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Original Article

Comparison of two vertical jump evaluation tests in young athletes: vertical impulse and laser sensor instrument test

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Abstract:
Vertical jumping is fundamental in many sports, as it can influence athlete performance. It is also considered an indirect method to evaluate lower limb muscle power in sports or in physically active subjects. The aim of this study was to compare two methods of vertical jump evaluation, the vertical impulse test and jump with laser sensor instrument. In total, 23 track and field athletes were evaluated, aged 14 to 16 years, members of a training program of a sport project based in Piracicaba - SP. The subjects were submitted to two different vertical jump evaluation procedures, vertical impulse test and jump with laser sensor instrument, both without counter movement and without upper limb swing. Descriptive data analysis was performed. To verify the normality of the population, the Shapiro-Wilk test was applied, and when normality was confirmed, the Student's t-test was applied, and Pearson's correlation to analyze the correlation between the methods. The vertical impulse test presented mean values of 36.84 ± 6.49 and the jump with the laser sensor instrument 31 ± 5.66. The mean difference between the methods was 5.84 cm. The correlation between the methods was positive and high, r = 0.80, indicating regularity in the performance between the methods. It was concluded that when compared, the vertical impulse test presents higher values than the laser sensor instrument; however, both methods were demonstrated to be viable to evaluate vertical jump performance, provided that the chosen test is standardized.
Key Words: - Evaluation Methods, Vertical Impulse, Laser Sensor Instrument Test, Explosive Force

Introduction

The ability to jump can be observed at various moments in sport, being fundamental in modalities that require complex game situations or in specific events that use jumping to improve performance[1]. Vertical jumping is an important motor skill and is considered a basic skill in some modalities, and secondary in others, however the ability to jump is related to locomotion activities, racing games, traditional games, or activities that combine other skills. Given its importance, the number of investigations surrounding this ability has been increasing[2].

Taking into account the methodological aspect, the vertical jump is an indirect method to evaluate muscular power of the lower limbs. Evaluations can present methodological variations, using single jumps, intermittent jumps, or continuous jumps, differentiating the muscular work required at the moment of the jump, which is the stored elastic energy and potentially contributes to performance[3]. Given the muscular contribution to jump performance, the single jump can be highlighted, for which two jump execution procedures can be adopted, the *counter movement jump* which is a jump against movement (stretching and shortening of the muscle fibers) and the *squat jump* without counter movement, methodologically stipulated by the initial position at the moment before the jump[4].

The evaluation of the power measured by the vertical jump is indispensable: when planning training in different groups; for athletes or individuals seeking to investigate aspects of muscle power development; to track the performance of this skill in training; and to verify and compare indices of the same skill in different groups, ages, and between sexes[5 - 8].

For the evaluation to be efficient, measuring equipment is used and the methods utilized to measure jump performance are different, as highlighted in some studies: contact mat [9], strength belt, force platform, Vertec [10], and vertical impulse test [11]. Based on the emergence of different vertical jump measurement equipment, testing different methods is important, in order to highlight reproducibility and reliability, for which

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some studies stood out[12, 13]. Few studies point to evaluation with laser sensors *(**L**ight **A**mplification by **S**timulated **E**mission of **R**adiation).* This protocol could be an important technique as it does not rigidly delimit the fall space or require touches on the wall.

In the case of jumping where restriction in counter movement is adopted as a protocol (Stretch-shortening cycle), the *squat jump*, for example, demonstrates a clear loss in potential elastic energy, which is caused by stretching the muscle moments before the jump[1]. These variables may justify the jump protocol, as it seeks to elucidate vertical impulse without the influence of variables that may overestimate lower limb power performance.

Procedures that characterize the jump are considered in studies that in turn seek to test variables that may influence performance, for example, upper limb swing in the upward phase and the counter movement[14,15]. Other authors have sought to compare jump evaluation procedures with and without counter movement and to diagnose consistency in jump evaluations[16-18].

In this sense, the present study aimed to verify the correlation between the methods of vertical impulse, which is a vertical impulse test characterized by the vertical jump based on jumping and reaching the highest height demarcated with the fingertips, with the laser sensor jump, based on a system of calculations from the flight time, evaluated by the light emission from a *laser*.

Material & methods

In total, 23 athletics practitioners from different modalities were evaluated. The volunteers were 14 to 16 years old, height 1.72 ± 8.04 cm, body weight 63.33 ± 6.66 Kg, members of a training program of this modality in a sport project based in Piracicaba – SP. Individuals who agreed to participate in the research, with their guardians, signed the informed consent form (ICF), which was approved by the UNIMEP Research Ethics Committee under protocol 91/11. The participants were submitted to two distinct vertical jump evaluation procedures, the vertical impulse test and vertical jump with laser sensor instrument.

Vertical Impulse Test

The vertical impulse test is a simple evaluation method, using chalk and a "cm" scale tape measure. For the evaluation, the subject stood, feet parallel, heels touching the ground, positioned with the body parallel to the wall, and extended their arm, marking the farthest distance reached with the fingertips. After marking the reference point, the subject laterally moved away from the wall to prepare for the jump, the jump was performed without upper limb swing and without counter movement, the upper limbs were raised and with slight flexion of the hip and knee, the subject performed the jump, touching the highest point reached in the jump with their fingertips [19]. In order to determine the best distance reached in the jump, three jumps with an interval of thirty seconds were performed, and the highest mark was considered. (Fig. 1).

