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Original Article

Can trunk control scales differentiate for dependent and independent ambulation in ischemic stroke patients?

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ABSTRACT

Objectives: This study aimed to compare the ability of trunk control scales (TCSs) to distinguish independent ambulation and investigate whether there was a relationship between TCSs and activities of daily living in patients with stroke.

Patients and methods: The prospective, cross-sectional study was conducted with a total of 126 patients (52 females, 74 males; mean age: 64.9±10.7 years; range, 40 to 88 years) between August 2018 and January 2020. According to their ability to walk 10 m, the patients were divided into three groups: the nonambulatory group (Group 1, n=31), those who required an assistive device while walking (Group 2, n=35), and those who could walk independently (Group 3, n=60). The Stroke Rehabilitation Assessment of Movement Instrument (STREAM), Postural Assessment Scale for Stroke Patients Scale (PASS), Trunk Impairment Scale, Trunk Recovery Scale, Trunk Control Test, and Modified Barthel Index (MBI) were used to determine the relationship between TCSs and activities of daily living.

Results: The median TCS scores differed between the groups; the lowest score was of Group 1, and the highest score was of Group 3 ($p<0.05$). The MBI was found to be correlated with all dimensions of STREAM in Group 1 and all dimensions of PASS in Group 2 (correlation coefficient was between 0.50 and 0.69).

Conclusion: All TCSs could distinguish ambulatory and nonambulatory patients. The STREAM and PASS correlated the most with MBI in Groups 1 and 2, respectively.

Keywords: Ambulation, Barthel index, stroke, trunk control.

The trunk is a crucial component of postural control necessary for the selective and coordinated movements of the limbs by stabilizing the pelvis and spine.[1] Trunk impairments are commonly reported in stroke patients. These impairments are typically characterized by diminished sitting balance, trunk coordination, and muscle strength.[2]

Trunk control after stroke is associated with functional balance and activities of daily living (ADL) and an important marker of functional recovery.[3] A study evaluating the correlation of the impairment of upper and lower limbs and the trunk with overall functionality in stroke patients reported that there was a close correlation between the independence in

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overall functionality in acute stroke patients and the severity of trunk impairment.[4]

Trunk performance can evaluate through several methods, such as clinical scales, isokinetic muscle tests, electromyography, muscle strength measurements, and movement analyses. Researchers often prefer trunk control scales (TCSs) owing to their affordability and feasibility. Several TCSs have been developed, such as Stroke Rehabilitation Assessment of Movement Instrument (STREAM),[5,6] Trunk Impairment Scale (TIS),[7] Trunk Control Test (TCT),[8] Trunk Recovery Scale (TRS),[9] and Postural Assessment Scale for Stroke Patients (PASS).[10] All scales are comparable in reliability, responsiveness, and reliability.[11] However, there is no standard gold test to evaluate trunk control,[12] and none of the tests considers all aspects of postural control.[13]

Although several TCSs have been reported in the literature to determine ambulation, there is only one study to compare different TCSs for ambulation.[14] Therefore, we aimed to compare TCSs to determine independent ambulation in stroke patients and whether there was a relationship between TCS and ADLs.

PATIENTS AND METHODS

This prospective, cross-sectional study was conducted on ischemic stroke patients who were admitted to the physical therapy and rehabilitation and neurology outpatient clinics of the Antalya Training and Research Hospital between August 2018 and January 2020. A total of 126 patients (52 females, 74 males; mean age: 64.9±10.7 years; range, 40 to 88 years) who fulfilled the inclusion criteria out of 413 patients were included (Figure 1). Inclusion criteria were as follows: disease duration of one to six months, patients without swallowing and speech problems, except for dysarthria and cognitive dysfunction, and independent walking without assistive devices before the stroke. Exclusion criteria included stroke associated with causes other than ischemia, bilateral hemiplegia, sensorial aphasia and negligence, scoliosis, visual and auditory defects, an orthopedic or neurological disease that may affect trunk balance, and those who underwent robotic rehabilitation. Data including age and sex of the patients, lateralization, dominant extremity, education status, marital status, occupation, spasticity, joint range of motion (ROM) limitation in the affected extremities, pain, use of an assistive device, lesion site, body mass index, comorbidity, cognitive function, disease duration, rehabilitation period, ADL, and trunk control were recorded.

