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The Relationship of Trunk Control with Lower Extremity Sense, Balance, and Walking in Individuals with Stroke

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ABSTRACT

Objective: This study was conducted to investigate the relationship between trunk control and lower extremity sense, balance and gait in stroke individuals.

Methods: Thirty subacute and chronic stroke patients were included in the study (mean age 52. 2 ± 14.4 years). Trunk Impairment Scale (TIS) and Turkish version of Postural Assessment Scale for Stroke Patients (PASS-T) was used for evaluating the body control, and Tinetti Balance Test (TBT) was used for evaluating balance. Tinetti Gait Test (TGT) and Ten Meter Walking Test (TMWT) were applied for evaluating walking. The light touch sense and proprioception, Fugl-Meyer Assessment of Sensorimotor Function (FMASF) for lower extremity were used. Furthermore, neglect, plantar pressure sense and stereognosis for lower extremity were evaluated.

Results: There was a significant positively strong correlation between TIS and TBT, TGT and FMSMFT, and negatively strong correlation between TIS and TMWT ($p<0.05$). There was a significant positively strong correlation between PASS-T and TBT, TGT and FMSMFT, negatively strong correlation between TMWT ($p<0.05$). TIS, PASS-T, TBT and TGT values were found significantly high in the presence of plantar pressure sense and stereognosis; and significantly low in the presence of neglect ($p<0.05$).

Conclusion: Trunk control is related with lower extremity sense and affects balance and walking.

Keywords: Stroke, postural balance, lower extremity, sensation, walking

1. INTRODUCTION

Stroke is characterized by the loss of neurons in the brain as a result of a decrease or interruption of blood flow. Although stroke ranks third as the cause of death in developed countries, it ranks first among neurological diseases in terms of mortality and disability (1). In general, stroke patients have a lack of physical function. In this respect, patients and their families face economic, social, and psychological distress and the quality of life of patients is affected negatively (2).

In stroke individuals, postural control affects functional status. The trunk is among the key points of the body. Proximal trunk control must be provided in terms of distal extremity movements, balance, and functional activities. Although trunk control provides static and dynamic posture, it also ensures the upright posture of the body and selective trunk movements (3). Peripheral input occurs in trunk balance, during sitting up and standing up from sitting. Extremity functions are associated with sensory information. Previous studies reported that sensory loss in the lower extremities affects standing, gait speed, balance during ambulation, and symmetrical gait negatively (4,5).

Sensory-perception disorders are among the problems experienced by individuals with stroke. This can be seen as the inability to perceive the senses or the inability to distinguish these senses. Sensory problems of patients must not be ignored during evaluations (6). Although the control of our movements is controled by the primary motor cortex area, the sense of position is controled by the sensory cortex (7). The initiation, continuity, and coordination of the movement are controlled by the sensory field. Adaptation to the environment is achieved with the development of perception (8). Previous studies reported that sensory impairment has effects on walking speed, gait symmetry, standing, and walking balance (9).

Balance is one of the important factor that affect standing and walking in stroke patients. The activity of daily life and social activities is provided by motor functions. Patients face difficulties in performing many motor functions e.g. walking with the deterioration of balance. In the literature, the effect of balance on many motor functions e.g. walking was investigated in stroke (10). However, studies that examine the relations between foot balance and gait with trunk control and lower extremity sense are limited. For this reason, it is important to evaluate the balance in detail. The hypothesis of the study is that presence of lower extremity sense increases

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trunk control, and increased trunk control improves balance and walking ability in stroke individuals.

The purpose of the present study was to evaluate the relations between trunk control and lower extremity sense, balance, and gait in stroke patients.

2.METHODS

2.1. Participants

The study was planned as a cross-sectional study. A total of 30 patients followed up with the diagnosis of stroke in two private hospitals between January 2021 and June 2021, were recruited voluntarily in the study. Those two hospitals were selected across by using a random sampling method. Individuals with stroke, who were 30-85 years old, able to walk 10 meters without assistive device, lower extremity functions in the 2-6 stage according to Brunnstrom Recovery Stages, patients having subacute and chronic stroke, those with 7 ≥ on Hodkinson Mental Score were included in the study. Individuals with neurological and orthopedic problems that may affect walking other than stroke, those who had a history of cardiovascular and rheumatological diseases that prevent their daily activities, with lesions or fractures in the lower extremities, lower extremity spasticity 4 according to the Modified Ashworth Scale (MAS), aphasia and communication disorders were not included (Fig. 1).

