Original Research

Motor Impairment and Its Influence in Gait Velocity and Asymmetry in Community Ambulating Hemiplegic Individuals

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Abstract *Objectives:* To determine the most important motor impairments that are predictors of gait velocity and spatiotemporal symmetrical ratio in patients with stroke.
Design: Cross-sectional, descriptive analysis study.
Setting: Human performance laboratory of the University of Santo Tomas.
Participants: Individuals with chronic stroke (N=55; 34 men, 21 women) who are community dwellers.
Interventions: Not applicable.
Main Outcome Measures: The gait velocity and spatiotemporal symmetrical ratio (step length; step, stance, swing, single-leg support, and double-leg support stance times) was determined using Vicon motion capture. We also calculated motor impairment of the leg and foot using Brunnstrom's stages of motor recovery, evaluated muscle strength using the scoring system described by Collin and Wade, and assessed spasticity using by the modified Ashworth Scale.
Results: Regression analysis showed that plantarflexor strength is a predictor of gait velocity and all temporospatial symmetry ratio. Knee flexor and extensor strength are predictors

in single-leg support time and double-leg support time symmetry ratio, respectively. On the other hand, hip adductor and quadriceps spasticity are predictors of swing time and step length symmetry ratio.

Conclusion: Different motor impairments are predictors of stroke gait abnormality. Interventions should be focused on these motor impairments to allow for optimal gait rehabilitation results.

Stroke results in a wide array of sensorimotor impairment, including weakness of contralateral extremities, decreased sensation and balance, spasticity, loss of motor control, and the inability to walk.[1,2] Gait recovery is one of the main goals of rehabilitation because gait impairment affects the quality of life and functional status of stroke patients.[3,4]

In general, poststroke hemiparetic gait is slow compared with healthy individuals with asymmetry in the spatiotemporal parameters such as step length, swing time (SwT), stance time (StT), single-leg support time (SLST), and double-leg support time (DLST).[3,5] However, there is a wide-range heterogeneity of gait patterns among stroke patients.[2] Because of the varied gait patterns, gait speed and symmetry ratios have been used to assess gait among stroke patients.[5,6] However, gait speed may be unable to determine the underlying impairments and compensatory mechanism in this patient group. Improvement may not be the result of motor recovery but could be a result of a compensatory mechanism by the nonaffected leg.[7] Temporospatial parameters are usually analyzed for symmetry, and step length is usually calculated for symmetry but has a less consistent pattern.[8] The pattern of temporal asymmetry is characterized by a shorter StT and a longer SwT on the affected leg.[9] SwT, StT, SLST, and DLST are temporal parameters used in calculating symmetry. Although the step length ratio is the most frequently used symmetry ratio in research, it has been suggested that the temporal symmetry ratio also be analyzed. With this, gait control in the phases of gait can be better understood and targeted ambulation training could be instituted for better gait recovery.[3,5,10-13] Analyzing the SLST and DLST is of interest because they have different subtasks, namely supporting the upper body during the stance phase and generating enough mechanical energy for leg propulsion respectively.[12] Furthermore, there is more temporal gait asymmetry compared with spatial asymmetry, as reported by Lauzière et al in their review, in which studies reported that 60% of stroke patients had temporal asymmetry whereas only 33% to 49% had step length asymmetry.[12]

Studies have determined the relationship of motor deficits of muscle strength, spasticity, and motor recovery with spatiotemporal symmetry ratio.[3,8,10,11,14-19] The strength of the plantarflexors and dorsiflexors has a negative correlation with SLST symmetry ratio, whereas the strength of plantarflexors and knee extensors have a negative correlation with the step length symmetry ratio.[10,11] However, a limited number of muscles were assessed. Spasticity of ankle plantarflexors was positively correlated with the symmetry ratio for step length, SwT, and SLST.[10,11,17] Spasticity of the knee extensors and ankle invertors was positively correlated with SwT, StT, and SLST symmetry ratio, whereas the spasticity of hip adductors and extensors was positively correlated with SwT symmetry ratio.[10,11,17] Spasticity measurement is commonly measured using the modified Ashworth Scale (MAS), although Lin et al used electromyography.[10,11,17]

