SENSITIVITY AND SPECIFICITY OF THE STRENGTH PERFORMANCE DIAGNOSTIC BY DIFFERENT VERTICAL JUMP TESTS IN SOCCER AND VOLLEYBALL AT PUBERTY

ORIGINAL ARTICLE

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ABSTRACT

Objective: To evaluate the sensitivity and specificity of different protocols for measurement of vertical jump tests for the diagnosis of explosive strength in soccer and volleyball players at puberty. Method: Cross-sectional study population of 110 non-probabilistic young male athletes (60 soccer players and 50 volleyball players) aged 13 to 18 belonging to clubs in the metropolitan region of Campinas, SP, Brazil. Participants had their biological maturation assessed by two methods: self-assessment and clinical measurement; after this evaluation, those classified as pubertal (25 soccer and 23 volleyball players) were included. Anthropometric data (body weight, height and skinfold thickness) and vertical jump tests: squat jump (SJ), countermovement jump (CMJ), drop jump (DJ, 40-cm height) and vertical jumps continuously with 5 seconds duration (CJ5s) were collected. The following measurements of diagnostic performance were calculated: sensitivity, specificity, and accuracy. Significance level of 5% was adopted for all tests. Results: Explosive strength estimated by the SJ and CMJ methods showed equivalent sensitivities, while the SJ presented higher specificity than the three methods, and accuracy of SJ was different from the other methods, which was high (above 80%). Conclusion: The diagnosis of explosive strength as SJ test presented high sensitivity and specificity with high predictive value at puberty.

Keywords: test, jump, strength, sensitivity and specificity, maturation, soccer and volleyball.

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INTRODUCTION

Assessment of the vertical jump is known for being an important diagnostic method of strength performance[1-5]. The vertical jump methods are widely used as filed tests for assessment of explosive strength of lower limbs in many sports. Such methods are frequently studied considering their confidence and validity in volleyball[6,7] and soccer players[8,9].

High frequency of investigation on vertical jumps in the adult population and their strong impact on the performance diagnosis of the explosive strength make this method one of the greatest attractions. Recently, some studies tend to outline studies using the jumps and tests procedures to estimate explosive strength in young athletes[10-12].

The vertical jump assessment presents as advantage the performance of measurements in any individual, including children and adolescents. However, such populations are influenced by factors of physical growth[13], biological maturity[14,15] and chronological age[16], and, if correctly used, would permit the reduction of wrong diagnosis applied in this population.

Due to the many questions related to measurement of the jumped height, it is of crucial importance to establish the real contribution of the jump methods used, centralized in reaching for a correct diagnosis for trainability, which can be understood as positive alterations of these children and adolescents, strongly influenced by the presence of many gradients of the strength manifestation which contribute to the performance potentiality in soccer[17] and volleyball players. There is some questioning in the use of the vertical jump method for explosive strength estimation in young athletes: which of the vertical jump methods have specific diagnosis and enable better prediction of the sensitivity in the adjustment of the biological maturation in puberty.

The aim of this study was to evaluate the sensitivity and specificity of different measurement protocols of vertical jumps tests for the diagnosis of explosive strength in soccer and volleyball players in puberty.

MATERIALS AND METHODS

Subjects sample

This was a transversal study with a non-probabilistic sample of 110 young male athletes aged between 13 and 18 years, belonging to clubs of the metropolitan area of Campinas, SP, Brazil. The participants had their biological maturation checked by two methods: self-evaluation and clinical measurement. Specifically, the athletes participated in two sports: soccer and volleyball. Thus, the sampling was composed of: soccer players' sample: 60 soccer players, age between 13 and 17 years, participated in this study. After the maturational assessment, the pre-puberty and post-puberty individuals were excluded. Therefore, the sample of this study ended up being of 25 male pubescent soccer players, from a club of the Campinas region, SP (14.90 ± 0.55 years; 62.03 ± 7.01 kg; 172.31 ± 7.77 cm; 4.34 ± 2.45 years of experience; %F = 13.87 ± 4.01).