The Ethics Committee approval of the study was taken from SANKO University, Non-interventional research ethics committee on 07.07.2020 with the number 2020/09. The study was registered at ClinicalTrials.gov (NCT05244850).

2.2. Measurements

2.2.1. Trunk Impairment Scale (TIS)

The Trunk Impairment Scale consists of 3 parts; static sitting balance (3 items), dynamic sitting balance (10 items), and coordination (4 items). The total score of TIS is between 0 and 23. High scores show good trunk control (11). Turkish validity and reliability study of TIS was conducted by Sag et. all (12).

2.2.2. Postural Assessment Scale for Stroke Patients – Turk (PASS-T)

It is used to measure balance in individuals with stroke inadequate in terms of physical performance and includes 12 items measuring balance performance according to the degree of difficulty.

In general terms, it includes conditions in changing positions, which are transitions e.g. lying down, sitting, standing up, and going from standing to sitting. There are two main headings in the scale; maintaining and changing the posture. The scale is scored between 0-36 points. The ability to move is tested between 0-3 points. “0” shows the lowest value and “3” the highest value (13). Kandemir et al. conducted the Turkish validity and reliability of this scale in 2018 (14).

2.2.3. Tinetti Balance and Gait Test (TBT and TGT)

Tinetti Balance Test and Tinetti Walking Test are often used in clinical practice (15). This test consists of two parts and a total of 16 questions, which are balance in 9 questions and walking in 7 questions. Score calculation is made by observation, 2 points show that the movement is performed correctly, 1 point shows that there are adaptations in the movement, and 0 points show that the desired movement cannot be performed. A total score of 18 or less after the test shows a high fall risk, 19-24 shows a moderate fall risk, and a score above 24 shows a low risk of falling. The Turkish version of the scale was studied by Ağırcan (16).

2.2.4. 10-Meter Walking Test (TMWT)

The patient is asked to walk at a normal walking speed for a distance of 10 meters and the time is noted in the 10-Meter Walking Test (17). Increased time shows slow walking speed.

2.2.5. Fugl-Meyer Assessment of Sensorimotor Function (FMASF)

Fugl-Meyer Assessment of Sensorimotor Function consists of 12 items; 4 assessing light touch, 8 assessing proprioception sense. The total score is between 0-24. The sense of light touch is tested from lef and foot subjectively. Position sense evaluation of the lower extremities is tested on the toe, ankle, knee, and hip joints (18). The therapist first asks the patient to move up and down by making joint movements on the unaffected side in the proprioception evaluation, then asks the patient to answer by making 4-5 repetitions on the affected side with the eyes closed, within the limits of approximately 10 degrees of joint range of motion.

2.2.6. Neglect, Plantar Pressure Sense (PPS) and Stereognosis

Clock drawing test was used for neglect. In this method, the patient is asked to place numbers from 1 to 12 in a circle drawn earlier. If the numbers do not scatter in the circle and add up in one half, it is considered to be a neglect.

PPS is evaluated with a stick. The patient is asked to tell the localization of the stick placed horizontally on the plantar surface. When the stick localization is not correct, the sense is considered absent.

Stereognosis is the ability to recognize an object from its shape, size and structural features. During the examination, the patient’s eyes should be closed. In the meantime, he is asked to name objects such as keys, pens, lighters that he can easily recognize (19). If the object are not identified correctly, it is considered asteregnosia (no stereognosis).

2.3. Analysis

The conformity of the data to the normal distribution was tested with the Shapiro Wilk Test. The Mann Whitney U Test was used to compare the two independent groups. The relations between numerical variables were tested with the Spearman rank correlation coefficient. As descriptive statistics, mean ± standard deviation was given for numerical variables, and number and % values were given for categorical variables. The Statistical Package for the Social Sciences (SPSS) for Windows version 24.0 was used for statistical analysis and $p<0.05$ was considered statistically significant.