The different assessment tools used to measure stroke impairment include the Chedoke-McMaster Stroke Assessment, Fugl-Meyer Assessment, and Brunnstrom stages of stroke recovery (BSSR).[3,8,10,11,14-17] These methods have been used to determine the relationship of stroke impairment with spatiotemporal symmetrical ratio.[11,13,14,16-19] However, only the BSSR assesses purely motor development and reorganization of the brain after stroke. The other assessment tools include sensory impairments, postural control balance, and ambulation.[11,13-15,17,19] The findings regarding the correlation of BSSR with spatiotemporal symmetry ratio have been inconsistent. Öken and Yavuzer[18] showed no correlation with SLST symmetry ratio, whereas Balasubramanian et al[16] reported a negative correlation with step length symmetry ratio. However, to our knowledge, no study has determined the relationship of hemiparetic severity, the strength and level of spasticity of each lower extremity muscle group with gait speed, and the different symmetry ratio of step length, StT, SwT, SLST, and DLST. The current study hypothesized that motor impairments are predictors of gait velocity and spatiotemporal symmetrical ratio, which include step length, StT, SwT, SLST, and DLST. Motor impairments include BSSR; muscle strength of the affected lower extremity (except hip abductor and adductors); and spasticity of hamstrings, quadriceps, gastrocnemius, tibialis anterior, and hip adductors using MAS.

Methods

The study was performed at the Human Performance Laboratory of the University of Santo Tomas from July to December 2018. Ethical approval was provided by the Institutional Review Board of the University of Santo Tomas Hospital and conformed to the tenets of the Helsinki Declaration. Informed consent forms were signed by all participants before entering the study protocol. The study was designed as a cross-sectional, descriptive analysis study.

Participants

The differences and the variability in the stance time between stroke patients and healthy individuals reported in a study by Ng et al[20] were used to determine the sample size for the current study. A sample size of 56 was computed, with a power of 0.90 and an alpha level of 0.05.

The inclusion criteria for the participants were men or women with unilateral hemiparesis secondary to stroke aged between 30 and 75 years who were able to understand instructions and were ambulatory (either independently or with the use of a cane). Participants with a limited range of motion for the lower extremity joints (appendix 1), or any cardiopulmonary, musculoskeletal, or other neurologic conditions that prevented them from walking at least 10 meters without pain were excluded from the study.

Outcome measures

The demographic and anthropometric data recorded included sex, age, comorbidities, height in meters, weight in kilograms, and body mass index. Stroke data included the

$$Step\ length\ asymmetry\ ratio = \frac{Step\ length\ of\ the\ affected\ side}{Step\ length\ of\ the\ unaffected\ side}$$

side of hemiparesis, stroke duration, and stroke classification.

The BSSR, which ranges from stage 1 to 6, was used to assess the severity of hemiparesis, indicating no voluntary movement to mild hemiparesis that allows patients to perform an isolated joint movement.[21] Muscle strength of both lower extremities was assessed using the scoring system described by Collin and Wade (table 1).[22] Spasticity of the lower extremity muscles was evaluated using MAS, which ranges from 0 (no increase in muscle tone) to 5 (joints are placed in rigid flexion or extension).[23]

A Vicon motion capture system[a] with 8 cameras was used to determine gait velocity and spatiotemporal asymmetry. Thirty-nine retroreflected markers were attached to the standard marker positions for data acquisition (fig 1). The Vicon motions were recorded using Nexus software[b] and were directly imported to Microsoft Excel[c] using a frame rate of 100 frames per second.

Data gathering procedure

Before the start of the study, the assessors conducted an orientation on the physical examination. Initially, participants answered questionnaires pertaining to demographic

and stroke data. Participants then underwent assessments for blood pressure, pulse rate, anthropometric measures, muscle strength, sensory deficits, MAS, and BSSR.[21-23] Next, gait performance was evaluated. The participants were asked to walk unassisted (use of a cane was permitted) at a self-selected speed along a 7-meter walkway 4 times.