Volleyball players' sample: 50 volleyball players, aged between 14 and 18 years, affiliated with the Volleyball Federation of São Paulo State (FPV). After the maturational assessment the pre-puberty and post-puberty individuals were excluded. Thus, the sample of this study consisted of 23 male pubertal volleyball players from a club of the Campinas region, SP (15.15 ± 1.07 years; 62.03 ± 7.01 kg; 192.56 ± 6.25 cm; 3.34 ± 2.31 years of experience; %F = 16.87 ± 5.31).

The measurements were performed at the beginning of preparation period of the Soccer Championship of São Paulo State in 2009. The study was approved by the Ethics in Research Committee of Unicamp (nº 526/2007). All subjects signed a consent form for participation as volunteers in the proposed study, as well as the legal responsible one for the volunteer who signed another consent form.

Measurement procedures

The performance of the vertical jumps was verified through vertical jump tests with the techniques: *squat jump* (SJ), *counter movement jump* (CMJ), 5-second continuous vertical jumps (CJ5s) and *drop jump* with drop height of 40 cm (DJ40). The equipment used in the measurements performance of the vertical jump was the *Jump Test* contact mat.

SJ test: this technique consists in the performance of a vertical jump with half squat which departs from a 5-sec static position, knee flexion of approximately 120º without previous countermovement of any segment; the hands should stay close to the hip, on the suprailiac region. The trunk should be vertical without excessive early move. A technical detail must be observed: it is important that the knees remain at extension during the fly. The interval between each attempt will be of 10 seconds. These technical procedures are described by Bosco[18].

CMJ test: the athlete stood from a position with erect trunk and knees at 180° extension. The maximal vertical jumps were performed with countermovement technique without help from the upper limbs (hands remained still and close to the hip). In that specific situation, the athlete performed the stretching and shortening cycle (knee flexion and extension), a procedures described by Bosco[18]. The knee flexion occurred approximately at 120° angle; the subject performed later knee extension, trying to push the body upwards and vertically, during this action the trunk remained still to avoid influence in the results. Some technical details have been observed, such as: the knees remained extended during the fly and the upper limbs did not contribute to the impulse. The interval between attempts was of 10 seconds[18].

CJ5s test: the athlete stood up from a position with erect trunk, with knees extended at 180°, with hands still and close to the hip (waist). The continuous vertical jumps were performed with the countermovement technique with 5-second duration. In that specific situation, the athlete performed the stretching and shortening cycle limiting the knee and ankle flexion with fast and brief ricochet bounce movements, jumping as high as possible. Some technical details have been observed, such as: contact with the ground after the fly was performed with metatarsi and not on the foot surface; knees remained extended during the fly and the upper limbs did not contribute to the impulse. The interval between each attempt was of 60 seconds. This technical procedure is described by Bosco *et al.*[19].

DJ40 test: the method of the drop jump test consists in having the subject on a 40 cm-high bench, fall on the mat test, at the contact with it, he must react with a stretch-shorten cycle to try to perform a maximal vertical jump. The drop height was of 40 cm. To begin, the subject must be standing on a bench at erect position, extended legs (180° knee angle), hands on the waist. He must then take one foot forward and fall with the gravity effect. At contact with the ground, he should react as fast as possible, jumping as high as possible. During this movement, knee flexion should be avoided[1].

For this study, the intraclass correlation coefficient was calculated for each variable of the tests, demonstrating high levels of confidence (CMJ = 0.98; SJ = 0.99; CJ5s = 0.91; DJ40 = 0.88) in the test/retest with vertical jumps, presenting low variation coefficients (CV = 2.34%; 2.68%; 3.41% and 4.32% for the tests, respectively, for SJ, CMJ, CJ5s and DJ40).

Anthropometry: the height (H) and body weight (BW) anthropometric measurements were used to characterize the body dimension of the studied subjects. These measurements taken based on standardization described by Lohman[20] used the equipment: a) wooden stadiometer; and b) Plena Lithium Digital electronic scale, with precision of 100 g.