Comorbidities were recorded using the Charlson comorbidity index.[15] Cognitive function was evaluated using the Standardized Mini-Mental State Examination, and patients who scored ≥24 were accepted as cognitively normal. The Turkish version of the Modified Barthel Index (MBI) was used to evaluate ADL, which comprised 10 items to measure daily activities, such as walking, stair climbing, dressing, eating, and going to the toilet, at five levels.[16] Brunnstrom recovery stages was used for assessing motor function.[17]

Trunk control was evaluated using five different scales: STREAM,[5,6] TIS,[7] TRS,[9] PASS,[10] and TCT.[8] The STREAM is reliable and consists of 30 upper limb and lower limb movements and essential mobility.[5,6] Limb movement assessments are evaluated over 2 points, whereas basic mobility movements are evaluated over 3 points. The maximum total score is 70, with each extremity subscale scored out of 20 and the mobility subscale scored out of 30.[6]

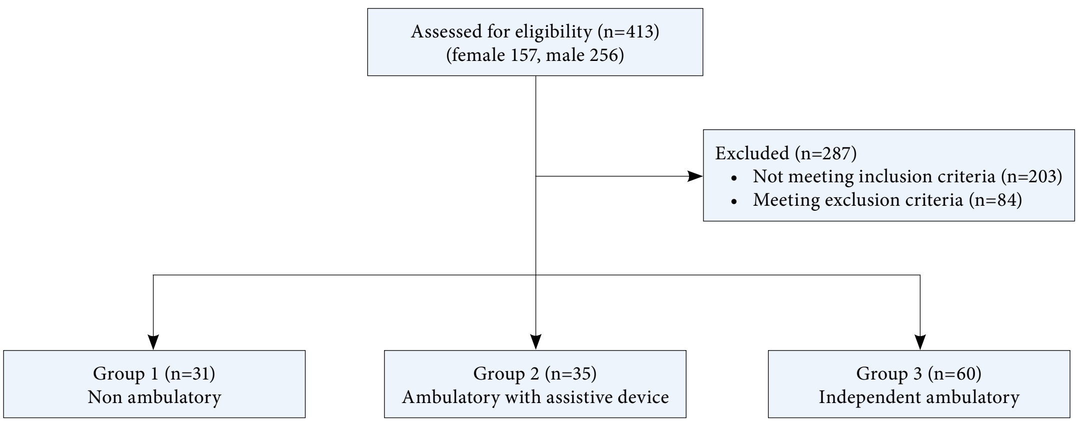

Figure 1. Consort statement.

The TIS, which is reliable in internal consistency and interobserver measurements, is the most frequently used scale in the literature.[14] This scale assesses static and dynamic sitting balance and trunk coordination, and the score ranges from 0 to 23 points.[7] Its reliability and validity were shown in the Turkish population.[18]

The TRS is assessed in supine (D1) and sitting (D2) postures by 12 items, which are scored on a 4-point scale ranging from 0 to 3, and a total score ranging from 0 to 18. Each score is converted to a percentage. These percentages are added together to produce a single score by calculating percentage D1 + percentage D2/2. The total score ranges from 0 to 100.[9]

The PASS contains 12 items of varying difficulty for assessing the ability to maintain (static) or change (dynamic) a given lying, sitting, or standing posture. The items are evaluated on a 4-level (0 to 3 points) rating scale: a score of 0 indicates the worst performance, whereas a score of 36 points is the best possible result.[10] Its reliability and validity were shown in the Turkish population.[19]

The TCT consists of four tests that examine axial movements. The scoring for each item is as follows: 0, 12, and 25. The total score (ranging from 0 to 100) is the sum of scores obtained on the four items.[8] The TCT is the first test developed to evaluate the trunk's performance. The literature has shown that it is reliable in terms of internal consistency and interobserver measurements.[8,20]

Each scale was applied to 13 randomly selected patients by two physiotherapists and a physiatrist twice a day with a one-day interval to assess interobserver agreement. All patients were divided into three groups according to their ability to walk 10 m to evaluate the association of the trunk tests with ambulation. Group 1 included patients who could not walk (n=31), Group 2 consisted of patients who could walk with an assistive device (n=35), and Group 3 contained patients who could walk independently (n=60).