Treatment of data

Gait velocity was obtained from the Vicon results. Using the ankle marker, gait velocity was computed by calculating the mean of all computed velocities between frames. The average gait velocity was then computed by obtaining the mean of the 4 trials. Spatiotemporal asymmetrical ratios were obtained for the following parameters: step length, SwT, StT, SLST, and DLST. The temporal symmetry ratio was calculated using the following[5]:

$$Temporal\ asymmetry\ ratio = \frac{Temporal\ parameter\ value\ of\ the\ affected\ side}{Temporal\ parameter\ value\ of\ the\ unaffected\ side}$$

To obtain the step length of the affected side, the distance between the paretic leg at the beginning of the stance phase and the unaffected leg at the end of the stance phase was measured. The step length symmetry ratio was calculated as follows:[5]

The BSSR, muscle strength, and MAS were dichotomized into 2 groups. For BSSR, binary grouping was determined between participants with scores of 3 and lower (considered severe hemiparesis) and those with scores of 4 and greater (considered mild to moderate hemiparesis).[16,18] For motor strength, a median of 25 was used. A score of 25 or greater corresponded to the Medical Research Council's Manual muscle testing scale of grades 4 and 5, which indicated an almost normal to normal muscle strength.[22] For MAS, those with a grade of 0 (considered low or normal muscle tone) and those with a grade of 1 or more were dichotomized into groups.[23]

Statistical analysis

All data were entered into a purpose-built MS Excel file. SAS software, version 9.2,[d] was used for the analysis. The Kolmogorov-Smirnov test was used to test normality and showed that the data had normal distribution. Means and SD were used for the descriptive data. The Student t test was used to determine whether there was a significant difference in the anthropometric measures, stroke descriptors and assessments, gait velocity, and all spatiotemporal symmetry ratios between the sexes and laterality

Table 1   Muscle strength grading using the scoring system of Collin and Wade[22]

Description of Muscle Movement	Score
No movement	0
Palpable contraction in muscle but no movement	9
Visible movement but not full range and not against gravity	14
Full range of movement against gravity but no resistance	19
Full range of movement against gravity but weaker than the other side	25
Normal power	33

of hemiparesis. Pearson's correlation coefficient was used to determine the correlation between the gait parameters and anthropometric measures. A P value of < .05 was considered significant.

A regression model was used to determine whether BSSR, individual muscle strength score, and MAS are predictors of gait speed and all spatiotemporal parameters. Univariate linear regression was tested for gait speed and spatiotemporal parameters. The significance level was set at 0.10. Those that were significant were entered into a stepwise multiple logistic regression model with the significance level at 0.05

Results

A total of 66 participants were recruited for this study. Seven were excluded for gait assessment because of uncontrolled hypertension, and 59 participants underwent gait analysis. However, the data of 4 participants were excluded because of errors during analysis. Therefore, 55 participants were included in the final analysis of this study (fig 2).

Table 2 shows the participants' demographics and stroke descriptors. The study included 34 men and 21 women with a mean age of 57.12±11.26 and 59.81±9.49 years, respectively. Thirty-three had left hemiparesis, and 22 had right hemiparesis. Spatiotemporal parameters, gait velocity, and spatiotemporal symmetry ratios are summarized in table 3. All spatiotemporal symmetry ratios were less than 1, except for the SwT symmetry ratio, which was 1.21±0.27. There were no sex- or laterality-related differences of demographics data, stroke descriptors, and spatiotemporal symmetry ratios, except for step length. For sex, the step length of the affected limb was statistically different, with men having a longer step length compared with women (0.43±0.09 vs 0.36±0.10 m; P=.018). Similar results were observed in the laterality of hemiparesis, in which the step length of both the affected and nonaffected limb was significantly longer for those with right hemiparesis (affected limb: right hemiparesis, 0.42±0.13m; left hemiparesis, 0.35±0.12m; P=.049; unaffected limb: right hemiparesis, 0.44± 0.11m; left hemiparesis, 0.38±0.08m; P=.01). There was no correlation of the different anthropometric measures with step length for both sexes. The data of all participants were pooled for subsequent regression analysis.

