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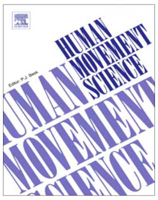

Full Length Article

Athletic background is related to superior trunk proprioceptive ability, postural control, and neuromuscular responses to sudden perturbations

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A B S T R A C T

Trunk motor control is essential for athletic performance, and inadequate trunk motor control has been linked to an increased risk of developing low back and lower limb injury in athletes. Research is limited in comparing relationships between trunk neuromuscular control, postural control, and trunk proprioception in athletes from different sporting backgrounds. To test for these relationships, collegiate level long distance runners and golfers, along with non-athletic controls were recruited. Trunk postural control was investigated using a seated balance task. Neuromuscular control in response to sudden trunk loading perturbations was measured using electromyography and kinematics. Proprioceptive ability was examined using active trunk repositioning tasks. Both athlete groups demonstrated greater trunk postural control (less centre of pressure movement) during the seated task compared to controls. Athletes further demonstrated faster trunk muscle activation onsets, higher muscle activation amplitudes, and less lumbar spine angular displacement in response to sudden trunk loading perturbations when compared to controls. Golfers demonstrated less absolute error and variable error in trunk repositioning tasks compared to both runners and controls, suggestive of greater proprioceptive ability. This suggests an interactive relationship between neuromuscular control, postural control, and proprioception in athletes, and that differences exist between athletes of various training backgrounds.

1. Introduction

Athletes require precise neuromuscular control, appropriate body awareness and accurate coordination of movements in order to excel in their sport. Regardless of the sport, all athletes must use their trunk to generate and coordinate changes in posture and movements about the limbs. Proficiency in standing postural control has been found to potentially determine successful athletic performance (Sell, Tsai, Smoliga, Meyers, & Lephart, 2007). Further, athletes have demonstrated superior standing balance control compared to healthy adults (Davlin, 2004). It is possible that athletes demonstrate greater proprioceptive abilities, as repetitive athletic movements can lead to improvements in this area (Allegrucci, Whiney, Lephart, Irrgang, & Fu, 1995). In addition, athletes have demonstrated faster responses to perturbations and greater neuromuscular

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control compared to healthy adults (Johnson & Woollacott, 2011). However, there are differences in athletic training depending on the objectives of the sporting task. It is possible that these differences in training could relate to differences in neuromuscular control, postural control, and proprioceptive ability.

Previous studies have found that deficiencies in trunk neuromuscular control can predispose athletes to low back and lower extremity injuries (Cholewicki et al., 2005; Zazulak, Hewett, Reeves, Goldberg, & Cholewicki, 2007). At the elite level, 75% of athletes have reported experiencing one or more episodes of low back pain during their career (Ong, Anderson, & Roche, 2003). Therefore, athletes require a combination of strength, mobility/stability, body awareness and appropriate muscle responses to perform at the highest level, but also to reduce risk of injury.

The purpose of this study was to determine if differences exist between athletes and non-athletic controls in terms of trunk proprioceptive ability, postural control, and neuromuscular response to sudden loading perturbations, in addition to determining if differences exist between two different athlete groups. For a long distance runner, the goal is to sustain a high running pace for a long duration, resulting in an emphasis on cardiovascular and endurance training, with little priority placed on trunk motor control. This differs from a golfer, as training to control the activation of trunk musculature in order to generate a repeatable swing, and accurately detect the position of their trunk throughout the swing sequence, is a priority. It was hypothesized that athletes would demonstrate greater trunk postural control, in a seated balance task, compared to controls. Second, it was hypothesized that athletes would demonstrate faster muscle activation onsets, lower muscle activation amplitudes, and less lumbar spine angular displacement in response to sudden trunk loading perturbations compared to controls. Finally, it was hypothesized that golfers in particular, due to their ability to perform a task that requires precise trunk movement patterns and training to sense position, would demonstrate less error in active trunk repositioning compared to runners and controls.

2. Materials and methods

2.1. Participants

Males competing in collegiate level long distance running (n = 12), golf (n = 12), and controls (n = 12) with no athletic experience were recruited (Table 1). Long distance runners and golfers were current members of a collegiate varsity team, with a minimum of 7 years experience in their respective sport. All participants completed a medical questionnaire to confirm the absence of low back pain and related musculoskeletal and neurological disorders, as well as completed the Baecke questionnaire of physical activity (Baecke, Burema, & Frijters, 1982). All procedures were approved by the University Research Ethics Board, and informed consent was obtained from all individuals who participated in the study.

2.2. Procedure

First, maximum isometric trunk flexor and extensor strength was measured, following a procedure consistent with previous literature (Plamondon, Marceau, Stainton, & Desjardins, 1999). Next, to measure trunk postural control, a balance board was placed on the centre of a force plate (True Impulse, Northern Digital Inc., Waterloo, ON) on top of a table. Participants placed their arms across their chest and a strap was used to loosely secure the legs below the knees. This was done to ensure the limbs would not contribute to the maintenance of trunk balance, but was not tight enough to generate a moment about the lower limbs. Participants were required to maintain balance in an upright trunk posture for one minute. A total of 5 trials were completed; outcomes of the 5th trial were compared amongst groups to account for a potential learning effect of this task (Hendershot, Toosizadeh, Muslim, Madigan, & Nussbaum, 2013). Force plate data were sampled at 2048 Hz.

Participants were then outfitted with eight pairs of disposable Ag/AgCl surface EMG electrodes (Ambu Blue Sensor, Medicotest Inc., Olstykke, Denmark). Electrodes were placed bilaterally over the muscle bellies of the erector spinae at the level of the 9th thoracic vertebra (TES) and 3rd lumbar vertebra (LES), and external and internal obliques (EO and IO). Maximum voluntary isometric contractions (MVIC) of the muscles were recorded, following standard procedures (Brown, Haumann, & Potvin, 2003; McGill, 1991). To record lumbar spine angular movement, participants were outfitted with two kinematic rigid bodies, created using dense foam and each consisting of three non-collinear infrared markers (marker-to-marker distance = 4.5 cm) (Optotrak 3D Investigator, Northern Digital, Waterloo ON, Canada). These rigid bodies were placed over the spinous process of the 12th thoracic vertebra and the spinous process of the 1st sacral vertebra. Active lumbar spine ranges of motion (ROM) were recorded in flexion-extension (FE), right and left lateral bend (LB) and axial twist (AT). Participants were informed that end range of motion was moving "as far as they felt they were actively able to, without inducing any pain or major discomfort". All ROMs (FE, LB, AT) were repeated three times and kinematic data were sampled at 128 Hz.

To assess trunk neuromuscular control, participants were seated in a kneeling chair, outfitted with a harness across their chest. The perturbation apparatus was composed of a force transducer in line with a cable, which was attached to the harness. The cable was fed through a series of pulleys, and a perturbation mass was attached to the distal end of the cable. The mass used for all perturbations was calculated to be equivalent to 10% of the participant's maximum trunk extensor strength, as previously determined. The mass was released at random during a 10 s window for all perturbations. Participants kept their eyes open during all perturbations, but were blinded to when the perturbation would occur. Perturbations were applied