TOPICS IN EXERCISE SCIENCE AND KINESIOLOGY

Expedited Article

Agreement of a Novel Vertical Jump System to Measure Vertical Jump Height: Brower Vertical Jump and Vertec Vertical Jump Systems

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ABSTRACT

Topics in Exercise Science and Kinesiology Volume 2: Issue 1, Article 12, 2021. Validity refers to the ability of a device to measure what it was intended to measure. Therefore, purpose of this study was to assess the validity and reliability of a novel vertical jump height tool designed by Brower Timing Systems (Salt Lake City, Ut). The Brower vertical jump system was compared to the Vertec jump tester. A convenience sample (n=67) of college students performed three maximum countermovement jumps, with the average score being recorded. Data was collected simultaneously for both devices. Results showed a strong and statistically significant correlation between the Vertec vertical jump tester and Brower vertical jump ($r = 0.971$, $p < 0.001$.) A paired t-test showed no significant difference ($p = 0.170$, $t = 1.386$) between the two systems. An analysis of equivalence was also performed with alpha set at 0.05 and an upper and lower bound set at +/- 0.5. The observed effect was statistically not different from zero and statistically equivalent to zero. Based on the statistical analysis, it can be concluded the Vertec and Brower vertical jump height systems have a high correlation and are equivalent. The Brower system can be an option for assessing vertical jump height, specifically, the Brower system may be useful for high throughput field environments such as testing teams or larger groups to provide valid data.

KEY WORDS: Muscular power, high throughput, field test

INTRODUCTION

Vertical jump height is frequently used to obtain an estimate of lower body muscular power. Lower body muscular power data can be used as an index to set benchmarks for athletes, to assess training effectiveness, and to manipulate training to enhance performance (5, 12, 15). Applications for vertical jump height range from athletes, law enforcement and military, to non-athletic populations including rehabilitation (6, 14). The vertical jump height assessment is often considered a mainstay data point for talent identification, pre/post assessment, and is even used in clinical outcomes in rehabilitation (6, 14). Given the importance of muscular power in performance and clinical populations, valid vertical jump height tools are needed to provide sport scientists, coaches, strength and conditioning coaches, and clinicians effective data points (3, 9, 10). In environments where teams and large groups of participants need to be assessed, the vertical jump height tool plays an important role in data collection and efficiency on data

throughput. The ability to quickly and accurately assess a large range of participants enhances the opportunity to use data capturing, analysis, and implementation for individual and group training modification.

Validation studies have been previously performed on several different vertical jump height assessment tools (2, 9, 13). In general, the criterion measure of vertical jump height is a force plate with motion capture analysis, but that technology is costly and time consuming and is not practical in many sport and gym settings. In the case of most field-testing applications, access to force plates and motion capture is unavailable. There is also a high cost and a significant time commitment required for consistent and repeated data collection. Field testing in vertical jump height assessment tends to rely on jump and reach or flight time testing instruments, one of the most common vertical jump tools is the Vertec (Vertec, Sports Imports, Hilliard, OH). The Vertec is a quick and cheap alternative to force plate and motion capture instrumentation for measuring vertical jump. The Vertec (Figure 1) contains plastic swivel slats arranged in 0.5-inch increments which are attached to a telescopic metal pole that can be adjusted to the participants' standing reach. The test requires the participant to use their hand to displace the slats with an overhead swinging motion at the peak of their vertical jump attempt. The highest displaced horizontal swivel slat determines the maximum jump height. To calculate vertical jump height, the difference between standing reach measurement and the highest displaced horizontal swivel slat is measured.

The Brower timing (Brower Timing Systems, Salt Lake City, UT) tool uses a series of lasers that are assembled vertically in an aluminum casing 0.2 inches apart and 48 inches in height. The device is powered by three AA batteries and is used to assess vertical jump height (Figure 1). The device is simple to set up, has a setting which enables quick throughput of participants, and provides immediate data results on vertical jump height. Anecdotally our laboratory has been able to test teams of between 30-50 athletes in about 15 minutes with each athlete completing a three-jump average. This dramatically lowers the barriers of data collection and implementation for coaches, athletes, strength and conditioning coaches, and sport scientists. To date, the validity of the Brower has not been assessed, therefore, we sought to examine the validity of the Brower in comparison to an established vertical jump system, the Vertec.