BSSR, motor score, and MAS of muscle groups with gait speed and spatiotemporal symmetry ratios

Table 4 summarizes the variables deemed as significant predictors of gait speed and temporospatial symmetry ratios. Ankle plantarflexor strength was a positive predictor of gait speed (β=0.16, P=.02) and StT symmetry ratio (β=0.21, P<.001).

Ankle plantarflexor strength was a negative predictor of SwT symmetry ratio (β=−0.24; P<.001), whereas hip adductor spasticity was a positive predictor of SwT symmetry ratio (β=0.24, P=.03). Ankle plantarflexor (β =0.14, P=.007) and knee flexor strength (β=0.19, P=.02) were positive predictors of SLST symmetry ratio with. Ankle plantarflexor strength was a positive predictor of DLST symmetry ratio (β=0.30, P<0.001), whereas knee extensor strength was a negative predictor (β=−0.28, P<0.001). Both ankle plantarflexor strength (β=0.28, P<.001) and quadriceps spasticity (β=0.30, P<.001) were found to be positive predictors of step length symmetry ratio.

Discussion

To the best of the authors' knowledge, this is the first study to use clinical examination for assessing motor impairment in predicting gait velocity and spatiotemporal symmetry ratio among stroke community ambulators. Furthermore, muscles assessed were not limited to the ankle musculature, but also included hip and knee muscles. The study also assessed the subphases of the stance phase. Plantarflexor strength of the affected leg was a predictor of gait speed and all spatiotemporal symmetry ratio, whereas knee extensor strength was a negative predictor of DLST symmetry ratio. Spasticity of hip adductors and quadriceps was a positive predictor in SwT and step length symmetry ratio, respectively.

Motor impairment and spatiotemporal symmetry ratio

The current study demonstrated that plantarflexors contribute to decreasing asymmetry in SLST and DLST. Plantarflexors were found to be active from midstance to the beginning of preswing. During SLST, plantarflexors contribute to vertical support and cause the progression of the center of pressure when the foot is flat on the floor. During DLST, the plantarflexors generate power for forward acceleration of the center of mass.[24] This could also explain why plantarflexors are predictors of step length symmetry ratio. In Balasubramanian et al's study, the step length ratio had a negative correlation with paretic leg propulsion. It was postulated that hip flexor, hip extensor, and plantarflexor activities are important in generating propulsive forces to decrease step length asymmetry.[16]

In the current study, the hamstrings were found to be a predictor in improving SLS symmetry ratio. Neptune et al[25] postulated that the hamstring muscle counteracted the deceleration of the forward movement of the body and leg and contributed the most force in accelerating the body forward in the stance phase. Furthermore,
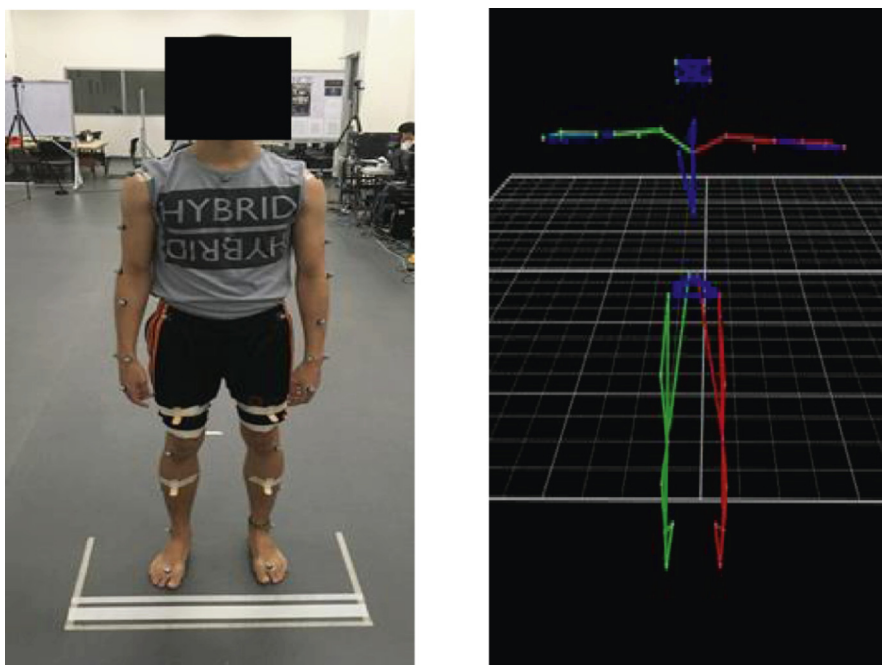
Locations:

1. Right and left shoulders

2. Right and left upper arms

3. Right and left elbows

4. Right and left forearms

5. Right and left wrists X2

6. Right and left index fingers

7. Right and left anterior superior iliac spines

8. Right and left posterior iliac spines

9. Right and left thighs

10. Right and left knees

11. Right and left tibia

12. Right and left ankles

13. Right and left first toes

14. Right and left heels

15. Both sides of the forehead

16. Both sides of Occiput

17. Right scapula

18. Clavicle

19. Sternum

20. C7 and T10 spinous processes.

Fig 1 Standard marker positions for data acquisition using 3-dimensional motion capture.

66 recruited patients

7 excluded because of uncontrolled hypertension

59 patients tested

4 excluded due to data error

55 stroke data used for the study
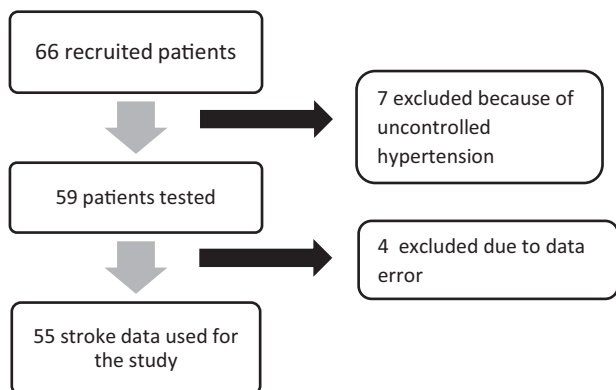
Fig 2 CONSORT diagram.

knee flexion during preswing is essential in generating enough leg kinetic energy at toeoff.[8] This is negated by the strength of the quadriceps of the affected side. Neptune et al showed that the vastus muscles and rectus femoris decelerated the forward motion of the leg during the beginning and the end of the stance phase, respectively.[25] Therefore, an increase in quadriceps strength will further increase asymmetry during DLST. A similar finding by Hsu et al[11] corroborated this and showed a significant positive correlation between SLST symmetry ratio and the total work of the ankle plantarflexor during walking comfortable speed. However, Lin et al[10] suggested otherwise, indicating that dorsiflexor strength and joint position error were significant predictors of SLST symmetry ratio. Nevertheless, Hsu et al[10] only evaluated the isokinetic strength of the hip flexors, knee extensors,

Table 2 Participants' demographics and stroke characteristics

Characteristics	Value
Sex, n (%)	
Men	34 (61.8)
Women	21 (38.2)
Weight, kg	
Men	64.66±8.24 $P=.017$*
Women	59.95±24.23
Height, cm	
Men	160.75±6.67 $P=8.3989E\text{-}08$*
Women	149.68±6.00
Body mass index, kg/m^2	
Men	25.10±3.47 $P=.60$
Women	26.97±12.61
Stroke duration, mo	56.84±94.24
Laterality of stroke, n (%)	
Right hemiparesis	22 (40)
Left hemiparesis	33 (60)
BSSR	
Stage of recovery, n (%)	
1	1 (1.8)
2	0 (0.0)
3	5 (9.1)
4	10 (18.2)
5	19 (34.5)
6	20 (36.4)

MAS per muscle

Muscle	Ashworth's Scale	No.	Percentage
Hamstrings	0	50	90.9
	1	4	7.3
	2	1	1.8
Quadriceps	0	47	85.5
	1	5	9.1
	2	2	3.6
	3	1	1.8
Gastrocnemius	0	45	81.8
	1	5	9.1
	1.5	1	1.8
	2	3	5.5
	3	1	1.8
Tibialis anterior	0	51	92.7
	1	1	1.8
	1.5	1	1.8
	2	2	3.6
Hip adductor	0	50	90.9
	1	5	9.1

