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Original research

Investigating the effects of maximal anaerobic fatigue on dynamic postural control using the Y-Balance Test

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ABSTRACT

Objectives: The Y Balance Test is one of the most commonly used dynamic balance assessments, providing an insight into the integration of the sensorimotor subsystems. In recent times, there has been an increase in interest surrounding it's use in various clinical populations demonstrating alterations in motor function. Therefore, it is important to examine the effect physiological influences such as fatigue play in dynamic postural control, and establish a timeframe for its recovery.
Design: Descriptive laboratory study.
Methods: Twenty male and female (age 23.75 ± 4.79 years, height 174.12 ± 8.45 cm, mass 69.32 ± 8.76 kg) partaking in competitive sport, completed the Y Balance Test protocol at 0, 10 and 20 min, prior to a modified 60 s Wingate fatiguing protocol. Post-fatigue assessments were then completed at 0, 10 and 20 min post-fatiguing intervention.
Results: Intraclass correlation coefficients demonstrated excellent intra-session reliability (0.976–0.982) across the three pre-fatigue YBT tests. Post-hoc paired sample t-tests demonstrated that all three reach directions demonstrated statistically significant differences between pre-fatigue and the first post-fatigue measurement (anterior; $p = 0.019$, posteromedial; $p = 0.019$ & posterolateral; $p = 0.003$). The anterior reach direction returned to pre-fatigue levels within 10 min ($p = 0.632$). The posteromedial reach direction returned to pre-fatigue levels within 20 min ($p = 0.236$), while the posterolateral direction maintained a statistically significant difference at 20 min ($p = 0.023$).
Conclusions: Maximal anaerobic fatigue has a negative effect on normalised Y balance test scores in all three directions. Following the fatiguing protocol, dynamic postural control returns to pre-fatigue levels for the anterior (<10 min), posteromedial (<20 min) and posterolateral (>20 min).

1. Introduction

Postural control can be defined as the maintenance of the body's centre of gravity within the limits of stability, as defined by the base of support.[1] Dynamic postural control involves the maintenance of balance while transitioning from a dynamic to a static state. It is essential for maintaining one's balance during functional tasks such as running, jumping and landing. To date, the Star Excursion Balance Test (SEBT) has been the most commonly used tool for measuring dynamic postural control.[2,3] The SEBT requires that the subject reaches as far as possible in eight directions, while maintaining a state of equilibrium.[2] More recently, research has highlighted the redundancy of five of the eight SEBT reach directions.[4] This has resulted in the development of an instrumented, commercially available assessment, known as the Y-Balance Test (YBT) (functionalmovement.com, Danville, VA). The YBT incorporates the anterior (ANT), posteromedial (PM) and posterolateral (PL) reach directions. Strength, range of motion, proprioception and balance are physiological properties which the YBT challenges, thus closely mimicking the demands of physical activity, and comprehensively challenging the sensorimotor integration of the motor function subsystems.

Measurement of dynamic postural control is commonly used in both clinical and research settings. Clinically, dynamic measurement is often used to determine if a player is fit to return to sport following injury,[5,6] as well as an indicator of increased risk of lower

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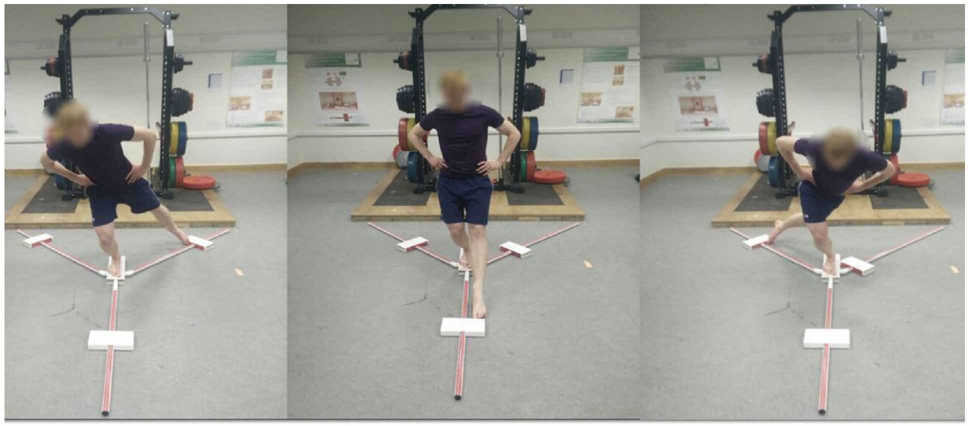

Fig. 1. Participant demonstrating the YBT in the posteromedial (left), anterior (centre) and posterolateral (right) reach directions on their right leg.

limb injury.[7,8] In the research setting, the effects of lower limb injuries such as chronic ankle instability and anterior cruciate ligament injury on dynamic postural control have been established.[3,9] The increasing popularity of the YBT as a balance outcome measure means that it is vital to identify biological factors that may influence its accuracy (Fig. 1).