Statistical analysis

Statistical analysis was performed using the IBM SPSS version 25.0 (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov test was used to verify the normality of continuous variables. Descriptive data were presented as mean ± standard deviation, median (min-max), or number and frequency. Normally distributed variables were evaluated using the analysis of variance and the Sidak test, while the Kruskal-Wallis and Mann-Whitney U tests were used to analyze nonnormally distributed variables. For the comparison between the categorical variables, the chi-square test was used. Motor function results were combined as stages 1-3 and 4-6 as each cell had insufficient data. The inter-rater agreement was assessed using an intraclass correlation coefficient (ICC) and 95% confidence interval (CI). A *p* value of <0.05 was considered statistically significant for baseline comparisons. The significance value was 0.008 (0.05/number of outcome measures) compared to the groups in terms of TCSs. The Spearman correlation analysis was used to examine the relationship between the trunk control test and MBI. The correlation coefficient® was considered very weak if it fell between 0.00 and 0.25, weak if it fell between 0.26 and 0.49, medium if it fell between 0.50 and 0.69, high if it fell between 0.70 and 0.89, and very high if it fell between 0.90 and 1.00.

RESULTS

The only differences among the groups were the motor function, ROM limitation, and the use of assistive devices (p<0.05). There was no difference in ROM limitation between the ambulatory groups (p>0.05). Lower extremity ROM limitation was higher in Group 1 than in the other groups. While there was no difference between Groups 1 and 2 in the upper extremity ROM limitation (p>0.05), the same value was higher in Group 3 (p<0.05). Most of the patients used wheelchairs in Group 1, and most used tripods in Group 2. The motor stages of the upper and lower extremities of Group 1 were lower than Group 2 and 3. While there was no difference between Groups 1 and 2 in hand stages, Group 3 was better than Group 1. The lower extremity motor stage of Group 2 was worse than Group 3 (Table 1). Interobserver reliability for the STREAM, TIS, TRS, PASS, and TCT trunk tests total score was high [ICC: 0.978 (95% CI: 0.929-0.993); ICC: 0.944 (95% CI: 0.835-0.983); ICC: 0.911 (95% CI: 0.735-0.972), ICC: 0.919 (95% CI: 0.765-0.974), and ICC: 0.958 (95% CI: 0.856-0.987, respectively].

The MBI, STREAM, TIS, TRS, PASS, and TCT scores were different among the groups, being the lowest in Group 1 and the highest in Group 3 (p<0.008, Table 2). In Group 3, 30% of the patients had a total score of 70 on the STREAM scale, and there was no patient with a maximum score in Groups 1 and 2. In addition, 1% of the patients in Groups 1 and 2 and 35% of the patients in Group 3

TABLE 1
Clinical and demographic characteristics of participants

	Group 1 (n=31)					Group 2 (n=35)					Group 3 (n=60)					
	n	%	Mean±SD	Median	Min-Max	n	%	Mean±SD	Median	Min-Max	n	%	Mean±SD	Median	Min-Max	*p*
Sex																0.815*
Female	12	39				16	46				24	40				
Male	19	61				19	54				36	60				
Lateralization																0.392*
Right	10	32				17	49				26	43				
Left	21	68				18	51				34	57				
Dominant extremity																0.472*
Right	26	84				32	91				55	92				
Left	5	16				3	9				5	8				
Education																0.525*
Illiterate	6	19				6	17				9	15				
Primary school	16	52				22	63				33	55				
High school	7	23				6	17				9	15				
University	2	7				1	3				9	15				
Marital status																0.500*
Married	25	81				27	77				42	70				
Single	6	19				8	23				18	30				
Employment																0.970*
Retired	13					15					28	47				
Housewife	11					11					20	33				
Employed	7					9					12	20				
Brunnstrom																
Upper extremity																
Stage 1-3	20	65				12	34				13	22				<0.001
Stage 4-6	11	36				23	66				47	78				
Hand																
Stage 1-3	21	68				15	43				16	27				0.001
Stage 4-6	10	32				20	57				44	73				
Lower extremity																
Stage 1-3	18	58				8	23				-	-				<0.001
Stage 4-6	13	42				27	77				60	100				
Spasticity	13	42				12	34				18	30				0.523*
ROM limitation	13	42				9	26				10	17				0.032*
Pain	14	45				12	34				14	23				0.098*
Assistive device																<0.001*
Tripod	9	29				16	46				-	-				
Cane	1	0.03				9	26				-	-				
Canadian crutch	3	0.1				4	11				-	-				
Wheelchair	14	45				-	-				-	-				
Walker	4	0.1				6	17				-	-				
MRI																0.652*
Total MCA	12	39				11	31				21	35				
Cortical MCA + frontal	4	13				3	9				8	13				
Lenticulostriate	5	16				3	9				8	13				
Extrathalamic posterior system	8	26				14	40				13	22				
Thalamus	2	7				4	11				10	17				
Age (year)			66.3±11.7					66.7±10.6					63.2±10.2			0.227†
Body mass index (kg/m^2)			25.6±2.6					27.5±3.4					26.8±3.2			0.052†
Charlson comorbidity index (point)				2	1-4				3	1-5				2	1-5	0.314‡
SMMSE (point)				27	24-30				28	24-30				28	24-30	0.084‡
Disease duration (month)				3	1-5				2	1-5				2.8	1-6	0.075‡
Rehabilitation session				25	45				30	15-60				27	15-90	0.386‡