The Vertec has previously been subject to Pearson r correlation and has demonstrated strong relationships with the laboratory force plate and laboratory force plate with motion capture analysis (2, 6, 8). The correlation by Buckthorpe et al. (3) was found to be 0.91, while the correlation for Leard et al. (9) was 0.906, and the correlation by Hutchinson and Stone was 0.91. A study by Whitmer et al. (16) examined the difference between the Vertec and vertical jump mat. They found no significant difference between the Vertec and vertical jump mat. However, some have reported lower jump heights compared to the force plate (3) laboratory force plate with motion capture analysis (9), and vertical jump mat (7). Although the Vertec has been reported to underreport jump height, it is still used for measuring vertical jump height in field analysis. When comparing jump and reach, flight time, and force plate systems, there appears

to be inherent differences between systems, further research is needed to potentially standardize said discrepancies.

Jump and reach tests are used frequently in field testing settings. The Vertec has previously been evaluated and is considered a good measurement tool for vertical jump height assessment. Reviewing the literature, to date no one has evaluated the Brower. The purpose of this study is to assess the validity and reliability of a novel vertical jump height tool designed by Brower Timing Systems. Our hypothesis is that there will be a high correlation between the Vertec and Brower, and no statistical difference between the measured vertical jump height, indicating that the Brower vertical jump is a valid system for measuring vertical jump height.

METHODS

Experimental Approach to the Problem

The experimental set-up consisted of the Vertec and Brower mounted in parallel (Figure 1), both instruments were adjusted for the participant, and a standing reach height was taken for both devices simultaneously. A countermovement jump was used as the mode of obtaining vertical jump height. This jump requires the individual to begin in an upright posture with their feet shoulder-width apart. The subject then moves into a semi-squat 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 (3, 9). The subject was instructed to stand in a taped-off area on the floor which aligned the participant to trigger the laser system from the Brower device while simultaneously hitting the height vanes on the Vertec. Three independent countermovement jumps were performed by each subject with the average of the three jumps used for analysis. Three participants had only 1 measurement recorded because error from one of the systems during one of their attempts and those participants' data was removed from this analysis (n=67). During the data collection, there was similar cueing by study administrators providing the same feedback to every participant before, during, and after each of the three countermovement jumps. After the third vertical jump height was collected the participant received a copy of his/her vertical jump height.

Subjects

Fifty-one males and nineteen females (n = 70; mean age = 22.8 +/- 5.7 years; mean height = 69.9 +/- 3.5 inches; mean body mass = 174.5 +/- 35.8 pounds) students from the Salt Lake Community College were recruited to participate. All participants were provided with a description of the study and signed an informed consent prior participation in the study. The institutional review board for the protection of human subjects approved this study.

Procedures

The participants reported for one test session, informed consent, height, weight, exercise status, and three maximal countermovement jumps were collected. Each participant received instruction on how to perform a countermovement jump and was able to practice while being coached by investigators three to five times. Each participant then was able to watch at least one

full demonstration of the vertical jump height calibration, set-up, and completion of the vertical jump height assessment protocol.

Figure 1. left picture is an example of a Vertec Vertical jump device, middle picture is an example of how the data collection was set, right is an example of a Brower Vertical Jump device.

Statistical Analyses

A Pearson product moment correlations r statistic was used to evaluate the relationship between Vertec and Brower vertical jump systems. A paired t-test was used to determine whether there was a difference between the measures. Alpha was set at 0.05. for all statistical significance testing. Equivalence testing was also performed, using the two one-sided tests (TOST) procedure. The TOST allows testing for absence of effect, to determine if the true effect is close enough to zero to claim equivalence (8). A correlation was also run between the two highest jumps performed by each participant. A t-test was then used to assess whether the two highest measured jumps were similar. Finally, Bland-Altman plot was created to illustrate the bias and limits of agreement (1).

RESULTS

The results (Table 1) showed a statistically significant correlation ($p < 0.001$) for the Pearson r moment correlation (Figure 2). There was a strong correlation ($r = 0.971$) between the Vertec and Brower vertical jump height values. The coefficient of determination (r^2) was strong at 97%. A paired t-test found no significant difference ($t = 1.386$, $p = 0.170$) between the Vertec and Brower systems. Equivalence testing (Figure 3) was carried out using the "two one-sided tests" (TOST) approach, with alpha set at 0.05 and an upper and lower bound set at +/-0.5. The observed effect was statistically not different from zero and statistically equivalent to zero. Mean and standard deviation estimates from the dataset were used to carry out the TOST analysis. Vertical jump height values were found to be equivalent over the tests ($q < 0.05$, false discovery rate

correction). Vertical jump height value estimates obtained using the two measurement devices were statistically equivalent (TOST P = 0.0031). Visual inspection of the Bland-Altman plots revealed a bias of 0.17 cm with limits of agreement between -1.79 cm and 2.13 cm (Figure 4). In addition, four subjects had data points that reside outside the upper and lower limits of agreement. A Pearson correlation analysis was conducted between the two highest jump scores. The result of the correlation coefficient, 0.97, was significant at p<0.001. A two-tailed paired samples t-test was conducted to determine whether the difference in the two jumps were similar. The results of the t-test were significant as seen in Table 2.

