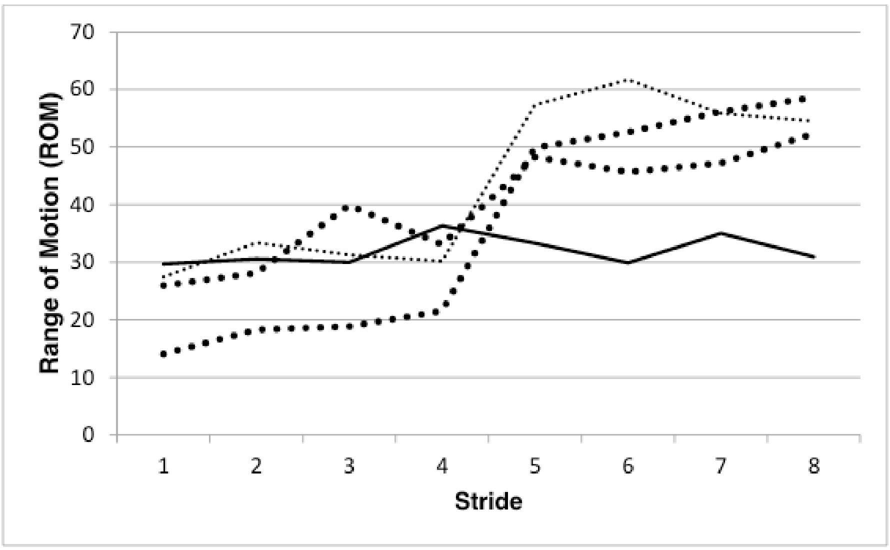

Figure 1: ROM values of the knee during swing phase for each stride of the retest session of the volunteers 7,14,15 which presented systematic error (dashed and dotted lines) and of volunteer 1 (solid line), which is similar to the other volunteers.

		Test		**Retest**	
		Support phase ICC (CI)	**Swing phase ICC (CI)**	**Support phase ICC (CI)**	**Swing phase ICC (CI)**
P	Pelvic obliquity	0.843 (0.733-0.929)	0.924 (0.863-0.967)	0.846 (0.737-0.930)	0.934 (0.880-0.971)
	Hip flex/ext	0.854 (0.749-0.934)	0.901 (0.824-0.956)	0.837 (0.724-0.926)	0.927 (0.869-0.968)
	Knee flex/ext	0.817 (0.694-0.915)	0.750 (0.570-0.878)	0.841 (0.728-0.927)	0.797 (0.652-0.907)
	Ankle dorsi/plant	0.870 (0.774-0.942)	0.839 (0.727-0.927)	0.869 (0.773-0.941)	0.731 (0.576-0.869)

NP	Pelvic obliquity	0.880 (0.790-0.946)	0.858 (0.756-0.936)	0.812 (0.687-0.913)	0.916 (0.849-0.963)
	Hip flex/ext	0.917 (0.851-0.964)	0.947 (0.902-0.977)	0.946 (0.900-0.977)	0.943 (0.896-0.976)
	Knee flex/ext	0.747 (0.597-0.878)	0.604 (0.405-0.796)	0.765 (0.620-0.888)	0.463 (0.297-0.717)
	Ankle dorsi/plant	0.702 (0.538-0.853)	0.688 (0.522-0.845)	0.738 (0.585-0.873)	0.712 (0.551-0.859)

Table 3: Values of ICC intra-day and their 95% confidence intervals (CI) for test and retest session paretic (P) and nonparetic (NP) limbs.

In table 4 it is possible to observe that the values of ICC inter-days is larger than those intra-days.

		Support Phase			Swing Phase		
		ICC (CI)	**SEM**	**MDC (°)**	**ICC (CI)**	**SEM**	**MDC (°)**
P	Pelvic obliquity	0.970 (0.919-0.989)	0.41	1.24	0.988 (0.967-0.996)	0.32	0.95
	Hip flex/ext	0.968 (0.915-0.988)	1.05	3.12	0.977 (0.936-0.991)	1.36	4.07
	Knee flex/ext	0.931 (0.815-0.975)	1.97	5.87	0.959 (0.888-0.985)	2.12	6.33
	Ankle dorsi/plant	0.945 (0.852-0.980)	1.68	5.02	0.960 (0.889-0.986)	1.10	3.27
NP	Pelvic obliquity	0.908 (0.751-0.966)	0.80	2.40	0.983 (0.953-0.994)	0.20	0.59
	Hip flex/ext	0.928 (0.807-0.974)	2.36	7.03	0.978 (0.940-0.992)	1.71	5.10
	Knee flex/ext	0.914 (0.759-0.969)	1.84	5.49	0.961 (0.894-0.986)	1.74	5.19
	Ankle dorsi/plant	0.871 (0.589-0.956)	1.81	5.39	0.863 (0.632-0.950)	1.74	5.18

Table 4: Values of ICC inter-days with thei 95% confidence intervals (CI), of the standard error of measurement (SEM) and of the minimal detectable change (MDC), for test and retest session paretic (P) and nonparetic (NP) limbs.

4 I DISCUSSION

With the analysis of gait carried out in the present study we intended to contribute with the literature by determining the values of the ROM and of its repeatability for the paretic and nonparetic limb, as well as identifying differences between limbs.