Body composition measurements: body composition was measured through the skinfolds: tricipital (TRSF) and subscapular (SBSF). The fat percentage (%F) was estimated through the prediction equations proposed by Slaughter *et al.*[21].

Maturational assessment: the participants self-evaluated their maturation[22]. The genital was used as maturational interpretation reference, which represented the biological maturation of the subjects, classified in pre-pubertal. Pubertal and post-pubertal. In order to check data quality in this study, their validity and confidence were investigated, for a sample of 12 subjects out of the participants in the study. After self-evaluation of sexual maturation was performed, the subjects were submitted to an observation by the doctor of the soccer club to check sexual maturation, making use of the Tanner scale[22]. Confidence was assessed using the statistical process of the intraclass correlation coefficient, while for validity, the variation coefficient (VC) was used.

The α confidence coefficient was high, 0.85 ($p < 0.01$). The variation coefficient was of 12.4%, with technical error of measurement of 0.86 per stage, respectively, for F. The results indicate that high level of confidence may be observed in the sue of self-evaluation in soccer players. Similar findings mention that self-evaluation is a vaid and reliable method for evaluation of sexual maturation in elite adolescent athletes[23].

Data collection procedure

Data were collected in the beginning of the preparation period for the volleyball and soccer championships. The subjects performed 15 minutes of warm-up through actions of: stretching, running, coordination exercises and exercises for neuromuscular activation specific to the jump tests. Each subject performed three maximal attempts for each one of the vertical jump tests. Recovery time was of 10 seconds between attempts and 60 seconds between tests. The best of the attempts of each vertical jump technique was used. The order set was SJ, CMJ, CJ5s and DJ40.

Statistical analysis procedure

In the statistical analysis, normality of the variables of the vertical jump tests was verified by the Kolmogorov-Smirnov test. Taking the definition of quality in the measurements as gold-standard, the measurements of diagnostic performance were calculated (sensitivity, specificity and accuracy). The significance level for all tests was set in 5%. The statistical analyses were taken with the SPSS programs for Windows® (version 17.0).

RESULTS

Table 1 presents that the estimated explosive strength by the SJ and CMJ methods presented equivalent sensitivity, while the SJ presented specificity higher than the four methods. Moreover, SJ accuracy was different from the other methods, which was high (higher than 80%).

The results demonstrated that the prediction value was high for SJ (S=96%; E=95%), while for the CMJ, they demonstrated high prediction value for sensitivity (S=85%) and low prediction value for specificity (SP=59%).

In the CJ5s method, joint reduction in the prediction values (S=73%; SP=45%) can be observed. Sensitivity and specificity were relatively low for the DJ40 method (55 and 29%).

Table 1. Estimated values of sensitivity, specificity and accuracy of the diagnostic performance measures of the methods with vertical jumps.

Diagnosis	Sensitivity (CI95%)	Specificity (CI95%)	Accuracy (CI95%)
SJ (cm)	96 (92.99)	95 (90.98)	81 (76.86)
CMJ (cm)	85 (75.93)	59 (46.76)	65 (57.82)
CJ5s (cm)	73 (62.93)	45 (32.58)	59 (48.80)
DJ40 (cm)	54 (11.98)	29 (14.42)	48 (27.69)

DISCUSSION

The results of the present study suggest that the SJ and CMJ tests present sensitivity higher than the other tests for identification of explosive strength in puberty, since this condition is highly prevalent. Additionally, the SJ test presented specificity prediction values which corroborate the SJ superiority in the vertical jump tests concerning the test's ability to present the explosive strength diagnosis, besides good ability of diagnostic correctness of the explosive strength manifestation, represented by the high accuracy level.

The method tested for the diagnosis of the elastic component (CMJ) presented higher sensitivity than specificity and suggests that this procedure presents performance similar to the one observed in the diagnosis of explosive strength by SJ; however, not as specific as the SJ in puberty. In the study by Lloyd *et al.*[24], height of SJ explained better the total variance for the index of reactive force expressed by the elastic component (r2 = 53.9%). Nevertheless, jump height in the CMJ and SJ height were the best predictors (r2 = 86%) of each other in puberty[24], which occurs due to the influence of the neural components by the velocity of contraction in the strength manifestation in puberty.

