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ORIGINAL ARTICLE

Validity and Reliability of the Timed 360° Turn Test in Individuals with Ankle Sprain

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Abstract

Background The Timed 360° turn test (T-360° TT) was developed to assess balance and turning ability. Although validity and reliability have been performed in different diseases, validity and reliability have not been performed in individuals with ankle sprain (AS).

Purpose The purpose of this study was to investigate the validity and reliability of the T-360° TT in individuals with AS.

Methods The study included 54 individuals with AS. Participants were initially evaluated with T-360° TT, Timed Up and Go (TUG) test and Biodex Balance System (BBS). To assess test–retest reliability, the T-360° TT was performed again 5 days after the first measurement by the same assessor.

Results At the end of the study, strong positive correlations were found between T-360° TT with TUG test and BBS ($p < 0.05$). In addition, T-360° TT had excellent test–retest reliability (Intraclass correlation coefficient = 0.87).

Conclusion The T-360° TT is a valid and reliable tool for the evaluation of balance and turning ability in individuals with AS. We also think that it can be used practically in clinical settings because it is a test that can be easily and quickly performed.

Keywords Ankle sprain · Balance · Turn · Timed 360° turn test

Introduction

The ankle is one of the most common sites of lower extremity injuries in the musculoskeletal system. Ankle sprain (AS) account for approximately 75% of ankle injuries [1]. In individuals with AS, limited range of motion, tenderness, swelling, ecchymosis, functional impairment, and loss of balance due to decreased proprioception and neuromuscular control may be observed with depending on the severity of the sprain [2]. AS is graded in three stages according to the West Point classification system proposed by Puffer [3]. A grade 1 injury involves the stretching of ligaments without any tear, accompanied by minimal swelling and tenderness. Mechanical instability is absent, and the anterior drawer

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and talar tilt tests are negative. A grade 2 injury includes a partial tear of the ligaments, resulting in minimal loss of movement. Mechanical instability is absent or minimal, the anterior drawer test shows mild to moderate positivity, and the talar tilt test is negative. A grade 3 injury is characterized by a complete tear of the ligaments, significant mechanical instability, severe swelling, bleeding, and tenderness [3].

Given that the foot and ankle complex is the sole part of the body in contact with the ground, ankle proprioception holds significant importance for balance control [4]. Balance and postural stability problems are observed in individuals with AS due to decreased proprioception and joint position-sense [5]. Studies have indicated that decreased neuromuscular control and proprioception increase the risk of re-injury [6]. In addition, studies have proved that the proprioceptive system plays an active role in the turn movement of the ankle joint through muscle spindles [7]. The purpose of the turn movements observed in the ankle is to keep the centre of mass trajectory upright and to maintain the rotation of the trunk during turn [8]. For this reason, turn ability has a very important place in balance assessment.

When the literature is examined; Biodex Balance System (BBS) [9, 10], Timed Up and Go test (TUG) [11], Single leg balance test [12], Star Excursion Balance Test [11], Berg Balance Scale [13] are frequently used in the evaluation of balance. Among these measurements and tests, the single-leg balance test evaluates only static balance [12]. The Berg Balance Scale, which is time-consuming to administer and challenging for patients to tolerate, assesses both static and dynamic balance rather than exclusively dynamic balance [13]. The Star Excursion Balance Test, focusing on multi-directional reaching with the foot, provides a less-extensive evaluation of turning and stepping balance. Moreover, this test, which is time-consuming to administer and requires specialized equipment, is difficult for individuals with AS to tolerate [11]. The BBS, requiring expensive equipment and specialized practitioner training, is a valid and reliable method that provides objective results in the assessment of dynamic balance [10]. On the other hand, the BBS is a specialized system that is not available in each clinic [9]. TUG is a valid and reliable test primarily used to evaluate dynamic balance and mobility in the elderly [11].

Timed 360° turn test (T-360° TT) developed by Gill et al. [14], is a quick and simple test for the assessment of dynamic balance and turning ability compared to the aforementioned tests [15]. While the T-360° TT was first used to evaluate dynamic balance in elderly individuals [14], it is also frequently used in patients with Parkinson's disease [16], multiple sclerosis [17], chronic stroke [15], cognitive impairment [18], and anterior cruciate ligament reconstruction [19].