Muscle strength

Muscle	Motricity Index	No.	Percentage
Hip flexor	14.00	2	3.6
	19.00	16	29.1
	25.00	20	36.4
	33.00	17	30.9
Hip extensor	14.00	1	1.8
	19.00	9	16.4
	25.00	24	43.6
	33.00	21	38.2

Table 2 (continued)

Muscle strength

Muscle	Motricity Index	No.	Percentage
Knee extensor	14.00	1	1.8
	19.00	9	16.4
	25.00	22	40.0
	33.00	23	41.8
Knee flexor	19.00	6	10.9
	25.00	23	41.8
	33.00	26	47.3
Ankle dorsiflexor	0.00	7	12.7
	9.00	2	3.6
	14.00	11	20.0
	19.00	7	12.7
	25.00	16	29.1
	33.00	12	21.8
Ankle plantarflexor	0.00	6	10.9
	9.00	2	3.6
	14.00	5	9.1
	19.00	10	18.2
	25.00	16	29.1
	33.00	16	29.1

* Indicates significance.

and ankle plantarflexors, whereas Lin et al[11] evaluated the isometric strength of ankle plantarflexors and dorsiflexors using a dynamometer. Although the assessment tools used in the previous studies were not the same as those used in the current study, a systematic review by Cuthbert and Goodheart[26] suggested that manual muscle testing, on which the scoring system by Collin and Wade was based, on has good concurrent validity when compared with a handheld dynamometer.[26] At the same time, there is an underestimation of the severity of muscle weakness in the knee and ankle compared with isokinetic dynamometry.[27]

Plantarflexor strength was a negative predictor of SwT symmetry ratio, which suggests that a stronger gastrocsoleus is associated with a more symmetrical SwT ratio. Previously, it was shown that leg kinetic energy at toeoff, which is generated by the plantarflexor and hip flexor, was reduced in the paretic limb of the stroke patients, which increased the SwT and energy cost to propel the leg.[8] Although the plantarflexors' excitation time is from midstance to preswing, the mechanical energy that it generated was an important predictor in shortening the swing phase of the paretic limb.[25]

In their study, Öken and Yavuzer showed poorer motor recovery using BSSR had a higher symmetry ratio in step length but no difference with the SLST symmetry ratio.[18] The difference in the results may be owing to the fact that we had only 6 participants with poor motor recovery.

Spasticity and spatiotemporal symmetrical ratio

In the current study, spastic muscles (ie, hip adductor and quadriceps) were significant predictors in SwT

Table 3 Spatiotemporal parameters, gait velocity, and spatiotemporal symmetry ratios

Spatiotemporal Parameters	Nonaffected Limb	Affected Limb	P Value
Stance time, s	0.75±0.32	0.63 ± 0.27	1.1739×10^{-7}
Swing time, s	0.46±0.10	0.55±0.13	.000003
Step length, m	0.40±0.10	0.38±0.13	.21
SLST, s	0.55±0.12	0.47±0.11	.000016
DLST, s	0.21±0.25	0.16±0.18	.000279
Gait speed			0.66±0.26 m/s
Stance time symmetry ratio			0.85±0.15
Swing time symmetry ratio			1.21±0.27
Step length symmetry ratio			0.94±0.22
SLST symmetry ratio			0.87±0.19
DLST symmetry ratio			0.88±0.30

symmetrical ratio and step length ratio. Finley et al[28] studied heteronymous reflexes in stroke patients, and their results showed that hip abduction perturbation caused an excitatory response in the adductor longus and rectus femoris, which could be owing to the descending coactivation of the motor neuron pools of both muscles. The response to stretch is reciprocal; such a stretch of the rectus femoris caused reflex excitation of the adductor longus, and findings are consistent with increased facilitation of heteronymous reflexes after neurologic conditions. In stroke patients, there is an increase in the amplitude of hip abduction during the swing phase to assist in the foot clearance in the swing phase that could trigger an excitatory response of adductor longus and rectus femoris.[29] Spasticity of the adductors could cause problems in the advancement of the paretic limb and its clearance during the swing phase, thereby increasing the SwT asymmetry.[30]

