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Full Length Article

The effect of variable rest intervals and chronic ankle instability on triplanar ankle motion during performance of the Star Excursion Balance Test

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ABSTRACT

Inadequate rest intervals may contribute to impaired performance during functional tests. However, the effect of different rest intervals on performance of the SEBT in individuals with and without CAI is not known. Our purposes were to determine whether different rest intervals impact ankle kinematics during the SEBT and whether there differences between those two populations. 24 controls and 24 CAI completed 3 trials in 3 reach directions (anteromedial; AM, medial; M, posteromedial; PM). The order of rest intervals and reach distance were randomized and counterbalanced. Three visits were required to complete the 3 rest interval conditions (10, 20, 40 s). Rest interval did not impact ankle kinematics between controls and CAI during the SEBT. Dorsiflexion (DF) (AM:partial $\eta^2 = 0.18$; M:partial $\eta^2 = 0.23$; PM:partial $\eta^2 = 0.23$) for all directions and tibial internal rotation (TIR) excursions (AM:partial $\eta^2 = 0.20$) for AM direction were greater in individuals with CAI regardless of rest interval length. Rest intervals ranging from 10 to 40 s did not influence ankle kinematics. Differences exist in DF and TIR between controls and CAI during the SEBT. These findings suggest that clinicians can use any rest interval between 10 and 40 s when administrating the SEBT. However, triplanar motion differs during a complex functional movement in controls compared to CAI.

1. Introduction

Ankle injuries are the most common musculoskeletal injury occurring in athletic, military, and physically active individuals (Almeida, Williams, Shaffer, & Brodine, 1999; Hootman, Dick, & Agel, 2007). It has been reported that as many as 50% of high school athletes are diagnosed with an ankle sprain during a given season (Fernandez, Yard, & Comstock, 2007). Further, 30% of the individuals with ankle sprains develop chronic ankle instability (CAI), defined as either a feeling of "giving way" at the ankle or recurrent ankle sprains or both (Yeung, Chan, So, & Yuan, 1994). CAI not only limits an individual's physical activity or activities of daily living, but also results in time lost from sport and high costs for treatment and rehabilitation (Arnold, Wright, & Ross, 2011).

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Some individuals with CAI demonstrate functional ankle instability, which is thought to be characterized by decreased neuromuscular control (Gribble et al., 2013; Riemann, 2002). Neuromuscular control and dynamic postural control can be measured in this population with the Star Excursion Balance Test (SEBT) (Hertel, Braham, Hale, & Olmsted-Kramer, 2006). The SEBT measures maximum lower extremity reach distances in an attempt to detect functional deficits related to the presence of CAI (Hertel et al., 2006). Further, the SEBT demonstrates high intratester and intertester reliability and validity in healthy populations (Hertel, Miller, & Denegar, 2000). To reduce the number of components in the SEBT, Hertel et al. examined the SEBT in subjects with and without CAI and found that anteromedial, medial, and posteromedial directions were the most sensitive in identifying deficits associated with CAI (Hertel et al., 2006). Although differences in maximum reach distance between healthy subjects and those with CAI exist, only a few potential factors related to this decreased distance have been established (Hertel et al., 2006).

While previous research has focused on kinematics of the lower extremity as factors that affect performances on the SEBT, most data has been collected in the sagittal plane. Static ankle dorsiflexion range of motion in healthy subjects is significantly related to the performance of the SEBT in the anterior direction, but not in the posteromedial and posterolateral directions (Hoch, Staton, & McKeon, 2011). Additionally, hip flexion was the strongest predictor of maximum reach distance for the anterolateral and anteromedial directions and knee flexion was strongest predictor for medial, posterior, posterolateral, and posteromedial directions (Robinson & Gribble, 2008a). Previous studies have only investigated secondary plane motion (frontal and transverse plane) at the hip during the SEBT (Fullam, Caulfield, Coughlan, & Delahunt, 2014; Hoch et al., 2011; Robinson & Gribble, 2008a).

