Time to Stabilization: A Method for Analyzing Dynamic Postural Stability

Scott E. Ross, MA, ATC-L, and Kevin M. Guskiewicz, PhD, ATC-L • University of North Carolina at Chapel Hill

A single-leg-stance test is one assessment tool used by clinicians to detect postural instability in athletes with lower extremity joint injury. Physically active individuals with joint instability, however, are quite capable of stabilizing normally on a single leg, and many sports-medicine clinicians question the functionality of this test. More dynamic tests would seem to offer a greater challenge than single-leg-stance tests, but clinicians have struggled to quantify postural stability during dynamic tests. The inability to quantify postural stability during dynamic tests, therefore, has hampered clinicians’ ability to speculate on the effects of joint instability on dynamic postural stability. Developing a measure that could quantify dynamic postural stability could help clinicians identify joint instability that might otherwise go undetected during a single-leg-stance test.

Our purpose is to describe a method for calculating time to stabilization (TTS). This parameter is a quantitative force-plate measure that is used to evaluate dynamic postural stability. The TTS measure provides an indication of how quickly individuals stabilize after a jump landing. Although relatively new, the TTS is one of very few dynamic postural-stability measures reported in the literature that has detected differences between individuals with stable and unstable joints during a dynamic test. The details of calculating the TTS have not been published, and our goal here is to provide a description of the data collection and analysis of the TTS during a jump-stabilization maneuver.

Jump-Stabilization Maneuver

Thus far, the TTS measure has been used to quantify dynamic postural stability in individuals with functionally stable and unstable ankles after a jump landing. The jump-landing task was selected as the criterion movement because many athletes perform jumping activities during competition. From a methodology point of view, the jump-landing task was selected because it provides a means to control for the jump height and distance that each athlete performs. Controlling for jump height and distance is important because the variance of the TTS measure can be reduced.

Athletes are measured for maximum vertical-jump height at a starting distance of 70 cm from a jump-height-measuring device before they perform the jump-stabilization maneuver. They then perform a two-legged jump at 50% of their maximum jump height to the center of a force plate. (The measuring device is set at 50% of the maximum jump height and is directly in line with the center of the force plate. This allows athletes to begin the maneuver starting 70 cm from the device.) The 50% jump, however, requires athletes to land on one leg. They are instructed to stick the landing, stabilize quickly, and remain as motionless as possible in a single-leg stance for the duration of the test. The data collection starts as the force plate is triggered by the landing and ends 20 s later.

Data Collection

The jump-landing data are collected on a force plate at a sampling rate of 180 Hz. Pilot testing has allowed us to determine the appropriate sampling rate during the jump-stabilization maneuver. A fast Fourier transformation analysis indicates that the raw analog signals of a single-leg stance and the jump-stabilization maneuver are below 30 Hz. Therefore, a minimum sampling rate of 60 Hz would be sufficient for collecting data.
The peak ground-reaction force (GRF) of the jump landing is a key component to calculating the TTS. In short, the peak GRF is a marker for a line fitting the GRF data. The line fitting the data is one of two factors that define the time to stabilization. A sampling rate that is too low might miss the peak force and consequently cause the TTS to be miscalculated. We selected, therefore, 180 Hz to provide a sampling rate six times greater than the raw analog-signal under-study.

**Data Analysis**

The components of the GRF were selected to calculate the TTS based on the findings in a study by Goldie et al, who concluded that the variation of the components of the GRF during a single-leg stance could discriminate between changes in postural stability resulting from alterations of the base of support. The variations of the components of the GRF, in addition, were determined to be best predictors of postural stability during a single-leg stance. The components of the GRF with the least variation during a single-leg stance might act as indicators of optimal stability. Dynamic postural stability can be defined, therefore, as the time it takes for the initial components of the GRF of a jump landing to become similar to the components of the GRF in a stabilized single-leg stance.

After filtering the noise out of the data, we analyzed the anterior–posterior (AP) and medial–lateral (ML) components of the GRF data separately by a computer software package. The software scans two windows of the last 10 s (10–15 s, 15–20 s) of the components of the GRF for each trial. The window with the smallest absolute GRF range is accepted as the optimal range-variation value. This value represents the window in which the athlete displays optimal postural stability. The AP and ML absolute GRF range-variation values are superimposed over the respective GRF data via horizontal lines. The data are then rectified, and starting at the peak GRF, an unbounded third-order polynomial is fitted to each of the components of the GRF. The TTS for each component of the GRF is the point at which the unbounded third-order polynomial transects the horizontal range-variation lines (Figure 1).

**Preliminary Findings**

The TTS after a landing from the jump-stabilization maneuver has been able to discriminate between individuals with functionally unstable and functionally stable ankles. The results of two studies indicate that individuals with functionally unstable ankles took longer to stabilize than did individuals with functionally stable ankles. The TTS after a jump landing, therefore, might be an additional diagnostic measure that clinicians can use in their evaluation of athletes with functionally unstable ankles.

**Future Research**

Additional research should be conducted using the TTS measure presented here. Performing the jump-stabilization maneuver might cause variation to be introduced into the TTS measure. The jump-stabilization maneuver was designed to control for jump height and distance during a jump landing. Although jumping