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Sport-specific endurance plank test for evaluation of global core muscle function

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ABSTRACT

Objective: To examine the validity and reliability of a sports-specific endurance plank test for the evaluation of global core muscle function.
Design: Repeated-measures study.
Setting: Laboratory environment.
Participants: Twenty-eight male and eight female young athletes.
Main outcome measures: Surface electromyography (sEMG) of selected trunk flexors and extensors, and an intervention of pre-fatigue core workout were applied for test validation. Intraclass correlation coefficient (ICC), coefficient of variation (CV), and the measurement bias ratio */÷ ratio limits of agreement (LOA) were calculated to assess reliability and measurement error.
Results: Test validity was shown by the sEMG of selected core muscles, which indicated >50% increase in muscle activation during the test; and the definite discrimination of the ~30% reduction in global core muscle endurance subsequent to a pre-fatigue core workout. For test-retest reliability, when the first attempt of three repeated trials was considered as familiarisation, the ICC was 0.99 (95% CI: 0.98–0.99), CV was 2.0 ± 1.56% and the measurement bias ratio */÷ ratio LOA was 0.99 */÷ 1.07.
Conclusion: The findings suggest that the sport-specific endurance plank test is a valid, reliable and practical method for assessing global core muscle endurance in athletes given that at least one familiarisation trial takes place prior to measurement.

1. Introduction

It is known that the definitions of core stability and associated anatomy in the rehabilitation sector differ to those in the sporting sector (Hibbs, Thompson, French, Wrigley, & Spears, 2008). In view of low back injury rehabilitation, which aims to enhance the ability of the lumbopelvic-hip structures and musculature for maintaining the intervertebral range of motion within a safe limit when daily activities are carried out, the musculatures of the diaphragm, abdominals, paraspinals, gluteals, pelvic floor and hip girdle are core (Richardson, Jull, Hodges, & Hides, 1999). In a sporting environment, core stability is defined as the ability to control the position and motion of the trunk over the pelvis to allow the optimum transfer of energy from the torso to extremities when performing athletic activities, which are often composed of highly loaded movements (Kibler, Press, & Sciascia, 2006). For this specific purpose, core muscles are commonly referred to as all the muscles between the knee and sternum with a focus on the abdominal region, low back and hip (Fig, 2005).

As a result of awareness of the importance of core stability to sports performance, core muscle training became a routine part of athletic training in most sports (Hibbs et al., 2008). For monitoring the specific training, core stability field tests were usually applied due to their convenience. These tests, in general, consisted of isometric measures of endurance and were originally designed for rehabilitation use (McGill, 2007). It has been shown that the core muscle load during various stability field tests depends on the joint torques required to hold a specific posture (McGill, Belore, Crosby, & Russell, 2010). Hence, testing results are specific and not interchangeable. This implies that those core tests established in rehabilitation settings may not be accurate to reveal the functional capacity of the complex core anatomy that is specific to dynamic athletic performance.

Due to the need for a means of monitoring the development of core muscle function in athletes, Mackenzie (2005) developed a sport-specific core muscle test. The core test requires the athlete to maintain a prone bridge (plank) position with their arms and legs lifted up alternatively for 15 s in each stage for eight stages, over a total of three minutes. Core muscle function is assessed based on

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the number of stages completed. Advocates of this test claimed that the plank manoeuvre interspersed with the alternate raising of the arms and legs challenges the trunk flexors and lumbar extensors in a manner that is similar to that occurring in performing sports movements where the muscles are being recruited for giving core stiffness to maximise the kinetic chains of upper and lower extremity function (Kibler et al., 2006; Schellenberg, Lang, Chan, & Burnham, 2007). However, this claim has not been validated, nor has the reliability of the test been established.

The purposes of this study were to examine the validity and reliability of the sports-specific core muscle test. In an attempt to advance the discrimination power of the test, the ceiling of the 3-min testing time was removed. Instead, the participants were asked to repeat the 3-min testing circuit until the maintenance of the prone bridge failed. Such modification was in accordance with the previous notion that core muscle endurance, rather than strength, is essential for trunk stability during exercise (Hibbs et al., 2008). Furthermore, the reliability of the sport-specific endurance plank test in the present study was evaluated, with the position of participants' elbows and feet were found to be identical among trials, while the hip displacement during the test was limited objectively within a narrow range.

