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VALIDITY OF TWO ALTERNATIVE SYSTEMS FOR MEASURING VERTICAL JUMP HEIGHT

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ABSTRACT. Leard, J.S., M.A. Cirillo, E. Katsnelson, D.A. Kimiatek, T.W. Miller, K. Trebincevic, and G.C. Garbalosa. Validity of two alternative systems for measuring vertical jump height. *J. Strength Cond. Res. 21(4):1296–1299. 2007.*—Vertical jump height is frequently used by coaches, health care professionals, and strength and conditioning professionals to objectively measure function. The purpose of this study is to determine the concurrent validity of the jump and reach method (Vertec) and the contact mat method (Just Jump) in assessing vertical jump height when compared with the criterion reference 3-camera motion analysis system. Thirty-nine college students, 25 females and 14 males between the ages of 18 and 25 (mean age 20.65 years), were instructed to perform the countermovement jump. Reflective markers were placed at the base of the individual's sacrum for the 3-camera motion analysis system to measure vertical jump height. The subject was then instructed to stand on the Just Jump mat beneath the Vertec and perform the jump. Measurements were recorded from each of the 3 systems simultaneously for each jump. The Pearson r statistic between the video and the jump and reach (Vertec) was 0.906. The Pearson r between the video and contact mat (Just Jump) was 0.967. Both correlations were significant at the 0.01 level. Analysis of variance showed a significant difference among the 3 means $F_{2,235} = 5.51$, $p < 0.05$. The post hoc analysis showed a significant difference between the criterion reference ($M = 0.4369$ m) and the Vertec ($M = 0.3937$ m, $p = 0.005$) but not between the criterion reference and the Just Jump system ($M = 0.4420$ m, $p = 0.972$). The Just Jump method of measuring vertical jump height is a valid measure when compared with the 3-camera system. The Vertec was found to have a high correlation with the criterion reference, but the mean differed significantly. This study indicates that a higher degree of confidence is warranted when comparing Just Jump results with a 3-camera system study.

KEY WORDS. Vertec, Just Jump, vertical leap, countermovement jump

INTRODUCTION

Vertical jump height is a measurement that coaches, health care professionals, and strength and conditioning professionals frequently use (20) as an objective functional measurement. Many coaches consider vertical jump as an essential skill contributing to higher performance in numerous sports, including football, basketball, diving, and volleyball (2, 11). Some authors consider vertical jump performance a measurement of muscular power of the lower extremity (13, 15, 19), whereas others see the vertical jump as a measurable coordinated activity (4, 8, 14, 18). Vertical jump is a frequently assessed athletic skill used to measure improvement of an athlete's capabilities throughout a specific training program (10). Some clinicians are using training techniques to improve vertical jump performance and biomechanics with the purpose of preventing lower extremity injuries (14). Other clinicians have used vertical jump as a functional test to determine the success of different treatment methods or protocols postoperatively (16). Vertical jump height measurement is a simple method that favorably compares with isokinetic testing as a measurement of knee extension power (13).

Many methods and tools are used to measure vertical jump. Aragon-Vargas (1) suggests that a video technique that measures the displacement of the center of gravity of the body from the standing position to the highest vertical displacement be used as the criterion reference, or "gold standard" method, for vertical jump measurement. This method requires expensive motion analysis equipment and the placement of reflective markers on the individual's body that are videotaped during the performance of the activity and then analyzed by a computer. The difference between the initial standing height and the peak height of the marker during the jump is the vertical jump measurement. Although considered to be highly valid, this system is not frequently used because it requires expensive equipment that is difficult to calibrate and transport and also requires trained individuals to accurately operate.

Alternative equipment has been manufactured to make vertical jump height measurement more convenient for testing in the field. Currently, 2 popular field tests to measure vertical jump are (a) jump and reach tests and (b) contact mats. Jump and reach test devices measure vertical jump height by how high a subject reaches to touch an overhead object or wall. One example of this type of measuring device is called the Vertec (Vertec, Sports Imports, Hilliard, OH). This piece of equipment comprises plastic swivel vanes arranged in 0.0127-m increments attached to a telescopic metal pole that can be adjusted to the subjects' standing reach. The test requires the subject to use their hand to displace the vanes with an overhead swinging motion at the peak of their vertical jump. The highest displaced horizontal swivel vane determines the maximum jump height. To calculate vertical jump height, the difference between standing reach measurement and the highest displaced horizontal swivel vane is measured (11).