Figure 1. Vertical Impulse Test

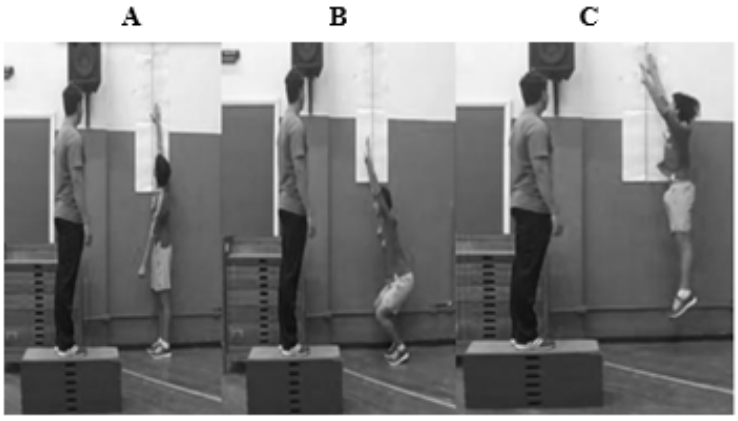

Figure 1. Vertical impulse test. (a) Marking of the reference point; b) Jump start position; c) Jump without counter movement and without use of upper limbs.

Jump with Laser Sensor Instrument

A laser sensor instrument was used to perform the test, which contains two sensory bars, a model digital oscilloscope (54501ª 100MHz-double-trace-HP), cables and connectors, forming a system that emits sensitive light rays capable of calculating height and flight time in milliseconds [20].

The subject stood between the partially flexed sensory bars, knees and hips partially flexed, and the jump was performed without upper limb swing and without counter movement. The subject performed three jumps with an interval of thirty seconds between jumps and the highest mark achieved was considered for analysis. The same jump protocol was used for the test with the laser sensors (Fig. 2).

Figure 2. Jump with Laser Sensor Instrument

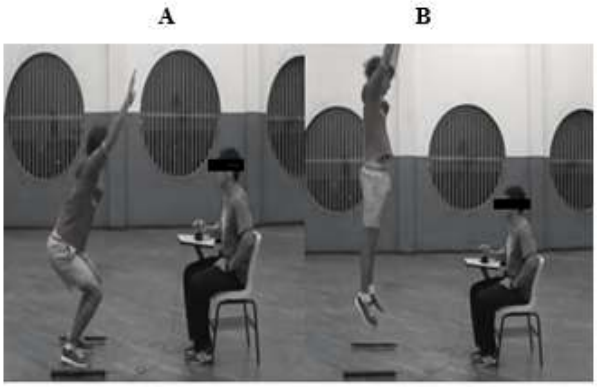

Figure 2. Jump with Laser sensor instrument. a) Initial position of the jump between the sensory bars; b) Jump without counter movement and without upper limb swing.

Statistical analysis Descriptive analysis of data was performed with mean and standard deviation. To observe the normality of the population, the *Shapiro-Wilk* test was applied. As the normality was verified, the *Student's t-*test was used to compare the evaluation methods, and Pearson's correlation to verify the correlation index in the performance between the methods. The statistical program used was *Bioestat* 5.0.

Results

The results showed that the evaluated individuals demonstrated higher performance in the vertical impulse test (36.85 ± 6.49 cm) when compared to the vertical jump with laser sensors (31.00 ± 5.66 cm). The mean difference between the two methods was 5.84 cm. The confidence interval (CI) demonstrated a high percentage, with (CI) 99% = 3.54 - 8.14 cm, indicating a value of $p \leq 0.01$ (Fig. 3).

Figure 3. Comparison of the results of the vertical impulse test and the laser sensor jump

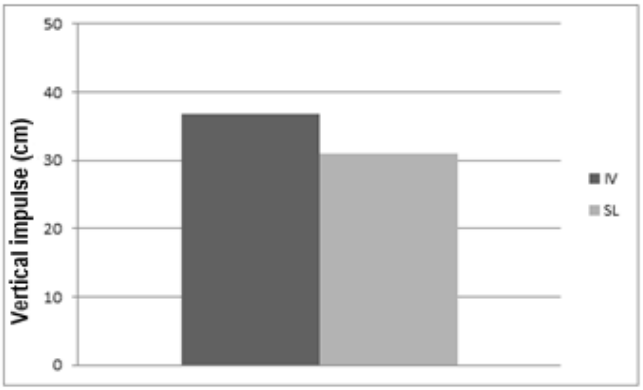

Figure 3. Comparison of the results in (cm) of the vertical impulse (IV) test and the laser sensor (SL) jump, n = 23. * $p \leq 0.01$. Figure 4 presents the correlation between the vertical impulse test and laser sensor jump.

