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Original article

Association between altered motor control of trunk muscles and head and neck injuries in elite footballers – An exploratory study

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ABSTRACT

Background: Head and neck injuries are common in football. Injuries such as concussion can have serious consequences. Previous studies have shown that size and function of trunk muscles are predictive of lower limb injuries in professional Australian Football League (AFL) players. It is unknown whether measurement of trunk muscles can also be used to predict head and neck injuries.
Objectives: To examine whether trunk muscle measurements predict head and neck injuries incurred by professional AFL players.
Design: Prospective cohort study.
Method: Ultrasound imaging of trunk muscles was performed on 165 professional AFL players at the start of the pre-season and 168 players at the start of the playing season. Injury data were obtained from records collected by the AFL club staff during the playing season.
Results/findings: The ability to contract the multifidus (MF) muscle at the L5/S1 vertebral level at the start of pre-season and start of the playing season predicted head and neck injury in the playing season. Sensitivity and specificity of the model were 56.3% and 76.6% for the pre-season and 50.0% and 77.2% for the playing season respectively.
Conclusions: A model with potential clinical utility was developed for prediction of head and neck injuries in AFL players. These predictive values will need to be validated in other teams. Ability to contract MF is modifiable and this information could be incorporated into pre-season injury prevention programs.

1. Introduction

Head and neck injuries are common in contact sports such as football. These can include concussion, facial fractures and neck sprains. Concussion is a common sports injury worldwide, with an estimated 1.6 to 3.8 million sports concussions occurring annually in the USA alone (Langlois et al., 2006). In Australia, recent collation of data on concussion among Australian Rules football players in the Australian Football League (AFL) found a rate of one concussion every five team games (Orchard et al., 2013). Concussion rates published in the annual AFL injury report have increased since 2011 and concussion causing a player to miss a game increased in 2014 (Orchard et al., 2015). Concussion can have serious consequences for the individual. It is therefore important to try to identify modifiable risk factors for head and neck injuries in football.

One approach which has been identified for prediction and prevention of lower limb injuries among AFL players is based on assessment of the size and function of trunk muscles (Hides et al., 2011; Hides and Stanton, 2012, 2014; Hides et al., 2014). Whilst all trunk muscles can contribute to spinal protection and control, a recent study showed that decreased size of the multifidus (MF) muscle at the L5 vertebral level consistently predicted injury in AFL players (Hides and Stanton, 2014). A program aimed at improving motor control of trunk muscles focussing on the MF and antero-lateral abdominal muscles resulted in less football games missed

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due to injury (Hides et al., 2012). The proposed explanation for this finding was that improved stability and control of the lumbopelvic region allowed safe production, transfer, and control of forces and motion to and from the distal segments of the kinetic chain (Kibler et al., 2006). In other words, improving motor control of the lumbopelvic area may have helped AFL players to cope with the high loads imposed on the body from playing their sport, ultimately reducing injury rates. A similar relationship could exist between motor control of the trunk and occurrence of head and neck injuries in AFL, but this has not been investigated.

Given football is a sport involving physical collisions and tackles, identifying factors involved in the dissipation of impact forces delivered to the head and neck are important considerations. Maintaining spinal curves is one way the spine deals with loading. In a biomechanical modelling study using finite element modelling, compressive axial loading was applied to the spine (Kiefer et al., 1997). The passive osseoligamentous spine translated into hypermobility under less than physiological loads without contributions from trunk muscles. Addition of muscle forces into the model increased the ability of the spine to withstand buckling and maintain spinal curves. Anterior pelvic rotation of only two degrees, (achieved by modelling the MF muscle) stiffened the spine and allowed it to carry significantly higher loads (up to 400 N). Furthermore, lumbar spinal posture has been shown to influence many important variables for athletes, including: lumbar muscle activity (Claus et al., 2009), respiratory efficiency (Lee et al., 2010), pelvic floor activity (Sapsford et al., 2006) and cervical muscle activity (Falla et al., 2007). A clinical application of this is that physiotherapists often focus on correcting thoraco-lumbar posture to improve head and neck posture in people with neck pain disorders (Caneiro et al., 2010). Further research is required to investigate whether a relationship between motor control of the trunk and occurrence of head and neck injuries exists in AFL players.