SD: Standard deviation; ROM: Range of motion; MRI: Magnetic resonance imaging; MCA: Middle cerebral artery; SMMSE: Standardized Mini-Mental State Examination; * χ^2 test, †one way ANOVA test; ‡ Kruskal Wallis test.

TABLE 2
Differences in MBI, STREAM, TIS, TRS, PASS, and TCT scores between the groups

	Group 1 (n=31)		Group 2 (n=35)		Group 3 (n=60)		Group difference	Difference between Group 1 and 2	Difference between Group 1 and 3	Difference between Group 2 and 3
	Median	Min-Max	Median	Min-Max	Median	Min-Max	*p*	*p*	*p*	*p*
MBI (score)	52	7-86	75	29-100	91	43-100	<0.001*	<0.001†	<0.001†	0.001†
STREAM, score										
UE	3	0-20	18	0-20	20	0-20	<0.001*	0.007†	<0.001†	0.043†
LE	5	0-19	12	2-20	20	7-20	<0.001*	<0.001†	<0.001†	<0.001†
BM	6	0-27	20	12-28	29	18-30	<0.001*	<0.001†	<0.001†	<0.001†
Total	15	0-63	49	14-68	68	32-70	<0.001*	<0.001†	<0.001†	<0.001†
TIS, score										
Static	5	0-7	6	2-7	7	3-7	<0.001*	0.008†	<0.001†	<0.001†
Dynamic	5	0-10	7	0-10	10	3-10	<0.001*	0.002†	<0.001†	<0.001†
Coordination	2	0-6	4	0-6	4	0-6	<0.001*	<0.001†	<0.001†	0.030†
Total	11	0-23	18	5-23	21	8-23	<0.001*	0.001†	<0.001†	<0.001†
TRS, score										
Lying	77.8	27.8-100	100	33-100	100	67-100	<0.001*	0.009†	<0.001†	0.001†
Sitting	72.2	16.7-100	100	39-100	100	61-100	<0.001*	0.017†	<0.001†	0.002†
Total	69.4	31-100	97	42-100	100	81-100	<0.001*	0.010†	<0.001†	0.001†
PASS, score										
Maintaining	6	2-12	12	7-18	15	7-18	<0.001*	<0.001†	<0.001†	<0.001†
Changing	8	2-16	12	5-18	18	12-18	<0.001*	<0.001†	<0.001†	<0.001†
Total	14	4-28	26	12-34	33	23-36	<0.001*	<0.001†	<0.001†	<0.001†
TCT, score	50	12-100	74	25-100	100	61-100	<0.001*	0.008†	<0.001†	<0.001†

MBI: Modified Barthel Index; STREAM: Stroke Rehabilitation Assessment of Movement Instrument; TIS: Trunk Impairment Scale; TRS: Trunk Recovery Scale; PASS: Postural Assessment for Stroke Patients; TCT: Trunk Control Test; UE: Upper extremity; LE: Lower extremity; BM: Basic mobility; * Kruskal-Wallis test; † Mann-Whitney U test.

TABLE 3
Correlation between the MBI and trunk scales

	Group 1 (n=31)		Group 2 (n=35)		Group 3 (n=60)		Total (n=126)	
	r*	*p*	r*	*p*	r*	*p*	r*	*p*
STREAM, score								
UE	0.556	0.001	0.470	0.004	0.314	0.015	0.541	<0.001
LE	0.530	0.002	0.281	0.102	0.359	0.005	0.620	<0.001
BM	0.572	0.001	0.475	0.004	0.376	0.003	0.699	<0.001
Total	0.621	<0.001	0.417	0.013	0.397	0.002	0.674	<0.001
TIS, score								
Static	0.317	0.083	0.198	0.254	0.286	0.026	0.473	<0.001
Dynamic	0.519	0.003	0.241	0.163	0.360	0.005	0.551	<0.001
Coordination	0.364	0.044	0.215	0.215	0.473	<0.001	0.560	<0.001
Total	0.489	0.005	0.260	0.131	0.457	<0.001	0.589	<0.001
TRS, score								
Lying	0.340	0.061	0.681	<0.001	0.065	0.620	0.550	<0.001
Sitting	0.568	0.001	0.404	0.016	0.090	0.363	0.517	<0.001
Total	0.463	0.009	0.605	<0.001	0.120	<0.001	0.554	<0.001
PASS, score								
Maintaining	0.564	0.001	0.565	<0.001	0.414	0.001	0.697	<0.001
Changing	0.259	0.002	0.643	<0.001	0.404	0.001	0.720	<0.001
Total	0.605	<0.001	0.644	<0.001	0.438	<0.001	0.738	<0.001
TCT, score	0.603	<0.001	0.509	<0.001	0.277	<0.032	0.622	<0.001