Table 1. Summary Table Validation of Brower Vertical Jump.

Data	**Vertec**	**Brower**
Mean (cm)	20.60	20.54
SD (cm)	4.02	4.27
SE	0.49	0.54
Paired t-test	1.386	
p-value	0.1703	
Pearson's product-moment Correlation		
t	32.44	
df	64	
95% CI	0.9527	0.9821
r	0.970	
p-value	< 2.2e-16*	
TOST	**p-value**	**0.0031***

**is statistically significant*

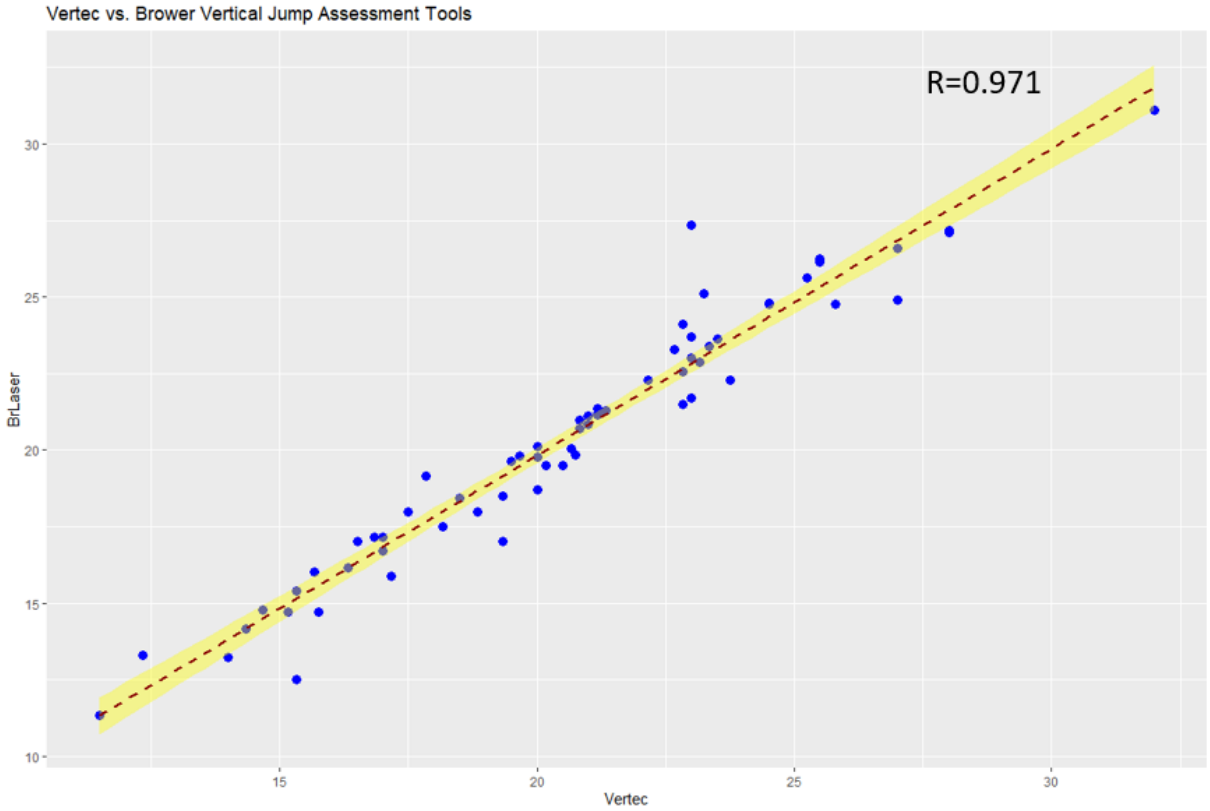

Figure 2. Pearson product correlation between Vertec and Brower vertical jump devices.