It has been stated that there is a negative association between balance control and ankle-injury risk [20]. Studies have shown that decreased balance ability increases ankle injuries [21]. In this context, it is essential to evaluate the turning ability and dynamic balance in individuals with AS after injury. On the other hand, to the best of the authors' knowledge, the validity and reliability of the T-360° TT, capable of assessing balance during immediate turning movement, which has an important role in the ankle sprain mechanism, has not been previously investigated in individuals with AS. There is a need to confirm the validity and reliability of the T-360° TT, which can be practically applied in the assessment of turning ability and dynamic balance, in order to be applied in individuals with AS. Thus, this study aimed to investigate the validity and reliability of the T-360° TT for the assessment of turning ability and dynamic balance in the evaluation and rehabilitation of individuals with AS.

Materials and Methods

Study Design and Participants

This cross-sectional study, approved by the local ethics committee (Number: 7-2023/38), was conducted with 54 individuals who applied to Muş State Hospital with symptoms of AS, were examined by a specialist physician and diagnosed with grade 1 and 2 AS according to the West Point classification proposed by Puffer [3] and met the inclusion criteria. The study adhered to the principles of the Declaration of Helsinki, and both verbal and written informed consent were obtained from all participants. Inclusion criteria were as follows: (a) individuals aged 18–45 who have had unilateral AS for at least 3 months and no more than 6 months and have been diagnosed with grade 1–2 AS according to the West Point classification [3] by a specialist physician; (b) sedentary individuals with a metabolic equivalence (MET) level < 600 MET per week according to the International Physical Activity Questionnaire [22]. Individuals with grade 3 AS according to the West Point classification [3], who had undergone surgery involving the ankle, who had an additional musculoskeletal, cardiac, neurovascular, metabolic or rheumatologic disease, and who were enrolled in a rehabilitation program for AS were excluded. The procedure proposed by Lexell and Downham [23] was followed in determining the sample size of the study. According to this procedure, it was suggested that a sample size of 30–50 participants may be sufficient for validity and reliability studies involving rehabilitation. In the current study, considering these, a sample size of approximately 50 participants was considered adequate.

Procedures

Before the clinical evaluations, demographic information such as gender, height, age, weight, and body mass index were recorded. In addition to demographic information, the injured extremity, time of injury, dominant extremity, and grade level were recorded. Then, T-360° TT, BBS, and TUG were performed for balance assessment. In order to evaluate the test–retest reliability of the T-360° TT, the all participants were re-administered with the T-360° TT by the same evaluator five days after the first evaluation. The assessments were performed by a physiotherapist specializing in orthopedic rehabilitation (H.A.).

Outcome Measures

Timed 360° Turn Test

Turn and dynamic balance abilities of individuals with AS were evaluated by T-360° TT. Participants were instructed to wait in a standing, upright position at a predetermined starting point. The participants were first asked to turn 360° clockwise around themselves and return to the starting position, and then to turn 360° anti-clockwise and return to the starting position. One test cycle was completed with clockwise and anti-clockwise turns. The duration of the test started with the assessor's command "start" and ended when the participants returned to their starting position. Participants were asked to perform the test cycle three times consecutively. Two-minute rest intervals were given between the three tests to minimize possible fatigue effects. The three test durations were averaged and recorded in seconds [14].

Biodex Balance System

In this study, concurrent validity of the T-360° TT was performed with the BBS (Biodex, Corp., Shirley, NY) After the initial T-360° TT test administration was completed, dynamic balance was assessed with the BBS after a 30-min rest interval to prevent fatigue and eliminate performance impairment. The BBS consisted of a movable balance platform that provides a 360° range of motion and a surface inclination of up to 20°. The platform moves around the anterior–posterior (AP) and medial–lateral (ML) axes. The device measures the deviation of the center of pressure in static conditions and calculates the degree of tilt of the axis in dynamic conditions. The difficulty of the test is adjusted by varying the range of movement of the moving platform and the surface inclination of the platform. The minimum stability of the platform can be set to 0 and the maximum stability to 12. BBS scores the loss of balance or stability during the test in ML and AP directions. The overall stability score is the average of AP and ML scores. The score obtained shows the amount of oscillation of the participants in cm. A high score indicates poor postural control and impaired balance [10].