MBI: Modified Barthel Index; STREAM: Stroke Rehabilitation Assessment of Movement Instrument; UE: Upper extremity; LE: Lower extremity; BM: Basic mobility; TIS: Trunk Impairment Scale; TRS: Trunk Recovery Scale; PASS: Postural Assessment for Stroke Patients; TCT: Trunk Control Test; * Spearman Correlation Analysis.

received 23 points from the TIS scale; 29% of those in Group 1, 46% of those in Group 2, and 73% of those in Group 3 had a total score of 100 on the TRS scale. In Group 3, 28% of patients received 36 points from the PASS scale, and there were no patients that received a maximum score in Groups 1 and 2. Ninety percent of the patients in Group 1 and all patients in Groups 2 and 3 received a static PASS score ≥3.5, while 42% of patients in Group 1, 89% of patients in Group 2, and all patients in Group 3 received a dynamic PASS score ≥8.5. Twenty-six percent of the patients in Group 1, 37% in Group 2, and 75% in Group 3 received a total score of 100 on the TCT scale.

In Group 1, the total and subdimensions of the STREAM scale, the dynamic subdimension of TIS, the sitting dimension of TRS, the total and maintaining dimension of the PASS scale, and the TCT score and MBI were moderately positive. There was also a moderate positive correlation between the total score and lying dimension of TRS, all subdimensions, and the total score of the PASS scale, TCT score, and MBI in Group 2. However, there was a weak or no relationship between trunk control tests and MBI in Group 3 (Table 3).

DISCUSSION

In the present study, we compared TCSs to determine independent ambulation in stroke patients and whether there was a relationship between TCS and ADL. Our study results showed that all trunk control tests could distinguish nonambulatory, assisted ambulatory, and independent ambulatory patients whose disease duration was between one to six months. Correlation between ADL, STREAM, and PASS was moderate in Groups 1 and 2. All scales in Group 3 were unrelated or weakly related to ADL. Additionally, all TCSs used in this study differentiated ambulatory and nonambulatory stroke patients.

A study argued that a score ≥50 in TCT at six weeks in hemiplegic patients could be a marker for improving the ability to walk at 18 weeks.[8] It was also reported that if the TCT score was ≤43, independent gait would be more difficult, but it would be possible with a score of ≥61 points.[21] In our study, we found that 26% of the patients in Group 1, 37% in Group 2, and 75% in Group 3 received a total score of 100 on the TCT scale. Consistent with the literature, the median TCT score was 50 in the nonambulatory group; 39% of this group had a score ≤43. In Group 2, the median TCT score was 74, and 1% of this group had a score ≤43. In the independent ambulatory group, the median TCT score was 100, and all patients in this group scored ≥61 points.

A previous study with 129 days of median disease duration reported that the median total TIS score was 8 in the nonambulatory group, while the median TIS score was 14 in the ambulatory group.[21] In our study, we observed a median total TIS score of 11 in Group 1, 18 in Group 2, and 21 in Group 3. A total of 13% of those in Group 1, 77% in Group 2, and 52% in Group 3 received a total score ≥20 on TIS. Kong and Ratha Krishnan[23] reported that 70% of patients with a TIS score ≥14 in the acute phase were likely to achieve an excellent ambulatory level. Although the disease duration differed in our study, 36% of Group 1, 80% of Group 2, and 95% of Group 3 had a score ≥14. We observed that 1% of the patients in Groups 1 and 2 and 35% of Group 3 had a total score of 23 on the TIS.