On the other hand, quadriceps spasticity was a positive predictor for step length asymmetry ratio. Our participants had a gait speed of 62 cm/s, which is approximately 57% of the speed of Filipinos between the ages of 40 and 59 years (102-108 cm/s) in our laboratory results. This classifies them as a fast walker group among stroke patients, which is approximately 44% of normal gait speed.[31] The gait is characterized as a decrease in heel rise in preswing because of plantarflexor weakness.[31] This is compensated by knee hyperextension in the stance phase so the body can roll forward onto the forefoot. Knee hyperextension can either be maintained by excessive plantarflexion torque or spastic quadriceps.[32]

Study limitations

Our study only included patients who are community ambulators with mild to moderate motor impairment and did not include patients with acute stroke. The results may not be generalizable to this subset of patients.

Table 4 Multiple logistic regression model of BSSR, MAS, and muscle strength of individual muscles for gait speed and spatiotemporal symmetry ratios

Gait Parameter/Dependent Variable Predictors	Unstandardized Coefficients		t	P Value
	B	Standard Error		
Gait speed				
(Constant)	0.57	0.05	10.97	$2.999E^{-15}$
Ankle plantarflexor strength	0.16	0.07	2.39	$2.04E^{-02}$
Stance time symmetry ratio				
(Constant)	0.73	0.02	32.09	$2.10E^{-36}$
Ankle plantarflexor strength	0.21	0.03	6.93	$5.74E^{-09}$
Swing time symmetry ratio				
(Constant)	1.34	0.05	26.01	$1.77E^{-31}$
Ankle plantarflexor strength	−0.25	0.06	-3.81	$3.67E^{-04}$
Hip Adductor Spasticity	0.24	0.11	2.18	$3.35E^{-02}$
Step length symmetry ratio				
(Constant)	0.74	0.05	15.59	$3.06E^{-21}$
Ankle plantarflexor strength	0.28	0.06	4.80	$1.36E^{-05}$
Quadriceps spasticity	0.29	0.08	3.72	4.91E-04
SLST symmetry ratio				
(Constant)	0.62	0.07	9.35	$1.01E^{-12}$
Ankle plantarflexor strength	0.14	0.05	2.83	$6.60E^{-03}$
Knee flexor strength	0.19	0.08	2.42	$1.90E^{-02}$
DLST symmetry ratio				
(Constant)	0.94	0.09	10.98	$3.64E^{-15}$
Ankle plantarflexor strength	0.29	0.08	3.80	$3.80E^{-04}$
Knee extensor strength	−0.29	0.10	-2.89	$5.50E^{-03}$

Furthermore, the researchers were not able to include trunk and pelvic parameters, which could have affected the spatiotemporal asymmetry.

Conclusions

Our study determined the motor predictors of spatiotemporal parameters using clinical assessment for a better comprehension of how motor deficits could contribute to stroke gait abnormality. In patients with mild to moderate deficits, intensive mobility training composed of graded strengthening using functional tasks, aerobic exercise, and walking activities with postural control demands will be an effective rehabilitation strategy.[33]

Suppliers

a. Vicon motion capture system; Vicon Industries.
b. Nexus software; Nexus Software LLC.
c. Excel; Microsoft Corp.
d. SAS software, version 9.2; SAS Institute, Inc.

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Acknowledgment

Appendix 1 Normal Joint Range of Motion[34]	
Joint	Normal Range of Motion
Hip	
Flexion	0 to 110-120
Extension	0 to 10-15
Internal Rotation	0 to 30-40
External Rotation	0 to 40-60
Abduction	0 to 30-50
Adduction	0 to 25-30
Knee	
Flexion	0-140
Extension	0-15
Ankle	
Dorsiflexion	0-20
Plantarflexion	0-50
Inversion	0-20
Eversion	0-10

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