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Reliability and validity of the 30-s continuous jump test for anaerobic fitness evaluation

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ABSTRACT

Objectives: To determine the test–retest reliability and concurrent validity of the 30-s continuous jump (CJ_{30}) test using the Wingate test as a reference.
Design: Descriptive validity study.
Methods: Twenty-one male volleyball players (23.8 ± 3.8 years; 82.5 ± 9.1 kg; 185 ± 4.7 cm) were tested in three separate sessions. The first and second sessions were used to assess the reliability of the CJ_{30} while in the third session the Wingate test was performed. In the continuous jump test, consisting of maximal continuous jumps performed for 30 s, jump height was determined by video kinematic analysis. Blood samples were collected after each test to determine lactate concentration.
Results: The CJ_{30} showed excellent test–retest reliability for the maximal jump height (ICC = 0.94), mean vertical jump height (ICC = 0.98) and fatigue index (ICC = 0.87). Peak lactate showed moderate reliability (ICC = 0.45). Large correlations were found between the mean height of the first four jumps of CJ_{30} and the peak power of the Wingate (r = 0.57), between the mean vertical jump height of CJ_{30} and the mean power of the Wingate (r = 0.70) and between the lactate peak of CJ_{30} and Wingate (r = 0.51). A moderate correlation of fatigue index between CJ_{30} and the Wingate was found (r = 0.43).
Conclusions: The continuous jump is a reliable test and measures some of the same anaerobic properties as WAnT. The correlations observed in terms of anaerobic indices between the tests provide evidence that the CJ_{30} may adequately assess anaerobic performance level.

1. Introduction

Assessment of anaerobic fitness is an important parameter in controlling and monitoring sports training performance. A number of tests have been proposed for evaluating anaerobic metabolism,[1–3] such as the Wingate Anaerobic Test (WAnT), which is one of the most popular.[4] Despite its widespread use, this test does not satisfy the specific demands of sports that do not involve cycling movements.[5] In addition, some motor actions involving a combination of eccentric and concentric muscular actions, i.e., the stretch-shortening cycle (SSC), enhance performance during the final phase (concentric action) of movement when compared to the isolated concentric actions[6] observed in WAnT. SSC is integral to many human movements including countermovement vertical jumps, which are used frequently in several sports.[2,6]

Some tests share little specificity with sports that require vertical jumps,[7,8] e.g., basketball and volleyball. In this context, Bosco et al.[2] devised a specific anaerobic power test in which continuous jumps are executed for a period of 60 s. In addition to the test's simplicity, the parameters obtained (e.g., jump height) may be more representative and have more practical application for coaches and athletes in sports that include such demands.[5]

Continuous jump tests have been extensively used by coaches and physical trainers, but insufficient information has been presented in the literature[2,5] concerning their validity and reliability. Bosco et al.[2] and Sands et al.[5] used only a correlation approach to find evidence for the validity of continuous jump tests applied for 60 s. Additionally, limited or inadequate information about reliability is available. According to Hopkins et al.,[9] the two most important aspects of measurement error are concurrent validity and test–retest reliability, which guarantee the quality of a measuring instrument.

A variation of the traditional Bosco test (60 s) using a shorter duration (i.e., 30 s) has recently been studied.[10,11] The 30 s duration is considered sufficient for eliciting ATP-PC power and capacity, as well as maximal glycolytic power,[12] which may contribute more effectively to sustain the subject throughout the entire test.[13,14] In addition to causing severe discomfort, anaerobic tests longer

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than 45 s tend to overestimate at power output because many individuals do not perform at maximum intensity throughout the test.[10,14,15] According to Inbar et al.,[15] the power generated in a 30-s test was higher than that recorded for the first 30 s in longer tests.

Given that no researchers have reported any information regarding the validity of a shorter continuous jump test (30 s) and the lack of data regarding its reliability in previous studies, this study aimed to determine the test–retest reliability and concurrent validity of the continuous jump test performed over 30 s (CJ_{30}), using WAnT as a reference.

2. Methods

Twenty-one healthy male volleyball athletes (23.8 ± 3.8 years old; 82.5 ± 9.1 kg; 185 ± 4.7 cm; fat percentage: 12.1 ± 3.5%) volunteered to participate in this study. They signed a written informed consent form, which was approved by the Human Research Ethic Committee of the Federal University of Santa Catarina in accordance with the Helsinki convention. Participants trained on a regular basis (three sessions per week) during the three years that preceded the study and were currently competing at the college level. Participants did not report injuries or other conditions that prevented them from training or otherwise influenced their maximal physical performance.

Participants were tested in three separate sessions with an interval of 48 h between sessions. The first and second sessions were used to determine the reliability of the CJ_{30} (test–retest). The third session was used to perform WAnT, the reference used to determine concurrent validity.

Anthropometric assessments (body mass, height and skinfolds to estimate body fat) were performed in the first session. Participants were allowed a short period (i.e., 10 min) to familiarize themselves with the testing procedures and performed a specific warm-up (described below). Blood samples were collected from the right earlobe after each test to determine lactate concentration. Participants were requested to refrain from training in the 24 h that preceded testing sessions and to maintain their regular diet. Participants were also asked to avoid smoking and caffeinated drinks. All procedures were applied at the same time of day and performed in a 24 °C laboratory environment.