According to the 'Trunk performance after stroke and the relationship with balance, gait and functional ability' study (20), when the effect size was 0.73, the required minimum number of patients was determined as 12 ($\alpha=0.05$, and the power of the test=0.80). When Post-hoc power analysis was examined according to the relationship between TIS and FMSMFT, PASS-T and FMSMFT, the power of the study was found to be 0.99 (G*Power 3.1, Düsseldorf, Germany).

3.RESULTS

The demographic data, disease information and presence of plantar pressure sense, stereognosis and neglect, results of TMWT, TBT, TGT, TIS, PASS-T, and FMASF of the individuals are given in Table 1.

Table 1. *Socio-demographic characteristics and clinic features of the participants*

Variables		n (%)	Mean±SD	Median (Min-Max)
Gender	Male	17 (56.7)	-	-
	Female	13 (43.3)	-	-
Age (years)		-	52.17 ± 14.44	52 (30 – 82)
Height (cm)		-	167.23 ± 8.8	169 (153 – 180)
Weight (kg)		-	76.7 ± 19	72.5 (40 – 110)
BMI (kg/cm^2)		-	27.49 ± 6.96	27.05 (15.63 – 44.85)
Smoking	No	23 (76.7)	-	-
	Yes	7 (23.3)	-	
Alcohol	No	28 (93.3)	-	-
	Yes	2 (6.7)	-	-
Dominant Side	Right	27 (90)	-	-
	Left	3 (10)	-	-
Affected Side	Right	12 (40)	-	-
	Left	18 (60)	-	-
Stroke Type	hemorrhagic	9 (30)	-	-
	Ischemic	21 (70)	-	-
Stroke Stage	Subacute	6 (20)	-	-
	Chronic	24 (80)	-	-
Other disease	No	11 (36.7)	-	-
	Cardiovascular Disease	3 (10)	-	-
	Hypertension	4 (13.3)	-	-
	Hypertension and Diabetes Mellitus	5 (16.7)	-	-
	Other	7 (23.3)	-	-
PPS	Yes	25 (93.3)	-	-
	No	5 (16.7)	-	-
TIS		-	18.23 ± 4.07	19 (6 – 23)
PASS-T		-	27.9 ± 6.19	28 (12 – 36)
Stereognosis	Yes	20 (66.7)	-	-
	No	10 (33.3)	-	-
Neglect	Yes	4 (13.3)	-	-
	No	26 (86.7)	-	-
FMASF		-	6.62 ± 2.05	7 (2 – 11)
TMWT		-	44.53 ± 15.04	40.5 (21 – 77)
TGT		-	13.16 ± 3.67	13.0 (6-19)
TWT		-	5.47 ± 1.98	5.5 (2 – 9)

BMI: Body Mass Index, PPS: Plantar Pressure Sense, TIS: Trunk Impairment Scale, PASS-T: Turkish version of Postural Assessment Scale for Stroke Patients, FMASF: Fugl-Meyer Assessment of Sensorimotor Function, TMWT: Ten Meters Walk Test, TBT: Tinetti Balance Test, TGT: Tinetti Gait Test.

The TIS values were found to be significantly higher in the presence of PPS (p=0.002) and stereognosis (p=0.001) and the absence of neglect (p=0.001). The PASS-T values were significantly higher in the presence of PPS (p=0.002) and stereognosis (p=0.001) and the absence of neglect (p=0.001) (Table 2).

Table 2. *Comparison of TIS and PASS-T Values with and without PPS, Stereognosis, and Neglect*

n=30		TIS Mean±SD	p	PASS-T Mean±SD	p
PPS	Yes	19.28 ± 3.05	0,002*	29.44 ± 5.24	0,002*
	No	13 ± 4.85		20.2 ± 4.92	
Stereognosis	Yes	20.1 ± 1.97	0,001*	30.9 ± 4.04	0,001*
	No	14.5 ± 4.7		21.9 ± 5.4	
Neglect	Yes	12 ± 4.55	0,001*	16.75 ± 3.4	0,001*
	No	19.19 ± 3.1		29.62 ± 4.49	