Timed Up and Go Test

TUG was another test used to assess the concurrent validity of the T-360° TT, as it is a time-based test and allows for the evaluation of dynamic stability. After completing the BBS test, a 30-min rest interval was provided to avoid any fatigue and eliminate performance impairment, and then the TUG test was administered. The individuals to be tested at TUG were seated on a standard chair, and a distance of 3 m was marked in front of the chair. The participants were asked to walk this distance at normal speed and pattern and then return and sit on the chair again. The time to complete the test was measured with a stopwatch and recorded in seconds [11].

Statistical Analysis

In normally distributed data, quantitative measurements were summarized via mean, standard deviation, minimum, and maximum values, whereas qualitative measurements were reported by frequency and percentage values. The relationships between the measurements of T-360° TT with TUG and BBS (including AP, ML and overall measurements) have been analyzed with Pearson correlation analysis. The results were qualified by confidence intervals of 95%. The interpretation reference itemized as follow [24]: low for $0.05 < r < 0.40$, moderate for $0.40 < r < 0.70$ and high for $0.70 < r < 1.00$. The reliability and consistency analyses of the T-360° TT scores between test and retest measurements have been evaluated via the standard error of measurement (SEM), intraclass correlation coefficient (ICC), and the minimal detectable change (MDC) score. The ICC coefficient was considered as good for the range [0.60–0.80] and as excellent for the range [0.80–1.0] [25]. The SEM_{95} and MDC_{95} were computed using the formulas given follows:

$$SEM_{95} = SD \times \sqrt{(1 - ICC)}$$

$$MDC_{95} = 1.96 \times SEM_{95} \times \sqrt{2}$$

where *SD* represents the standard deviation depending on the difference values of the measurements. To visually visualize the reliability of the measurements, a Bland–Altman graph has been plotted. Furthermore, a box plot of the distribution of test and retest measurements of the turn test is provided. The normality of the measurement scores has been tested by Shapiro–Wilk test and skewness and kurtosis scores, and the linearity assumption has been checked using a scatter plot. IBM SPSS (v.26) and MedCalc (v.22) software have been

used during the analysis process and the statistical significance level of the study has been set as equal to 0.05.

Results

Out of the 93 individuals referred to the clinic with a diagnosis of AS by a specialist physician, 54 were ultimately included in the study. Exclusions comprised 12 individuals with bilateral AS, 5 individuals with grade 3 AS, 7 individuals with an additional musculoskeletal or other diseases, 6 individuals undergoing treatment for the lower extremities, and 9 individuals with a MET level of 600 or more per week.

The summary statistics of the demographic measures considered in the study are presented in Table 1. The mean age of the individuals was 30.16 ± 4.12 and the mean duration of injury was 15.91 ± 2.28 ranging 12–21 weeks. Of the participants, 57.4% were male, 81.5% had a right-sided dominant lower extremity, 64.8% had a right-sided injury, and 53.7% had a grade 1 injury.

The characteristics of the clinical variables of the participants are summarized in Table 2. The mean ± standard deviation value for T-360° TT was 3.68 ± 0.61 for the first measurement and 3.57 ± 0.53 for the retest.

The findings of the correlation analyses of the test measurements of the T-360° TT and the TUG and BBS measurements are tabulated in Table 3. There were positive high correlations between the T-360° TT with TUG ($r = 0.779$) and BBS (ML $r = 0.824$, AP $r = 0.799$, and overall $r = 0.846$) measurements ($p < 0.001$).

Table 4 presents the SEM, ICC, and MDC scores of the T-360° TT scores. The ICC suggests an excellent consistency (reliability) across test and retest measurements (ICC = 0.879). With respect to acceptable and sufficient SEM and MDC scores, the lower values indicate more consistent and generalisable results.