Contact mat systems use a basic kinematic equation to calculate jump height by flight time (1). An example of this type of device is the Just Jump System (Probotics, Huntsville, AL). The microswitches embedded in the mat (0.6858 by 0.6858 m) time the interval between subject liftoff from the mat and their landing (10). The mat is attached to a hand-held computer that records air time and determines the height of the jump. The system uses

TABLE 1. Descriptive statistics for 3 vertical jump measuring systems.

	3-Camera system	Just Jump	Vertec
Mean	0.4379	0.4417	0.3947
SD	0.0937	0.1029	0.1125
Range (m)	0.2471–0.6495	0.2184–0.6655	0.2032–0.635

the formula: height of body center of gravity = $(t^2 \times g)/8$. In the equation $g = 9.81\ \text{m}\cdot\text{s}^{-2}$ and t is air time (11).

Garcia-Lopez et al. (7) compared several methods of measuring vertical jump using a force plate as the criterion reference. They found differences large enough between each of the systems examined to recommend it necessary to take into account which system is being used when comparing and analyzing vertical jump performance. Isaacs (10) compared the Vertec and the Just Jump system to one another with children ages 7–11 years and found a significant difference between the 2 measuring devices. In reviewing the literature, articles could not be found that tested the concurrent validity of the Vertec or Just Jump system by comparing it with a criterion reference 3-camera motion analysis system (Peak Motion Analysis System, Vicon Peak, Centennial, CO). Therefore, the purpose of this study is to determine the concurrent validity of the jump and reach (Vertec) and the contact mat (Just Jump) systems with the 3-camera system as a criterion reference. We hypothesize that there will not be a difference between the vertical height measurements taken by the criterion reference 3-camera motion analysis system and the jump and reach system or the 3-camera motion analysis system and the contact mat system.

METHODS

Experimental Approach to the Problem

Literature has indicated that studies of vertical jump by the jump and reach and contact mat assessment methods are not comparable. One aim of this study is to compare these 2 methods of measuring vertical jump height to better interpret past research that employed these devices. Another aim of this study is to determine the validity of both methods by comparing them to a criterion reference or gold standard measurement. A methodological study design was used to investigate the validity of 2 methods of measuring vertical jump height (3). The 3-camera motion analysis system served as the criterion reference, the Vertec served as the example of the jump and reach system, and the Just Jump served as the example of the mat system device that measures vertical jump height.

Subject

Forty college students, 26 females and 14 males between the ages of 18 and 25 (mean age 20.65 years), were recruited to participate in this study with the use of a convenience sample. All subjects that had undergone lower extremity surgery in the last 6 months or who currently had a lower extremity injury were excluded from this study. The University of Hartford Human Subjects committee approved the method and purpose of this study. Subjects were instructed to read and sign the informed consent. Subjects wore dark clothing and nonreflective sneakers to avoid erroneous data from the 3-camera motion analysis system.

Procedures

Subjects were educated on how to perform the countermovement jump. This jump requires the individual to begin in an upright posture with their feet shoulder width apart. The subject then moves into a semisquat position while swinging their arms back to prepare for the jump. The arms swing forward above their head as they jump straight up into the air, landing on both feet at the same time (9). Arm swing has been shown to influence vertical jump height (12) and performance biomechanics (5).

The 3-camera motion analysis system was calibrated before data collection to ensure that the 3 measurement tools calculated vertical jump simultaneously. This was achieved by placing a coordinate frame on the ground around the perimeter of the Just Jump and Vertec. This frame contained reflective markers that were used as reference points by the 3-camera motion analysis system. A wand with a reflective marker on each end was then moved throughout the reference frame to calibrate the limits of the test area. The frame was then removed.

The experimental set-up consisted of the Just Jump mat placed on the ground with the Vertec adjacent to it. The vanes of the Vertec were directly above the front portion of the Just Jump mat. A reflective marker was placed at the base of the individual's sacrum with double-sided carpet tape. Each camera of the 3-camera motion analysis system was placed so that they could capture the subject's sacral reflective marker throughout the jump to determine the marker's vertical displacement. The subject was then instructed to stand on the Just Jump mat and perform the countermovement jump. Measurements were recorded from the 3 systems with each jump simultaneously. Two independent jumps were recorded for each subject. Two subjects had only 1 measurement recorded because of a malfunction of the 3-camera motion analysis system during one of their attempts.