A study evaluating trunk performance with PASS on days 30 and 90 reported that 38% of the patients reached the maximum score on day 90. Therefore, PASS use after day 90 would not be appropriate.[10] O'Dell et al.[24] compared the patients' walking speed grouped according to their walking speed in the first 10 days after CVA with the PASS results after an average of one month. They showed that the PASS scale might be decisive in independent ambulation in the early period, but this may be more effective in determining the level of ambulation in the three to six-month period.[23] Huang et al.[18] compared the PASS results before and after rehabilitation of nonambulatory and ambulatory patients with a disease duration of up to six months. They concluded that patients with a static PASS result ≥3.5 points at baseline or a dynamic PASS result ≥8.5 points had a three-fold more tremendous potential to walk than those with lower scores. In the present study, 28% of the patients in Group 3 received 36 points from the PASS scale, and there were no patients who received a maximum score in Groups 1 and 2. We observed that those with static PASS ≥3.5 were 90% of Group 1 and 100% of Groups 2 and 3, while those with dynamic PASS ≥8.5 were 42% of Group 1, 89% of Group 2, and 100% of Group 3. Forty-two percent of the patients in Group 1, 89% of those in Group 2, and 100% in Group 3 had static PASS ≥3.5 and dynamic PASS ≥8.5.

The STREAM scale has a low ceiling effect, and it is influential in determining the functional status and walking speed of stroke patients. However, all studies used this scale to determine patients' progress instead of predicting walking ability.[5,6] In this study, the median total STREAM score was 15 in Group 1, 49 in Group 2, and 68 in Group 3. In addition, 30% of the patients in Group 3 received 70 points on the STREAM scale. There were no patients in Groups 1 and 2 with total scores.

Montecchi et al.[9] reported that the TRS was valid and reliable in 59 patients with severe brain injury, including cerebrovascular accident (CVA), whose disease duration exceeded one month on average. In the current study, 29% of Group 1, 46% of Group 2, and 73% of Group 3 scored 100 on the TRS scale. However, there is no study investigating the TRS scale difference in ambulatory and nonambulatory patients after stroke, a comparison could not be made.

Verheyden et al.[22] concluded that a total TIS score >20 points could indicate normal trunk function and independence in the ADL. In this study, 52% of patients in Group 3 received a total score of ≥20 on TIS and 100 on MBI. We observed a moderately positive correlation between the STREAM scale total score and also the subdimensions, TIS dynamic subdimension, TRC sitting subdimension, PASS scale stability subdimension, and the total score, TCT score, and MBI in the nonambulatory group. In the ambulatory group with assistive devices, there was a moderate positive correlation between the total score of the TRS scale, all subdimensions of the PASS scale, and the total score, TCT score, and MBI. In the independent ambulatory group, there was a weak or no correlation between trunk control tests and MBI.

Previous studies reported a strong correlation between balance, walking, and functionality.[21] In our study, we found that, as the level of ambulation improved, functional independence also increased. A study found that in which cut-off scores of the MBI and Modified Rankin Scale were determined to evaluate functional independence, stroke patients with an MBI score ≤54 had incontinence and required constant nursing care and attention and had severe disability. The patients who scored 55 to 77 could not walk without assistance, and those who scored 78 to 93 required some help to do their work but could walk without aid.[25] Hong et al.[26] found that patients with an MBI score ≥85.1 were competent, requiring short-term goals. In our study, the median MBI score was 52 in Group 1 (those unable to walk) and 91 in Group 3 (those able to walk without assistance).

One of the limitations of this study is the inclusion of patients with a disease duration of more than one month, as the common feature of the trunk scales used in the study required patient cooperation. The exclusion of patients with aphasia, neglect, and cognitive dysfunction in this study limited the evaluation of patients in the first month after stroke. Another limitation is determining the change in the trunk control tests and scales over time. Patients who reached the level of independent ambulation did not attend regular patient check-ups. Not determining the detailed treatment program of the patients is another limitation of this study. We were unable to control the nonambulatory patients due to their socioeconomic status and the difficulties experienced. The main strength of the study was the use of multiple trunk control tests, STREAM, TIS, TCT, TR, and PASS, for the same patient population.

In conclusion, the TCSs can differentiate ambulatory and nonambulatory stroke patients in the subacute period. In addition, there was a weak correlation between ADL and trunk control tests, particularly in independent ambulatory patients. However, we believe that it would be appropriate to determine the cut-off values and conduct research with more samples.

Ethics Committee Approval: The study protocol was approved by the Health Sciences University Antalya Training and Research Hospital Clinical Research Ethics Committee (date: 06.06.2018, no: 11/12). Clinical trial number: NCT04525742, August 25, 2020. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Consent for Publication: A written informed consent was obtained from each patient.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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