For enhanced clarity and to validate the reliability of the measurements, the Bland–Altman plot of the test and retest measurements was generated and is presented in Fig. 1. Figure 1 demonstrates that the test difference scores fall within the 95% confidence interval and are distributed close to zero. Furthermore, a box-whisker plot was constructed to provide a clearer understanding of the dispersion of the scores, as depicted in Fig. 2. It is evident from Fig. 2 that the test

Table 1 Descriptive statistics of demographic variables

	Mean ± standard deviation	Minimum	Maximum
Age (years)	30.16 ± 4.12	22	37
Body mass index (kg/m^2)	23.56 ± 1.39	21	26
Duration of injury (week)	15.91 ± 2.28	12	21
		n	%
Gender	Male	31	57.4
	Female	23	42.6
Dominant lower extremity	Right	44	81.5
	Left	10	18.5
Injured lower extremity	Right	35	64.8
	Left	19	35.2
Level of injury	Grade 1	29	53.7
	Grade 2	25	46.3

Table 2 Descriptive statistics of clinical variables

Variables		Mean ± standard deviation	Minimum	Maximum
T-360° TT (test) (second)		3.68 ± 0.61	2.82	4.98
T-360° TT (retest) (second)		3.57 ± 0.53	2.71	4.75
TUG (second)		7.46 ± 0.87	6.17	8.91
BBS (cm)	Medial–lateral	3.28 ± 0.58	2.11	4.32
	Anterior–posterior	3.54 ± 0.73	2.42	5.23
	Overall	5.66 ± 0.95	4.03	6.47

T-360° TT Timed 360° Turn Test, *TUG* Timed Up and Go Test, *BBS* Biodex Balance System

Table 3 The relationships between T-360° TT and TUG and BBS scores

			T-360° TT
TUG (second)		*r*	0.779
		CI (95%)	[0.674–0.871]
		p	**< 0.001**
BBS (cm)	Medial–lateral	*r*	0.824
		CI (95%)	[0.716–0.898]
		p	**< 0.001**
	Anterior–posterior	*r*	0.799
		CI (95%)	[0.696–0.883]
		p	**< 0.001**
	Overall	*r*	0.846
		CI (95%)	[0.731–0.911]
		p	**< 0.001**

T-360° TT Timed 360° turn test, *TUG* Timed Up and Go Test, *BBS* Biodex Balance System, *CI* Confidence interval, *r*: Pearson correlation coefficient

Table 4 Reliability analysis results of the T-360° TT

	ICC	CI of ICC (95%)	SEM_{95}	MDC_{95}
T-360° TT	0.879	0.791–0.932	0.101	0.279

ICC Intraclass correlation coefficient, *CI* Confidence interval, *SEM* Standard error of measurement, *MDC* Minimal detectable change, *T-360° TT* Timed 360° turn test

scores exhibit a considerable degree of similarity, consistency, and stability, with no significant deviations observed.

Discussion

This is the first study to examine the test–retest reliability, validity, SEM_{95}, and MDC_{95} of the T-360° TT in individuals with AS. Based on the results of the study, it can be concluded that the T-360° TT is a practical and less time-consuming test method than other balance assessment tools that can be used to assess turning ability and dynamic balance in individuals with AS.

In line with findings from prior studies, the present results illustrate excellent test–retest reliability. Especially, the T-360° TT exhibited reliability among individuals with stroke [15]. In addition, favorable test–retest reliability was observed among Parkinson's Disease patients [16], community-dwelling older adults [14], patients with multiple sclerosis [17], and patients undergoing anterior cruciate ligament reconstruction [19].