Statistical Analyses

A Pearson product moment correlations r statistic was used to quantify the relationship between the video and jump and reach system and the video and contact mat system. One-way analysis of variance (ANOVA) was used to determine whether there was a difference among the measures. Alpha was set at 0.05; least significant difference post hoc comparisons were conducted to determine where these differences occurred. A power analysis was conducted according to the method suggested by Portney and Watkins (17) for the ANOVA to determine whether the design was sufficiently powerful to allow detection of an interaction effect. With an N of 78 and an effect size (f) of 0.21, power was 0.80.

RESULTS

The Pearson r between the 3-camera motion analysis system and the jump and reach (Vertec) was 0.906. The Pearson r between the 3-camera motion analysis system and contact mat (Just Jump) was 0.967. Both correlations were significant at the 0.01 level. ANOVA showed a significant difference among the 3 means $F_{2,235} = 5.51$, $p < 0.05$. The post hoc analysis showed a significant difference between the criterion reference ($M = 0.4369$ m) and the Vertec ($M = 0.3937$ m, $p = 0.005$) but not between the criterion reference and the Just Jump system ($M = 0.4420$ m, $p = 0.972$). Descriptive statistics are found in Table 1.

DISCUSSION

The purpose of this study was to determine the concurrent validity of the jump and reach (Vertec) and the contact mat (Just Jump) systems with the 3-camera system as a criterion reference. The results indicated that both systems were very highly correlated (3) with the 3-camera reference system. Although the correlation was statistically significant, the mean scores among the 3 devices measuring vertical jump height were different. Significant differences were found between the Vertec, but not the Just Jump, system and the 3-camera system.

All 3 devices measure vertical jump height, so it was expected that this study would find a high correlation between measurements with each device. One of the goals for conducting this study was to determine whether vertical height measurement from different devices could be compared. The difference between the mean scores of the 3 devices was taken to determine whether the results of each device could be interchangeable. On the basis of the results of this study, it appears that the Just Jump method of measuring vertical jump height is more accurate than the Vertec when compared with the criterion reference 3-camera motion analysis system. The high correlation and the minimal difference in the means between the Just Jump and the criterion reference 3-camera system strengthens the argument that Just Jump is a more valid test for measuring vertical jump height than the Vertec. Both of these methods are valid tests but the accuracy of the Just Jump would appear to be slightly better on the basis of the results of this study. Comparison of the Just Jump to the 3-camera system results could be made with more confidence than with the Just Jump or 3-camera system results to the Vertec.

Several factors influence the height measurements recorded by each of the systems. The accuracy of the Vertec depends on the ability of the subject to contact the vanes of the device at the peak of the jump. The subject must have sufficient shoulder range of motion and precise timing and coordination of arm swing to insure that the measurement is recorded at the maximum height of the jump. The measurements can be underestimated if the participant does not make contact with the vanes at the peak height of the jump. The Vertec relies on the test administrator to accurately count the number of vanes displaced and accurately determine the starting position of the vanes with the subject reaching overhead before the jump. The Just Jump system does not allow for much human error with accuracy because the system's computer determines vertical jump height. With Just Jump, the subject is only required to perform the countermovement jump with proper technique and land back on the device's mat. The simplicity of the Just Jump test procedures could lead to improved accuracy in the measurement. The literature suggests that vertical jump height might also be influenced if the subject has a visual goal or target to reach during the jump, as they do with the Vertec system (6). Within the design of this study, that influence was not a factor because the Vertec, Just Jump, and 3-camera systems were simultaneously measuring vertical jump height.

The limited subject profile was a limitation to this study. The subjects were an athletic population of college age students, so the variability in vertical jump height might also have been limited. Having subjects with greater variation in age and jump performance would allow a wider range of vertical height measurement to be measured. In addition, only 2 jumps for each subject further decreased the variability of the measurements. The limited difference in vertical jump height might not allow differences in the accuracy of each of the devices to be revealed.

Future research should test different device categories of vertical jump height measurement to better interpret past research with those types of devices. A larger number of subjects with greater variability in their vertical jump height ability would improve the ability to compare the mean of the Just Jump and the criterion reference 3-camera system with a larger population to further determine the confidence of the interchange of measurement results.

PRACTICAL APPLICATIONS

The results of this study indicate that a higher degree of confidence is correct when comparing Just Jump results with those of a 3-camera motion analysis system. Others have recommended that comparisons between vertical jump height measurement devices not be made because of discrepancies between device results (7, 10). The results of this study indicate that comparison between these 2 devices might be appropriate.

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