Because the foot and lower extremity remain in constant contact with the ground during the entirety of SEBT performance, it is reasonable to assess triplanar motion at both distal and proximal joints. Specifically, with the foot fixed on the floor, the closed-chain movement of the rearfoot for pronation and supination requires significant motion in the secondary planes (Hubbard & Hertel, 2006; Richie Jr, 2001). These motions are transferred up the chain to the knee and hip through the tibia and are likely to have an effect on performance of the SEBT. To our knowledge, no one has examined coordination of the secondary planes of motion at the ankle (eversion and tibial internal rotation) during the SEBT in healthy and CAI individuals.

During performance of the SEBT, rest intervals of 10 or 15 s between trials have been reported, although there are no consistent or accepted norms (Hertel et al., 2000, 2006; Linens, Ross, Arnold, Gayle, & Pidcoe, 2014). Therefore, clinicians may choose variable rest times between trials of the SEBT and this may potentially affect the results and reliability of the test. The relationship between rest interval time and changes in performance on various tasks other than the SEBT has been previously studied (Abt, Siegler, Akubat, & Castagna, 2011; Dabbs, Munoz, Tran, Brown, & Bottaro, 2011; Gribble, Hertel, & Denegar, 2007; Nogueira et al., 2012; Willardson & Burkett, 2006). Additionally, the presence of CAI may further modify the amount of time needed between trials to be successful on performance of the SEBT.

Therefore, the two purposes of this study were to: (1) assess the impact of different rest intervals on triplanar ankle kinematics (2) to evaluate differences of triplanar ankle kinematics between individuals with and without CAI during performance of the SEBTWe hypothesize was that a shorter rest interval (10 s) during the SEBT would result in bigger differences in ankle kinematics between healthy individuals and those with CAI compared to a longer rest interval (40 s). We further hypothesize that individuals with CAI will demonstrate reduced angles of ankle kinematics when compared to healthy individuals on the SEBT.

2. Methods

2.1. Participants

Twenty-four participants with CAI (age: 22.7 ± 1.6 years, height: 170.9 ± 7.2 cm, mass: 65.4 ± 7.6 kg) and 24 uninjured participants (age: 21.9 ± 2.3 years, height: 168.4 ± 6.6 cm, mass: 68.9 ± 6.5 kg) participated. Each group consisted of 12 male and 12 female participants. Uninjured participants' height and weight were matched to those in the CAI group. Chronic ankle instability was operationally defined for this study as repeated episodes of the ankle giving way, regardless of the existence of neuromuscular deficits or pathologic laxity. All participants in the CAI group had unilateral CAI. For inclusion in the CAI group, participants were required to meet the following criteria: (1) regular physical activity defined as at least 3 h per week of moderate intensity activity (2) a history of at least 1 significant ankle sprain, (3) multiple episodes ($\geqslant 2$) of the ankle giving way within the past 6 months, and/or (4) feeling of instability, (5) free of cerebral concussions, vestibular disorders, and lower extremity injuries for the previous 6 months, and (6) no prior rehabilitation or balance training. For inclusion in the healthy group, participants were required to meet the following criteria: (1) regular physical activity defined as at least 3 h per week of moderate intensity activity (2) no history of ankle sprain, (3) no episodes of the ankle giving way within the past 6 months, and/or (4) no feeling of instability, (5) free of cerebral concussions, vestibular disorders, and lower extremity injuries for the previous 6 months, and (6) no prior rehabilitation or balance training. In addition, all participants completed the Cumberland Ankle Instability Tool (CAIT) to further confirm ankle instability (Healthy score = 29.0 ± 2.0, CAI score = 18.5 ± 5.0; $p < 0.001$). A score of less than 25 on the CAIT indicates ankle instability (Wright et al., 2013). A score of $\geqslant 28$ indicates a healthy ankle. All participants gave written informed consent approved by the University Institutional Review Board. The rights of the participants were protected. An a priori power analysis ($\alpha = 0.05$, $\beta = 0.80$) performed on sim-