**p<0,05, Mann Whitney U testi.*
PPS: Plantar Pressure Sense, TIS: Trunk Impairment Scale, PASS-T: Turkish version of Postural Assessment Scale for Stroke Patients

A positive correlations was found between TIS and TBT (r=0.542, p=0.002), TGT (r=0.641, p=0.001) and FMASF (r=0.730, p=0.001). Although negative significant correlation was found between TMWT (r=-0.736), p=0.001) (Table 3), a positive correlations were found between PASS-T and TBT (r=0.646, p= 0.001), TGT (r=0.769, p=0.001), FMASF (r=0.695, p=0.001), and a significant negative correlation was found with TMWT (r=-0.862, p=0.001) (Table 3).

Table 3. *Correlations between TIS and PASS-T to TMWT, TBT, TGT, PASS-T and FMASF*

n=30		TBT	TGT	FMASF	TMWT
TIS	r	0.542*	0.641*	0.730*	-0.736*
	p	0.002	0.001	0.001	0.001
PASS-T	r	0.646*	0.769*	0.695*	-0.862*
	p	0.001	0.001	0.001	0.001

**p<0,01, Spearman rank correlation coefficient.*
TIS: Trunk Impairment Scale, PASS-T: Turkish version of Postural Assessment Scale for Stroke Patients, FMASF: Fugl-Meyer Assessment of Sensorimotor Function, TMWT: Ten Meters Walk Test, TBT: Tinetti Balance Test, TGT: Tinetti Gait Test.

The TBT values were significantly higher in the presence of PPS (p=0.001) and stereognosis (p=0.014) and the absence of neglect (p=0.001) and TGT values were found to be significantly higher in the presence of PPS (p=0.001) and stereognosis (p=0.004) and the absence of neglect (p=0.026) (Table 4).

Table 4. *Comparison of TBT and TGT Values with and without PPS, Stereognosis, and Neglect*

n=30		TBT Mean±SD	p	TGT Mean±SD	p
PPS	Yes	20.32±3.96	0.001*	5.96±1.74	0.001*
	No	15±5.74		3±1	
Stereognosis	Yes	21.45±3.1	0.014*	6.2±1.74	0.004*
	No	15.4±4.7		4±1.63	
Neglect	Yes	10.75±2.99	0.001*	3.5±1.29	0.026*
	No	20.77±3.17		5.77±1.9	

**p<0,05, Mann Whitney U Test. PPS: Plantar Pressure Sense, TBT: Tinetti Balance Test, TGT: Tinetti Gait Test*

4.DISCUSSION

In the present study, in which we aimed to examine the relations between trunk control and lower extremity sense, balance, and walking in stroke individuals, it was found that trunk control was associated with lower extremity sense, balance, and walking.

Many studies were conducted on the loss of postural control in individuals who had a stroke before (21,22). In a study that was conducted by Çekok et al., 42 stroke patients were included and postural control was evaluated by using the PASS-T Scale (23). Postural control was found to be weak in previous studies. In the present study, postural control was evaluated with PASS-T, and postural control was found to be weak in parallel with the literature data.

The common opinion reached in studies is that sensory impairments are found in most stroke individuals. The somatosensory function impacts on activity performance and length of hospital stay (24). In their study, Sommerfield et al. evaluated regression and deterioration in sensory functions and observed them in 40% of individuals who had a stroke (24). Approximately half of the stroke patients face sensory impairments, mainly tactile sense and proprioceptive sense. In general, they face problems in receiving, interpreting, and responding to sensory inputs. Impaired proprioception sense was detected in approximately 50% of stroke patients (25). It was reported that because of sensory impairment, patients cannot adequately feel the extremities of the affected side, perceive it as a foreign limb, and for this reason have difficulty in performing functions (26). Previous studies reported that patients with stroke had impaired balance because of loss of PSS (27). In a study conducted by Kafa et al., it was found that the time to stand in balance and the sense of light touch showed a significant relation (28). In another study, it was found that different environmental conditions cause different effects on the body. Different surfaces used in this study affected sitting balance to varying degrees although lying down. it was reported in another study that individuals with stroke could not transfer enough weight to the affected side because of

low muscle strength and sensory problems, and for this reason, exhibited poor sitting. In another study, it was found that the contact surface of the sole and the back of the thigh changed the center of gravity (29). For this purpose, the relations between trunk control and lower extremity sensation were examined in the present study where we used FMASF for lower extremity sensation, it was found that trunk control increased as sensation increased. Although there are few studies on trunk position sense in patients with neurological problems, it was concluded that trunk or extremity position sense affects balance and functional activities. For this reason, it was emphasized that trunk training must be included in rehabilitation programs (30-32). The data obtained from the present study show parallelism with the results of the literature, and as a result, as lower extremity sensory impairment increased, walking speed and ability decreased.