These reliability outcomes can be attributed to standardized testing procedures conducted by the same rater in a consistent environment. To mitigate the impact of fatigue, participants received explicit instructions and were allotted a 2-min rest period between assessments. Furthermore, the 5-day interval between the two assessment sessions was

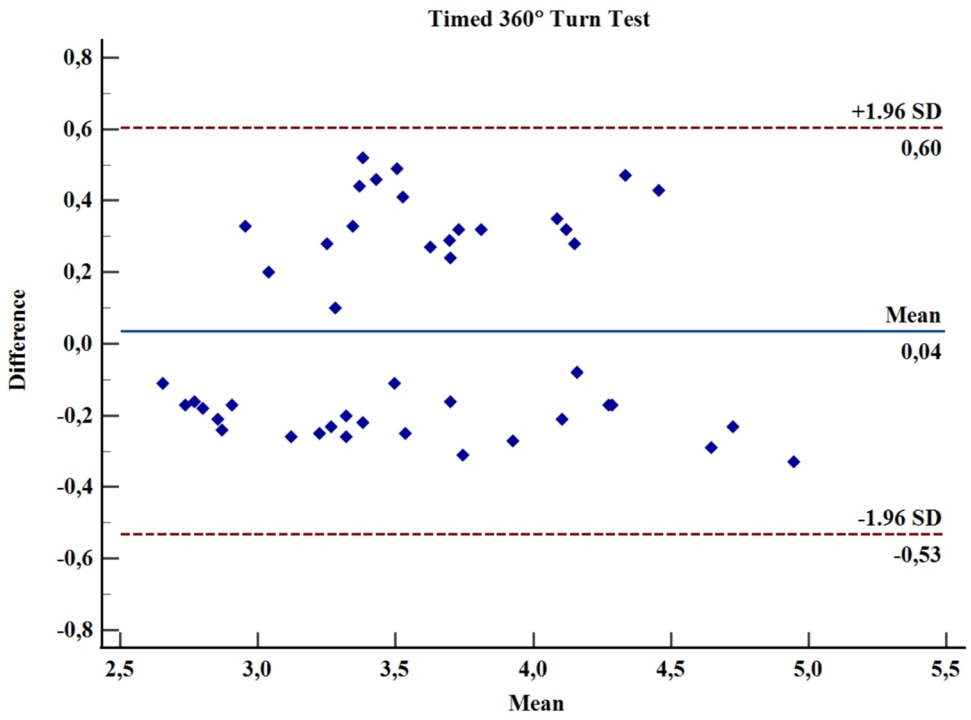

Fig. 1 Bland–Altman plot constructed according to test and retest assessments for T-360° TT