Muscle fatigue can be defined as exercise induced decreases in maximal voluntary force or power produced by a muscle or group of muscles.[10] Fatigue mechanisms induced during anaerobic exercise include central and peripheral fatigue mechanisms. Peripheral fatigue refers to exercise-induced processes that lead to a reduction in force production occurring at or distal to the neuromuscular junction. Central fatigue refers to more centralised processes and can be defined as a progressive exercise-induced failure of voluntary activation of the muscle.[10] It can be postulated that the combined physiological effects of central and peripheral fatigue can lead to changes in the sensorimotor integration of balance information, resulting in alterations in one's ability to maintain dynamic postural control.

It has been demonstrated that dynamic postural control, as measured by the SEBT, is influenced by different forms of fatigue.[11–13] Whyte and co-workers[5] demonstrated the effects of high intensity intermittent exercise (a combination of peripheral and central fatigue mechanisms) on dynamic postural control using the SEBT. However, to date, the effects of maximal anaerobic fatigue (predominantly central fatigue[14]) on YBT performance has not been established. Investigating the effects of maximal fatigue on YBT performance is of utmost importance, as the alterations in neuromuscular control may result in poorer control of movement, leading to an increased risk of an individual sustaining non-contact lower limb injuries such as an anterior cruciate ligament injuries and lateral ankle sprains.[7,8,15] Additionally, while Whyte and co-workers established the effects of high intensity exercise on dynamic postural control performance, they did not investigate the period of recovery required for an individual to return to their baseline pre-fatigue levels. The importance of developing an understanding of the time-frame for recovery of dynamic balance following fatigue is two-fold; firstly, clinicians and strength and conditioning professionals need to understand the length of time an individual may be at risk of sustaining an injury following fatigue. Secondly, to ensure a reliable and accurate measurement, representative of the individual's baseline, the length of time for balance performance recovery following fatigue is required. Such information may aid clinicians and strength and conditioning coaches in the implementation of injury risk factor screening protocols, and the development of injury prevention programs that consider neuromuscular control training under fatigued conditions.

Therefore, the primary aim of this study was to investigate the effects of maximal anaerobic fatigue on a dynamic postural control test (YBT). A secondary aim was to investigate how long it takes for dynamic postural control (YBT) to return to baseline levels.

2. Methods

Participants consisted of 20 male and female (age 23.75 ± 4.79 years, height 174.12 ± 8.45 cm, mass 69.32 ± 8.76 kg) university students engaged in competitive sport, aged between 18 and 40. Participants were excluded if they suffered from chronic ankle instability, vestibular or visual impairment, lower limb musculoskeletal injury in the previous 6 months, cardiovascular disease or previous reports of chest pain, any neurological disease, balance disorder or if they were currently taking medication for balance disorders. Participants were also excluded if they answered yes to any question in the PAR-Q[16] or were not taking part in competitive sport. Ethical approval was obtained for the study from the Human Research Ethics Committee of University College Dublin. All participants read the participant information leaflet and provided written consent prior to testing.

Participants were required to attend one 90-min session in a university performance laboratory. Participants were instructed on how to complete the YBT and completed 4 practice trials in each direction, on their dominant limb as per the guidelines previously outlined by Gribble and co-workers.[2] Leg dominance was attained by asking the participant which leg they would kick a ball with.[17] Following the practice trials, participants completed three recorded YBT's in each direction (randomised order) on the dominant stance limb. This was repeated at time points of 0, 10, and 20 min to provide a pre-fatigue baseline measurement of the individuals dynamic postural control. A 10-min rest period was chosen between YBTs to allow for a standard rest period for the pre- and post-fatigue measurements, and allow for the creation of an intra-session reliability dataset. Following completion of the pre-fatigue YBTs, the subject then completed a modified Wingate maximal anaerobic exercise test. Participant's heart rate (HR) was recorded at baseline, prior to, and immediately post the Wingate test to establish the physiological effects of the Wingate protocol on the participants, and demonstrate the physiological stress exerted by the test. The YBT was immediately assessed following the Wingate test at time intervals of 0, 10 and 20 min.

The YBT utilises three directions derived from the SEBT (ANT, PL and PM). The YBT is a commercially available tool for assessing dynamic postural control, and possesses excellent intra-tester (0.85–0.89) and inter-tester (0.97–1.00) reliability.[4] Its design has addressed the limitations of the traditional SEBT testing methods,