First, we have found that there was no difference between ROM of the paretic and the nonparetic limbs for the pelvic obliquity and hip flexion during the swing phase and for the ankle dorsiflexion during both phases (Table 2). Although this result might seem counter-intuitive, it is in accordance with previous studies that identified that curves of joint angles of both P and NP limbs present abnormalities (OLNEY ANF RICHARDS,1996; KIM AND ENG, 2008; DEVETAK et al., 2016; CORREA et al., 2017) the aim of this study was to determine the reliability and Minimum Detectable Change (MDC, due to the compensatory mechanisms (CHEN et al., 2005healthy controls at matched speeds. The hemiparetic subjects walked on the treadmill at their comfortable speeds, while each control walked at the same speed as the hemiparetic subject with whom he or she was matched. Kinematic and insole pressure data were collected from multiple, steady-state gait cycles. A large set of gait differences found between hemiparetic and non-disabled subjects was consistent with impaired swing initiation in the paretic limb (i.e., inadequate propulsion of the leg during pre-swing, increased percentage swing time, and reduced knee flexion at toe-off and mid-swing in the paretic limb;KERRIGAN et al., 2000) and/or because subtle motor and sensory deficits in the nonparetic side of the body after an unilateral stroke (SON et al., 2013; YANG et al., 2015).

Moreover, the results of (PAILLARD et al., 2010) indicated that the presence of fatigue mainly occurs in the unaffected side, caused by the effort to compensate the deficits of the other side. Actually, the relevance of compensations during hemiparetic gait, mainly the circumduction and the pelvic elevation, has been discussed extensively in the literature (CHEN et al., 2003; YAVUZER et al., 2008; CATY et al., 2009; CARMO et al., 2012; STANHOPE et al., 2015) and our results indicate that the ROM of the corresponding joints might be used as measures to investigate them. On the other hand, differences between ROM of P and NP limbs have been found for knee joint in both phases and for pelvic and hip joints during support phase (Table 2). Considering the knee, specifically, the ROM is much smaller in the paretic limb due to the limited capacity of knee flexors in lifting the leg against gravity. All these results are consistent with the study of (KERRIGAN et al., 2000), who described the gait pattern of post-stroke hemiparetic subjects, in which the circumduction is commonly present, as well as changes in knee flexion and extension and ankle dorsiflexion reported by (CRUZ et al., 2008; ALLEN et al., 2014).In order to discuss the repeatability, it is necessary to stablish standards to evaluate our results. Even though there is no consensus in the literature about the classification of ICC values, we will adopt the one proposed by (FLEISS, 1987) in which ICC values lower than 0.40 denote poor repeatability, values between 0.40 and 0.75, moderate to good repeatability, and above 0.75, excellent repeatability. In this way, according to table 3, almost all variables exhibited intraday ICC values ranging from 0.70 to 0.94, corresponding to moderate or excellent repeatability.

Moreover, in general, ICC values were similar in test and retest sessions (table 3), evidencing the same intraday behavior of the variables under analysis. The exception is the ICC value for NPL knee in swing phase, with ICC value of about 0.46. This result is due to the systematic error during swing phase in retest session, identified by ANOVA test, and presented in Figure 1.

Considering the ICC values in Table 4, it can be said that the inter-day repeatability was excellent irrespective of the joint or gait phase. Inter-day repeatability was better than intra-day one because we have used the average of eight strides to calculate the former one, similarly to what was done in (CORREA et al., 2017) where the same behavior was observed. Curiously, the joint with the worse ICC values was the ankle of the NP limb, what might be related to the exaggerate propulsion of non-paretic limb to compensate the abnormal ankle dorsiflexion at toe-off (ÖKEN et al., 2005). In a similar study (KESAR et al., 2011), the ICC and MDC were calculated for the peak values of hip, knee and ankle flexion, during the swing phase of hemiparetic gait. Their results indicated moderate to excellent repeatability, with ICC values smaller than those we obtained here, even though, that study was conducted on a treadmill, what should reduce variability in gait execution. Therefore, we consider that the ROM are more reliable variables than the peaks.

Although ICC is usually reported in studies of repeatability, SEM and MDC are more important and useful from the clinical point of view. These measures will allow to estimate of real changes for one individual, as they are not influenced by between-subject variability (WEIR, 2005). SEM determines the difference between the real value of variables and the value obtained in one measurement for each subject. MDC plays a similar role when the differences between two measurements must be considered. Regarding all the measurements, the results showed MDC values reaching values of up to 7°, but most of joints presented MDC values close to 5° or smaller.

The differences between the results of gait analysis in the present study and in the available literature may result from different measurement conditions, varying specifications of the gait laboratories, or from the methods used for data collection and processing. Additionally, one possible limitation of this study is the imbalance in the number of subjects with hemiparesis at the right and at the left side. We recognize that ideally one should have a balanced sample regarding this criterium as the lesions in different hemispheres will lead to different deficits.

5 I CONCLUSION

In summary, repeatability between days can be considered excellent, with ICC values above 0.86 for all ROM, in both phases of gait and for the paretic and non-paretic limbs. However, the MDC values range from 0.41 to 7.0 and, for the same joint, exhibit differences between limbs.

We conclude, therefore, that the ROMs analyzed here exhibit sufficient reliability to be adopted as outcome measures, for assessing clinical interventions, provided that the MMD values are observed when analyzing the changes between moments pre and post therapy.

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