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The purpose of this study was to evaluate the reliability of time to stabilization in single leg standing. Time to Stabilization (TTS) is a measurement which can be used to analyze both static and dynamic stability of an individual. Twenty seven college students participated in this study. All the subjects were asked to perform a single leg standing task on the force platform placed on the floor. Five trials were performed by each subject to estimate the reliability of TTS. TTS was calculated as the time taken to reach body weight and stay within 5% of the body weight for one second. The results showed that the reliability was optimal with moderate correlation for the first two trials.

KEY WORDS: stabilization, posture, balance, dynamic stability.

INTRODUCTION: Time to Stabilization (TTS) is a measure recently proposed to evaluate both static and dynamic stability (Wikstrom et al, 2004). This measure incorporates both the sensory and mechanical systems to analyze one‘s balance. TTS as a measure of functional balance is used in various settings including the care of elderly (Ross et al, 2003) and in children (Cook et al, 2003). TTS is commonly used in measuring functional balance following ankle injury, or bracing of the ankle (Ross et al, 2005), in lower extremity muscle injury and fatigue (Wikstrom et al, 2004). Measures of TTS could also provide researchers with a mechanism to assess the importance of balance in an activity (Flanagan et al, 2008). TTS may also be a useful tool to evaluate one‘s balance and effect of balance on body posture. Activities like single leg balance are necessary in more demanding sports such as cross country skiing in which the skiers predominantly move and shift weight alternately on each leg during the gliding phase. Long duration activities may also cause fatigue which can alter the balance and affect performance. Hence we chose single leg standing as a task to assess TTS component using a force platform. The main purpose of this study was to estimate the reliability of TTS as a measure of dynamic stability in normal population. We hypothesized that there would be consistency in the time taken to reach a stable state during single leg standing for five trials.

METHODS: Twenty seven college students (Mean ± SD: age = 20.6 ± 3.0 years) were recruited for the study, 16 female and 11 male. Written informed consent was provided by all twenty seven participants for the study, which was approved by the University Institutional Review Board (# HS08-192).

Single leg stance was performed on a standardized force platform (FP) (OR6-5-2000, AMTI, Watertown, MA, USA) mounted on the ground. Ground Reaction Force (GRF) data were collected at 1000 Hz, real time displayed and saved with the use of computer software (NetForce 2.0, AMTI, Watertown, MA, USA) for later analysis.

The aim of the current study was to estimate TTS using a simple task of single leg standing on the FP, which involves stepping onto the FP and maintaining single leg balance for 30 seconds. Before the actual testing trials, participants performed several practice trials to practice the movement required for testing. Step Length was measured for all subjects before the test session. Subjects were asked to stand from one’s step length distance away from the FP and asked to step on a line drawn in center of the FP (Jacobs et al, 2006). Subjects were instructed to step on the force platform and asked to achieve and maintain a stable state as soon as possible. Subjects were allowed to use arm movements to maintain their balance.

Time taken to attain stability was calculated from the acquired data (Flanagan et al, 2008) Time to stabilization was measured by the time taken for vertical ground reaction force to

reach and remain within 5% of their own body weight for one second of duration. (Wikstrom et al, 2005)
All statistical analyses of the data were carried out in SPSS © (Version 16.0). Trial-to-trial reliability analysis of recorded variables used both single (ICC_{single}) and average (ICC_{ave}) measures intra-class correlations of absolute agreement. A one-way repeated measures ANOVA was used to determine possible differences between trials. Outliers were tested and subjects with data in excess of three standard deviations were eliminated from the analysis. The criterion for significance was set at an alpha level of $p \leq 0.05$.
Munro (2001) has suggested that Intraclass Correlation Coefficient (ICC) values be used to describe the degree of reliability with the following descriptors for ICC values: 0.00 to 0.25 = little, if any correlation; 0.26 to 0.49– low correlation; 0.50 to 0.69 – moderate correlation; 0.70 to 0.89 – high correlation and 0.90 to 1.00 – very high correlation. Thus high ICC were sought and deemed acceptable for comparison.