Figure 4. correlation between the vertical impulse test and laser sensor jump

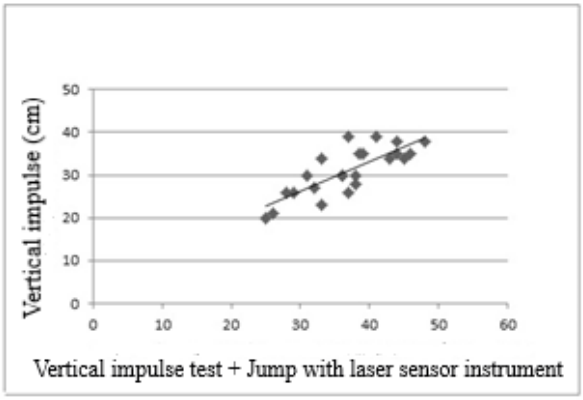

Figure 4. Correlation between vertical impulse test (IR) and jump with laser sensor instrument (SL). $p \leq 0.01$, r = 0.80.

Performance in the vertical jumps presented positive and high correlations between the two methods. The athletes who performed good jumps in the vertical impulse test also demonstrated good performance in the jump with laser sensors. Pearson's correlation showed a high power of correlation strength, r = 0.80, when comparing performance between the tests.

Dicussion

The present study investigated vertical jump performance measured by different evaluation methods. For the impulse evaluation, the vertical impulse test and laser sensors were used. The result showed a difference of more than five centimeters in the mean values of the jumps, with the vertical jump test presenting better performances than the evaluation with laser sensors. It should be noted that the procedure used for both tests was the jump without counter movement and without the use of upper limb swing.

Some studies have compared different evaluation methods. Braz et al.[21]and Hutchison and Stone[22], considering the agreement of the devices in relation to the vertical jump measurement, found that methods that use similar procedures demonstrate a greater possibility of agreement when performed with the same jump procedure.

The correlation between the methods investigated in the present study was positive and high, r = 0.80, indicating that the participants performed uniform jump performances between the methods; those who obtained good performance in one protocol, reproduced the performance in the other protocol. Other studies have evaluated the correlation between methods. Nuzzo, Anning and Scharfenberg[23] found high correlation rates, r = 0.95, in the comparison between the *Vertec* jump method and the *Myotest* device. In that study the authors point out a difference of three to four centimeters between methods. Similarly, Dias et al.[24] found r = 0.98 in their investigations correlating the performance between a flight time calculation device and a video method. Based on individual performance, the present study obtained a lower correlation strength (r = 0.80). In relation to the above studies, this may have been due to the fact that two of the twenty-three athletes included achieved higher values in the laser sensor method.

The reliability interval was tested parallel to the correlation, and the results reported reliable measurements, $p \leq 0.01$, considering differences in the comparison of the methods. These data indicate that the difference found when comparing the tests was high and may point to the influence of factors related to the procedures adopted in each evaluation method, taking into account the movement, equipment, environment, jumping performance possibilities, and limitations. Castagna et al.[25] demonstrated divergences between two methods, the *optojump* and *myotest* system, which use different procedures, indicating an average difference of 7.2% between them, recommending caution when evaluating a capacity using different systems. In contrast Requena et al.[26] tested the validity and reliability of a system based on the Keimove™ system to evaluate jumps using flight time compared to other systems such as the force platform and a high speed camera, using the same procedure based on the flight time of the participant at the time of the jump, and found positive results and that the methods agreed in relation to the vertical jump performance.

The fact that the present study showed differences in the vertical jump measurement verified by different methods, may have occurred due to the procedure that the methods adopted to measure the height of the jump, for example, the vertical jump with laser sensors included no upper limb swing, since at all times the upper limbs remained above the head of the subject without having to touch anything, while in the vertical impulse test, the subject also kept the upper limbs above the head, but was required to touch the wall to leave a mark and use the distal phalanges to touch the highest point reached, indicating that the procedures adopted in the tests differed. Another aspect that can be addressed is the evaluation method used in each condition; while the vertical impulse test calculates the height reached by the difference in the jump, the laser sensors present the measurement of the flight time of the evaluated individual in milliseconds. Therefore we can highlight that the methods did not present the same height reached in relation to the measure of the vertical jump.

However, the correlation of the results indicates that the tests are reliable, since the athletes' results do not change when observed in each test regarding the order of performance. Either of the protocols can be used for evaluation of training programs and training control, bearing in mind that the same procedure should be applied throughout the periodization. Ziv and Lidor[27] pointed out in an observational study that the use of more than one jump evaluation protocol was a limiting factor of studies that sought to test performance in training programs with different methods.

Conclusions

The current study demonstrated that when comparing the two methods of vertical jump evaluation, although the vertical impulse test and laser sensor instrument differed in relation to the measurement of the height of the jump, the positive correlation reinforces that the procedures are reliable to evaluate vertical jump performance of athletes.

Thus, both methods proved to be viable, since they present characteristics that enable effectiveness of vertical jump evaluation for power evaluation. Both can be utilized, provided that there is standardization when

used at different moments, as well as maintenance of the methodology of the vertical jump and the equipment used.

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Conflicts of interest The authors declare no conflicts of interest.

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