2. Methods

2.1. Participants

28 male and 8 female participants (age: 22.4 ± 3.7 years, height: 168.6 ± 5.2 cm, weight: 58.7 ± 5.9 kg) were recruited from a convenient group of athletes in a university who received training in different sports, including long-distance running, swimming and team ball games for at least two years. They were trained for 2–3 h d^{-1}, 3–4 days wk^{-1} in order to compete in intercollegiate and local competitions. All athletes had no orthopaedic or cardio-respiratory contraindications to exercise. After being fully informed of the experimental procedures and possible discomfort associated with the exercise test, athletes gave their written consent. Ethical approval for this study was obtained from the Committee on the Use of Human and Animal Subjects in Teaching and Research of Hong Kong Baptist University.

2.2. Study design

Evaluations of the sport-specific endurance plank test were conducted in two phases: validation and reliability.

2.2.1. Validation

In the present study, the validity of the test was evaluated based on the electromyographic analysis of selected core muscles during the test, and the acute alterations of the performance of the test subsequent to an intervention of pre-fatigue core workout. For the surface electromyographic (sEMG) assessment, eight of the 28 male participants were randomly selected. The sEMG of selected core muscles during the sport-specific endurance plank test, expressed as a percentage of the corresponding sEMG output during maximum voluntary isometric contraction, were analysed. For further examination of the construct validity of the test, another eight of the resting male participants were randomly selected. The performance of the sport-specific endurance plank test with and without a pre-fatigue core workout was compared. Half of the participants performed the plank test with and then without pre-fatigue core workout, while the others performed the tests in reverse order. Prior to the experiments, a trial was undertaken to familiarise the participant with the test to exhaustion.

2.2.2. Reliability

For examining the reliability of the sport-specific endurance plank test, the resting 12 male participants and the 8 female participants repeated the test three times on separate days. Both the absolute and the relative measures of reliability were assessed to determine whether the amount of measurement error fits the analytical goals of the test (Cowley & Swensen, 2008). Prior to the tests, a non-exhausted trial was undertaken to familiarise the participant with the testing protocol.

All experimental and familiarisation trials were performed in an air-conditioned laboratory with the temperature and relative humidity set at 22 °C and 70%, respectively. Before each trial, the participants refrained from eating for at least two hours and from participation in strenuous physical activity for at least one day. All trials were scheduled to occur at the same time of day and were separated by a minimum of 3 days.

2.3. Sport-specific endurance plank test

Participants started the test by holding a basic plank position – a prone bridge supported by the forearms and feet (Fig. 1). Elbows were vertically below the shoulders with the forearms and fingers extending straight forward. The neck was kept neutral so that the body remained straight from the head to the heels. Participants were required to maintain the prone bridge in a good form throughout the following stages with no rest in between: (1) hold the basic plank position for 60 s; (2) lift the right arm off the ground and hold for 15 s; (3) return the right arm to the ground and lift the left arm for 15 s; (4) return the left arm to the ground and lift the right leg for 15 s; (5) return the right leg to the ground and lift the left leg for 15 s; (6) lift both the left leg and right arm from the ground and hold for 15 s; (7) return the left leg and right arm to the ground, and lift both the right leg and left arm off the ground for 15 s; (8) return to the basic plank position for 30 s; (9) repeat the steps from (1) to (9) until the maintenance of the prone bridge failed.

In this study, in regard to the sport-specific endurance plank test that each participant repeated with identical body posture, the distances between the left and right elbows (medial epicondyle), the left and right feet (1st metatarsal), and the elbow and feet on the left and right sides of the body were measured during the familiarisation trial while the participant was comfortably performing the prone bridge basic plank position on a bench. Further, two elastic strings of ~80 cm length which were attached horizontally to a pair of vertical scales were placed beside the bench during the test (Fig. 1). The two strings maintained at a distance of 10 cm were adjusted up and down until a height was reached that was at the same level as the participant's hip (the iliac crest was

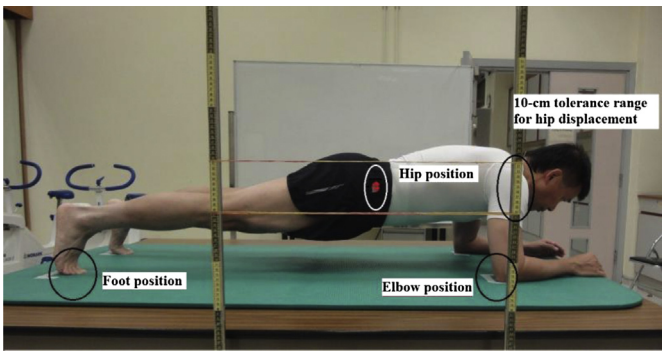

Fig. 1. The setting of the sport-specific endurance plank test (from the view of test administrator), with the subject remaining in the basic plank position, is shown.