In the present study, both the light touch and proprioceptive sense of the lower extremity were assessed with FMASF, which was used to evaluate the lower extremity sense along with PSS and stereognosis. It was found that there was a significant relationship between lower extremity sense and trunk control and postural control. It was also found that hemiplegic side sensory impairment affects gait and balance. As a result, the central nervous system needs as much enhanced environmental information as possible to initiate and maintain motor activity. The central nervous system adjusts the joint angles, the position of the extremities, and the body according to the information it receives from the senses. For this reason, the importance of sensory education in stroke rehabilitation must not be overlooked.

The evaluation of balance in stroke patients gives clinicians an idea of the severity of the stroke. In this respect, the most appropriate physiotherapy method is determined and the treatment results are evaluated (33,34). Clinically useful, short, and sensitive measurements are preferred. In clinical settings to reduce the burden of evaluation that forces patients and assessors to assess balance (35).

In the present study, trunk control was evaluated with TIS and PASS-T, the balance was evaluated with TBT, and trunk control was found to be associated with balance in parallel with the literature. We believe that it is important to create rehabilitation programs for trunk control in balance training in stroke patients.

The main target in the rehabilitation of stroke individuals is to ensure independent walking (36). Approximately 85% of patients walk with an assistive device after stroke (37). The problems faced by such people regarding walking are decreased walking speed and asymmetric gait pattern (38). The main target of gait training is to provide a normal gait pattern and speed (37). The criteria for successful walking in hemiplegic patients have not been identified fully, however, the positive effect of rehabilitation in terms of endurance and walking speed has been proven (39).

There are many methods employed to evaluate gait. These scales are often preferred because of their low cost and easy application. For walking to be effective, neural and non-neural structures must continue in a coordinated manner. To ensure this agreement, somatosensory input must be provided with proper postural control. Also, muscle tone and muscle strength must be normal, a normal range of motion must be provided and cognitive control is necessary. Gait function is significantly affected by the involvement of these structures. In hemiplegic patients Verheyden et al. examined the relations between trunk performance, balance and walking, and functional abilities in 21 chronic stroke patients. When the results of the study are evaluated, it was concluded that there is deterioration in trunk stability in stroke individuals and this affects walking, balance, and functional skills (19). Similarly, in a study that was conducted by Kim et al., 23 individuals with chronic stroke, TIS was used to assess trunk impairment along with the Berg Balance Scale, TMWT, and Timed-Up Go Test (TUG) to evaluate balance and walking ability. As a result of their study, they reported that trunk performance affects balance and walking activities in individuals with stroke (40). Isho et al. examined the relations of trunk control with mobility performance and gait in their study using TIS, Berg Balance Test, and TUG. They found a significant relationship between the total score of TIS and TUG. Takuya Isho et al. concluded that trunk impairment affected mobility performance and trunk stability in walking negatively (41).

As a result, they reported that dynamic balance increased with the improvement of trunk control. They also mentioned the necessity of trunk control for extremity movements (42).

In this regard, present study had some limitations. First, due to the crosssectional design of the study, the long-term causal relationships between various factors, could not be evaluated. Also the included individuals with and without sensory loss, stroke type and stage are not equal. Therefore, our study findings may not be generalizable to the all stroke patients.

5. CONCLUSION

In conclusion, not only motor disorders but also sensory disorders must be considered in the evaluation and treatment of balance and postural stability problems in individuals with stroke. As well as the treatment programs focusing on motor problems, treatment methods aimed at improving the trunk control must also be included. We believe that the results of our study will contribute to the studies to be conducted in this field and will give a different perspective to those who want to work in this field.

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