RESULTS: Data were obtained from all twenty seven subjects. Two subjects were removed due to data outliers and we performed One-way repeated measures ANOVA for twenty-five subjects. Thus to estimate the reliability of TTS, we performed a statistical analysis with twenty-five subjects. To estimate how many trials would be necessary to obtain acceptable reliability estimates of TTS we analyzed data using the first two trials, the first three trials, the first four trials and all five trials. The results of the data analysis are shown in the Tables 1 and 2. From the analysis no significant differences were found between the means of two, three, four or five trials with $p>0.05$

Table 1: Descriptive data for TTS trials: N=25

	Trial 1	**Trial 2**	**Trial 3**	**Trial 4**	**Trial 5**
Mean (s)	961.2	963.2	958.1	1000.5	914.4
Stand. Deviation (s)	311.7	353.1	263.3	267.5	254.8
Range (s)	1292	1545	1306	1006	1094

Table 2: Intraclass Correlation Coefficient and 95% Confidence Interval (ICC: 95% CI) for two, three, four and five trials of the TTS (n=25).

Number of Trials	**ICC-single measures (95% CI)**	**ICC-Average measures (95% CI)**
2	0.494 (0.131 – 0.740)	0.662 (0.232 – 0.851)
3	0.352 (0.105 – 0.603)	0.619 (0.260 – 0.820)
4	0.183 (0.007 – 0.420)	0.472 (0.029 – 0.744)
5	0.260 (0.097 – 0.478)	0.637 (0.350 – 0.821)

ICC- Intraclass correlation, CI-Confidence interval

ICC values for the various trials showed differences in repeatability of results for the TTS. $ICC_{average}$ measure for two (0.662), three (0.619) and five (0.637) trials had moderate correlations compared with four trials analysis (0.472) which was a low correlation. ICC_{single}

measures show all combinations of different trial analyses had low correlations (see Table 2). Since there was no significant difference among five trials we did not perform post hoc test for the data.

DISCUSSION: This study is the first that is known to the authors to estimate the reliability of TTS for single leg standing in an adult population. Results indicate that the reliability differed depending on the number of trials used to estimate reliability of TTS. From the data analysis no significant differences were found among the trials whether the comparisons consisted of two, three, four or five trials ($P > 0.05$).

Despite a lack of difference between the trials, the four trials analysis resulted in low $ICC_{average}$ (0.472) compared to two, three and five trial analyses. $ICC_{average}$ measures for two trials was r =0.662, three trials r =0.619 and five trials r =0.637 indicating moderate correlation among these numbers of trials. ICC_{single} measure for two trials was r =0.494, three trials r =0.352, four trials r =0.183 and five trials r =0.260. Thus although average measures ICC is moderate for all but four trials, single measures ICC is low for all trials (Table 2).
The results showed that with two, three and five trials analysis the correlation stayed within moderate level of significance. Hence to estimate TTS for single leg standing it may be sufficient to perform just two trials instead up to five trials.
Subjects participated in a practice session to ensure they could reproduce the actual movement required for the study. Only a few subjects could not maintain their balance in the initial phase of stepping on the FP. Because all the subjects were healthy college students without any known balance problems, it is likely there was very little difference between the individuals and this may have decreased the variability throughout additional trials. The decreased variability would have allowed a greater crossover between subjects, thus lowering the ICC. Another possible reason for the difference among trials could have been due to attention demands during trials. Since all subjects performed several practice trials and testing, lack of attention in subsequent trials may be a factor causing difference among trials (Simoneau et al, 2006). Individual variation is also one of the factors to be considered in the low significance of reliability among five trials. Hence the most possible reason we could think about this variation could be attention demands of the subjects while performing the single leg standing on the FP.

CONCLUSION: In summary TTS displays moderate reliability based on the ICC and lack of difference across trials for 2, 3, or 5 trials. However, because two trials provide the same degree of reliability as performing more (up to five trials), we recommend the use of two trials when assessing standing single leg balance performance.

This may also be applicable to other tests used to measure TTS as well. Since single leg standing is one of the most common methods used to test the lower extremity balance, there needs to be consistency of results and reliability of single leg standing in assessing lower extremity balance. More studies are recommended to reproduce similar results and provide further information on the reliability of TTS in single leg standing.

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