The aim of this study was to determine whether size or the ability to contract trunk muscles had diagnostic potential for predicting head and neck injuries in AFL players.

2. Materials and methods

A prospective cohort study was undertaken. STROBE guidelines for reporting observational studies were utilised (von Elm et al., 2008).

2.1. Participants

Players aged 18–35 years old from four professional AFL clubs which agreed to participate in the study were eligible for participation in the study ($n = 174$). No exclusion criteria were applied to eligible participants. All participants gave written informed consent and their rights were protected. This study was approved by the Human Research Ethics Committee of the host institution.

2.2. Procedures

Assessments were conducted at the start of pre-season and at the start of the playing season. Self-report questionnaires and ultrasound imaging assessment of trunk muscle size and function were included. Incidence of head/neck injuries was recorded during the playing season.

2.3. Self-report questionnaires

Self-report questionnaires were used to collect information regarding player demographics, regular playing position and number of years playing professional football in the AFL.

2.4. Assessment of trunk muscle size and contraction

Ultrasound imaging was conducted on-site at the football clubs using a LOGIQ e ultrasound imaging apparatus equipped with a 5 MHz curvilinear transducer (GE Healthcare, Wuxi, China). To image the MF muscle, participants were positioned in prone lying. For cross-sectional imaging of the muscle, gel was applied, and the transducer was placed transversely over the spinous process of each vertebral level being measured (L4 and L5) (Hides et al., 1995). To capture contraction of the MF muscle, imaging was performed in parasagittal section, allowing visualisation of the L4/5 and L5/S1 zygapophyseal joints, muscle bulk and thoracolumbar fascia (Wallwork et al., 2009). Participants were instructed how to perform a voluntary isometric contraction and the MF muscle was imaged at rest and on contraction (Wallwork et al., 2009). This procedure has been validated by comparison with measurements obtained using fine wire electromyography (EMG) (Kiesel et al., 2007).

Ultrasound images of the muscles of the antero-lateral abdominal wall were captured in supine lying at rest and on contraction. A transverse image was obtained along a line midway between the inferior angle of the rib cage and the iliac crest for the right and left sides (Hides et al., 2007). The transducer was aligned perpendicular to the fascia covering the anterolateral abdominal muscles. In order to standardize the location of the transducer for each participant, the anterior fascial insertion of the transversus abdominis (TrA) muscle was positioned approximately 2 cm from the medial edge of the ultrasound image when the subject was relaxed (Hides et al., 2007). For assessment of contraction of the abdominal muscles, participants were asked to draw in the lower abdomen without moving the spine (Hides et al., 2007). This procedure has been validated by comparison with measurements obtained using fine wire electromyography (EMG) (Hodges et al., 2003).

Ultrasound images were stored and measured offline. Image visualization and measurements were conducted using OsiriX medical imaging software (Geneva, Switzerland). Cross-sectional areas (CSAs) of the MF muscles were measured by tracing the borders of the muscles (Fig. 1). Thickness of the MF (Fig. 1) and anterolateral abdominal muscles, TrA and Internal oblique (IO) (Fig. 2) were measured in relaxed and contracted conditions. All measurements were conducted by physiotherapists with extensive experience and demonstrated reliability in ultrasound imaging of the relevant trunk muscles (Hides et al., 1995; Hides et al., 2007; Wallwork et al., 2007).

2.5. Injury data collection

Injury data were collected from medical records by club staff during the playing season (mid-March to end of August). An injury was defined as a physical condition related to football training or playing that prevented a player from completing a game or participating in a training session. Injuries were diagnosed by medical staff that assessed a player's ability to participate. The incidence of players incurring one or more head or neck injuries was used for the quantitative analysis. Injury during the playing season was coded as either “head/neck injury” or “no head/neck injury.” The “no head/neck injury” group included players with no injury and those with any other (non-head/neck) injury in the playing season.

2.6. Statistical analysis

SPSS version 22.0 [IBM, USA] was used for analyses. The measurements tested as predictive factors included both categorical and