However, the results of the present study let us suitably compare the performance of the four test methods with vertical jumps in puberty. A limitation of the present study is the absence of control of the independent variable of the signal of electrical activation of the muscles involved in the vertical jump movement, which made the identification of the real value of the reflex elastic component difficult. However, the comparison of the diagnosis of explosive strength methods was not compromised.

The superiority assessed comprehends only the characteristics of the measurements intrinsic to sensitivity and accuracy of the methods in puberty and should not be interpreted as a substitution of a method for another, at adulthood, since it has been acknowledged in the literature that the variety of methods available has a complementary character in the diagnosis of strength production, which makes it possible to diagnose different gradients of the manifestation of explosive strength.

Thus, it is not simply the case of concluding about the superiority of a method over another, rather alerting for the existence of different methods which can be used in order to avoid wrong diagnosis due to the expression of different components. However, the quality of the diagnosis measurement in puberty is an indication by the SJ in puberty in volleyball and soccer players.

The most influential factor is intense training in its specific manifestation for these sports, especially with the training which stimulates the recruiting component in pubertal youngsters[25]. It is worth mentioning that the justifications concerning these alterations of explosive strength are not due to the increase in the recruiting of the motor units alone, but also by the increase of the contraction velocity.

Bojsen-Møller *et al.*[26], in high-level athletes, have observed correlation between maximal among strength, stiffness in SJ and CMJ ($r = 0.64$; $p < 0.05$ and $r = 0.55$; $p < 0.05$). These data determine that the production of maximal strength of the muscles is positively related to the stiffness of the structures of the tendon organs, possibly through more efficient transmission of the contractile elements strength to the bones.

Concerning the elastic and reflex components of the strength manifestation through the stretching and shortening cycle, we diagnosed in the CMJ, DJ40 and CJ5s tests that specificity constitutes the best marker of diagnosis in puberty due to their low prevalence. The results found evidence that the combination of these components was more efficient in the diagnosis of explosive strength, whose explanation is that the hierarchy activity condition among the components influences on the other manifestations, especially on the strength production rate[27,28].

The results suggest that the test protocols used in the study of the elastic component were representative of different performance examples of the stretching/shortening cycle[24], in the CMJ, DJ40 and CJ5 tests, and, consequently, the test with higher sensitivity and accuracy to diagnose this component was the CMJ.

It seems almost certain that the adjustments in the accelerated adaptation may exist for jump height in SJ, CMJ, DJ40, and CJ5s in male young subjects; however, the stiffness results of the legs suggest that the reflex elastic components present manifestation with function which may follow a tendency for different development in puberty[16]. Thus, we carefully consider that the DJ40 and CJ5s tests

resent low accuracy in the diagnosis of explosive strength of soccer and volleyball players in puberty.

In another point under consideration, in the differences of variance among vertical jumps test methods in the diagnosis in the strength manifestations with their respective correlations, it was observed that the reflex elastic behavior was one of the manifestations which have suffered the highest maturational influences when compared to the others. This fact may be explained by the tendency of higher influence of the body weight and muscle area of the thigh on the strength production of this expression in the CJ5s and DJ40[13,29,30]. The study also shows that the SJ test, if used according to determinations which guarantee its suitable application, is a viable, safe and cheap method which may help in the diagnosis of explosive strength.

CONCLUSION

The diagnosis of explosive strength with the SJ test presented high sensitivity and specificity, with high prediction value in puberty. On the other hand, decrease in CMJ specificity was observed, which indicates decrease in the prediction value of the result; therefore, the impact of this test is low.

Additionally, we can observe that the CJ5s, as well as the DJ40, when concomitantly reducing sensitivity and specificity, cause dramatic reduction in the prediction value of the result of strength performance in soccer and volleyball players in puberty.

All authors have declared there is not any potential conflict of interests concerning this article.

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