Initially, the CJ_{30} were preceded by five static stretching exercises (one set of 10 s) with emphasis on the lower limbs, standardized for all participants. After the stretching exercises, a specific warm-up and familiarization that involved one minute of hopping on a trampoline, three series of ten hops on the ground and eight to ten vertical jumps simulating the real test were performed.

The CJ_{30} consisted of maximal continuous vertical jumps performed for 30 s. Participants were required to keep the trunk as vertical as possible, and hands were placed on hips (akimbo). According to recommendations of the protocol,[2] participants were also asked to flex their knees at ~90° in the transition between the eccentric-concentric phases, which is considered the best angular position to maximize the vertical jump performance.[2] Verbal feedback was provided to the subject during the test to encourage them to maintain knee angle approximately 90° and maximum performance until the end of the test.

The tests were filmed using a calibrated camera (VPC-HD2000 Xacti, Sanyo Electric Co., Japan) with a resolution of 1920 × 1080 pixels, sampling at 60 frames s^{-1} positioned perpendicularly at six meters from the right sagittal plane of the movement for two-dimensional (2D) kinematics analysis. A set of landmarks was placed on the right side of the participant's body at the following sites: (1) lateral malleolus, (2) lateral femoral epicondyle of the knee, (3) the most prominent protuberance of the greater trochanter and (4) acromial process. These landmarks were digitized (Skill Spector, Video4coach, Denmark) and their coordinates were used to calculate the linear and angular kinematics. The maximal vertical displacement of the greater trochanter marker (analogous to total body center of gravity) was used to determine the vertical jump height, taking into account the initial standing position as a reference.[16,17] An algorithm implemented in Scilab 5.3.3 software (INRIA, France) was used to identify each maximal jump height.

The maximal jump height (H_{MAX}), the mean jump height of the first four jumps (H_{MEAN_4J}), the mean jump height of all jumps (H_{MEAN}) and the fatigue index were calculated. The fatigue index was obtained considering the first (H_{MEAN_4J}) and the last ($H_{MEAN\text{-}end4J}$) four jumps of the test,[14] according to Eq. (1):

$$\text{Fatigue index} = \frac{H_{MEAN\_4J} - H_{MEAN\_end4J}}{H_{MEAN\_4J}} \times 100 \quad (1)$$

The H_{MEAN_4J} was used as an equivalent of peak power in an attempt to determine an analogous measure in the CJ_{30}. This is similar to WAnT and is generally obtained in the first 5 s of the test.

WAnT was performed with a specific cycle ergometer (Excalibur Sport®, Lode, Netherlands), according to the recommendations proposed by Inbar et al.[15] Initially, the participants performed a warm-up of 5 min in the cycle ergometer with a load of 50 W. A maximal sprint between 3 and 5 s was performed at the end of each minute. The test started 2 min after the warm-up. WAnT was performed at maximal intensity for 30 s with a load corresponding to 7.5% of body mass. Resistance was applied after 3 s of maximal acceleration with no load. Participants were instructed to remain seated throughout the test and received verbal encouragement to sustain their maximum effort throughout the test. A one-minute period of cycling with no load was included at the end of the test.

The following variables were obtained in WAnT: peak power, mean power, and fatigue index, calculated according to Eq. (2) [14]:

$$\text{Fatigue index} = \frac{\text{Peak power} - \text{lowest power}}{\text{Peak power}} \times 100 \quad (2)$$

After WAnT and CJ_{30}, a blood sample (25 μl) was collected from the right earlobe with a heparinized capillary tube in the third, fifth, seventh, ninth and eleventh minutes of recovery. Blood samples were stored in 1.0 ml sealed polyethylene tubes with 50 μl solution (sodium fluoride, 1%) and were subsequently assayed with an electrochemical analyzer (YSI 2700 model Stat Select, Yellow Springs Inc., USA). The equipment was calibrated before each measurement according to the manufacturer's manual. The highest blood lactate concentration during the recovery period was used for further analysis.

The test–retest reliability was determined by calculating the intra-class correlation coefficient ($ICC_{2,1}$) with a two-way random effects model with absolute agreement. Additionally, the typical error of measurement (TEM) and the Bland–Altman plot were used to verify the measurement agreement between test and retest. The ICC values were classified as follows: <0.4 = poor reliability; 0.4–0.75 = fair to good reliability; and >0.75 = excellent reliability.[18] The paired *t* test was used to verify the difference between BIAS and zero (value reference for perfect agreement).

Pearson's correlation coefficients were used to establish the correlation between WAnT and CJ_{30} parameters. Considering the strong reliability of test–retest previously analyzed, the retest data were randomly selected to compare with WAnT parameters. The following criteria were adopted for interpreting the magnitude of correlation between variables: <0.1, trivial; 0.11–0.3, small; 0.31–0.5, moderate; 0.51–0.7, large; 0.71–0.9, very large; and 0.91–1.0, almost perfect.[9] Additionally, independent *t* test was used to compare the blood lactate concentration between tests.