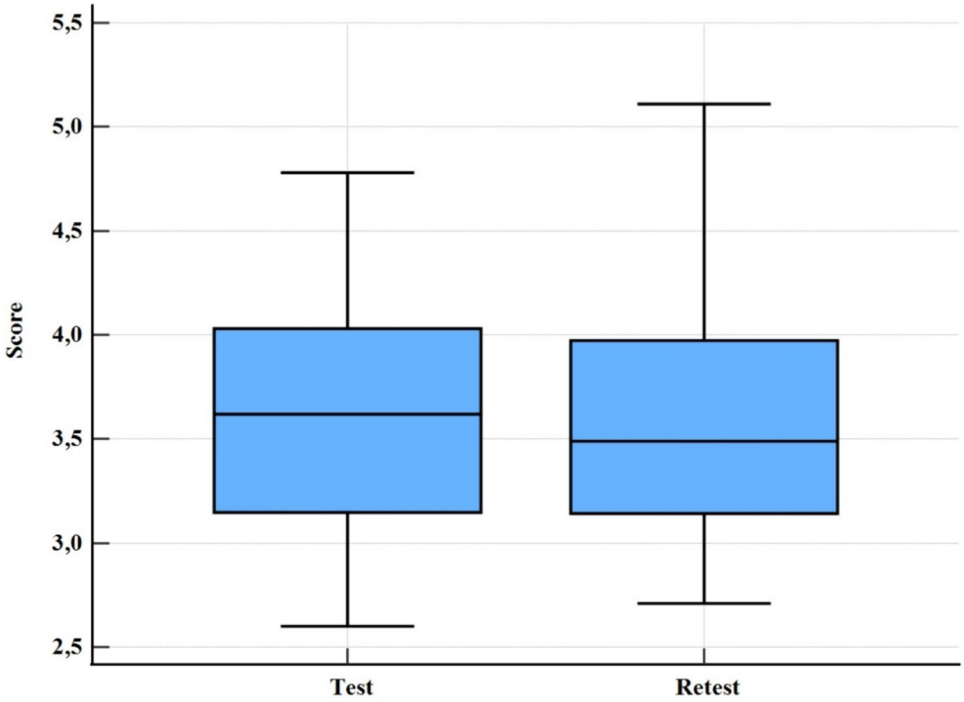

Fig. 2 The box whiskers plot of the test and retest assessments for T-360° TT

deemed adequate to attenuate the influences of training, fatigue, or substantial alterations in bodily functions [17].

Research investigating the concurrent validity of T-360° TT in evaluating dynamic balance across various populations has consistently reported validity. The Berg Balance Scale and TUG were predominantly utilized for assessing concurrent validity in these studies [15–17].

When the results of studies conducted in different populations were analyzed, a significant relationship was found between T-360° TT, Berg Balance Scale, and TUG [16, 17, 26]. In our study, we used TUG and BBS to evaluate the concurrent validity of T-360° TT. The reason for using these measurement tools is that TUG is a time-based dynamic balance assessment test such as T-360° TT, while BBS objectively evaluates dynamic balance [9]. As a result of our study, T-360° TT showed a positive correlation with both TUG and BBS (AP, ML, and overall). The correlation between T-360° TT and TUG can be interpreted as a T-360° TT that can be used in mobility assessment as well as dynamic balance assessment.

The MDC_{95} may denote the minimum difference indicative of a genuine alteration in the patient's health status [27]. In a prior study, the MDC_{95} value for the T-360° TT test-time component in patients diagnosed with osteoarthritis was found to be 0.253 [26]. In a study conducted with patients with Parkinson's disease, MDC_{95} values for the T-360° TT test duration component were 1.48 for the non-dominant lower extremity and 1.98 for the dominant lower extremity [16]. In our study, the MDC_{95} value of 360° turn test times of individuals with AS was 0.279. This MDC value indicates the minimum change necessary to accurately reflect genuine alterations in performance during the T-360° TT, distinguishing them from chance variations. This heightened sensitivity may help clinicians make more accurate decisions about patient treatment and management strategies.

The SEM_{95} value of clinical assessment tests represents the potential error that may arise during measurements. Clinicians should take note of this value when utilizing the respective measurement test to avoid misinterpretation. Therefore, it is essential to include SEM_{95} values in the literature pertaining to clinical tests. SEM_{95} indicates the percentage of this error value relative to the test result value [28]. In the validity and reliability studies of the T-360° TT, the SEM_{95} value was generally not analyzed. Yarar et al. [26] found the SEM_{95} value of the T-360° TT to be 0.091. Similarly, in our study, the SEM_{95} value of the T-360° TT duration was found to be 0.101.

The strength of this study is the evaluation of the concurrent validity of the T-360° TT with BBS, an objective balance assessment device. Similar to any research endeavor, our study encountered certain limitations. First, in our study, the T-360° TT was conducted by one evaluator. Having a second rater would have enabled us to evaluate the inter-rater reliability of the T-360° TT. Another limitation is that the T-360° TT was not evaluated separately in the dominant and non-dominant extremities in our study. We evaluated the participant in clockwise and anti-clockwise directions and averaged the results. In future studies, the reliability of the T-360° TT should be examined by different evaluators

and evaluated separately in dominant and non-dominant extremities.

Conclusions

In conclusion, the T-360° TT has test–retest reliability and showed a strong positive correlation with the TUG test and BBS, which are frequently used in the literature for dynamic balance assessment. Moreover, with an MDC_{95} value of 0.279, it can be used by clinicians and researchers to assess rotational and dynamic balance ability after an intervention.

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Data availability The data analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest No potential conflict of interest was reported by the author(s).

Ethical Standard Statement This cross-sectional study, approved by the local ethics committee (Number: 7-2023/38).

Informed Consent Written and verbal informed consent was obtained from all participants for this study.

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