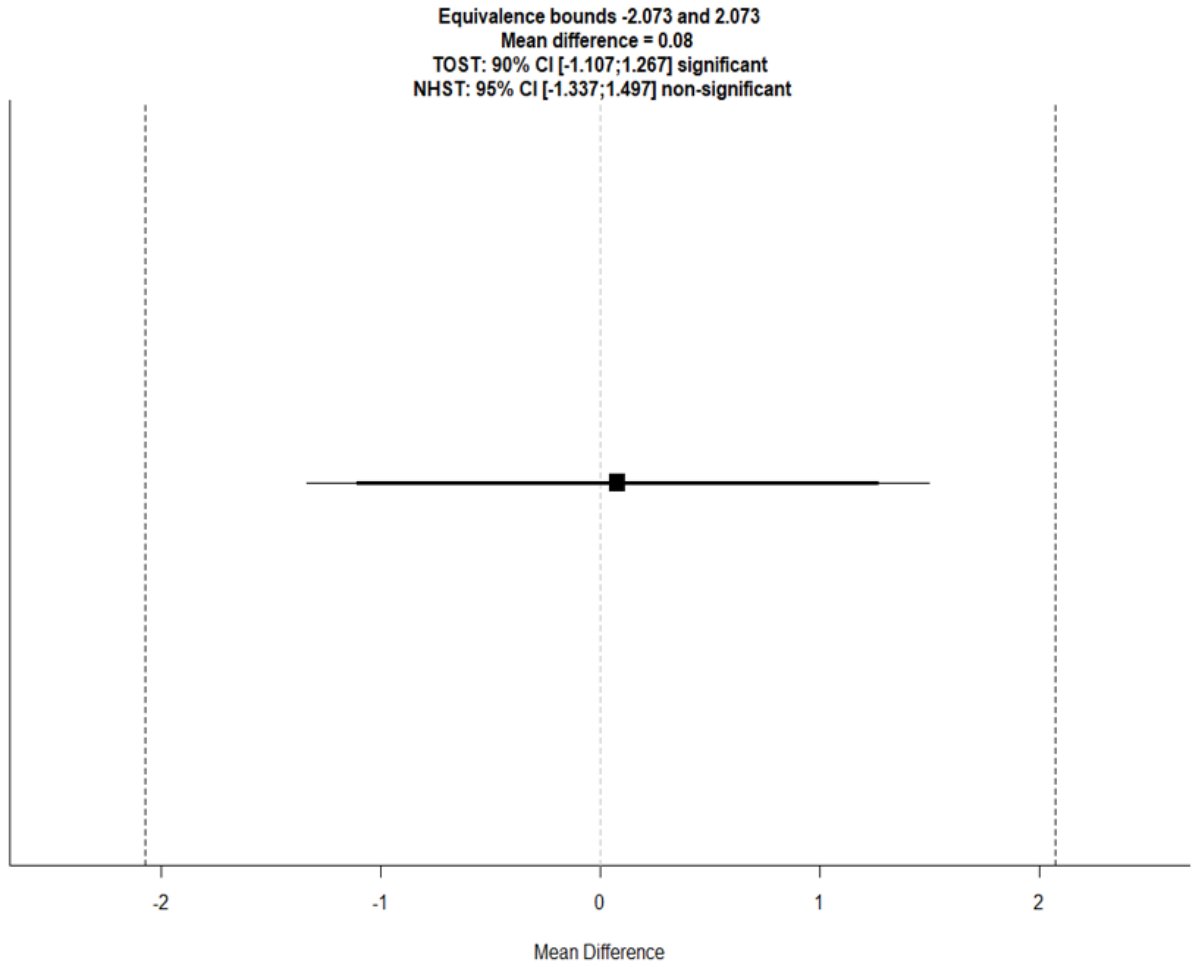

Figure 3. TOST Equivalence test showing the mean difference and equivalence to zero.

Table 2. Two-Tailed Paired Samples t-Test for the Difference Between the two highest scores.

Score 1		Score 2				
M	SD	M	SD	t	p	d
20.64	4.25	21.10	4.36	-3.35	.001	0.42

Note. N = 63. Degrees of Freedom for the t-statistic = 62. d represents Cohen's d.

DISCUSSION

For strength and conditioning coaches, clinicians, and researchers it is important to conduct physical assessments with tools that are valid, meaning they measure what they are intended to measure**.** The aim of this study was to validate the Brower vertical jump system with the Vertec vertical jump system. Both devices measure vertical jump, and it was expected that there would be a strong and significant correlation between the two**,** which the authors hypothesized no significant difference in vertical jump measured between the two devices. The comparison of the two jump and reach tools from this data collection and statistical analysis of Pearson's product, t-test, and equivalence testing is highly correlated, are not significantly different, and are considered the same which support the authors hypothesis.

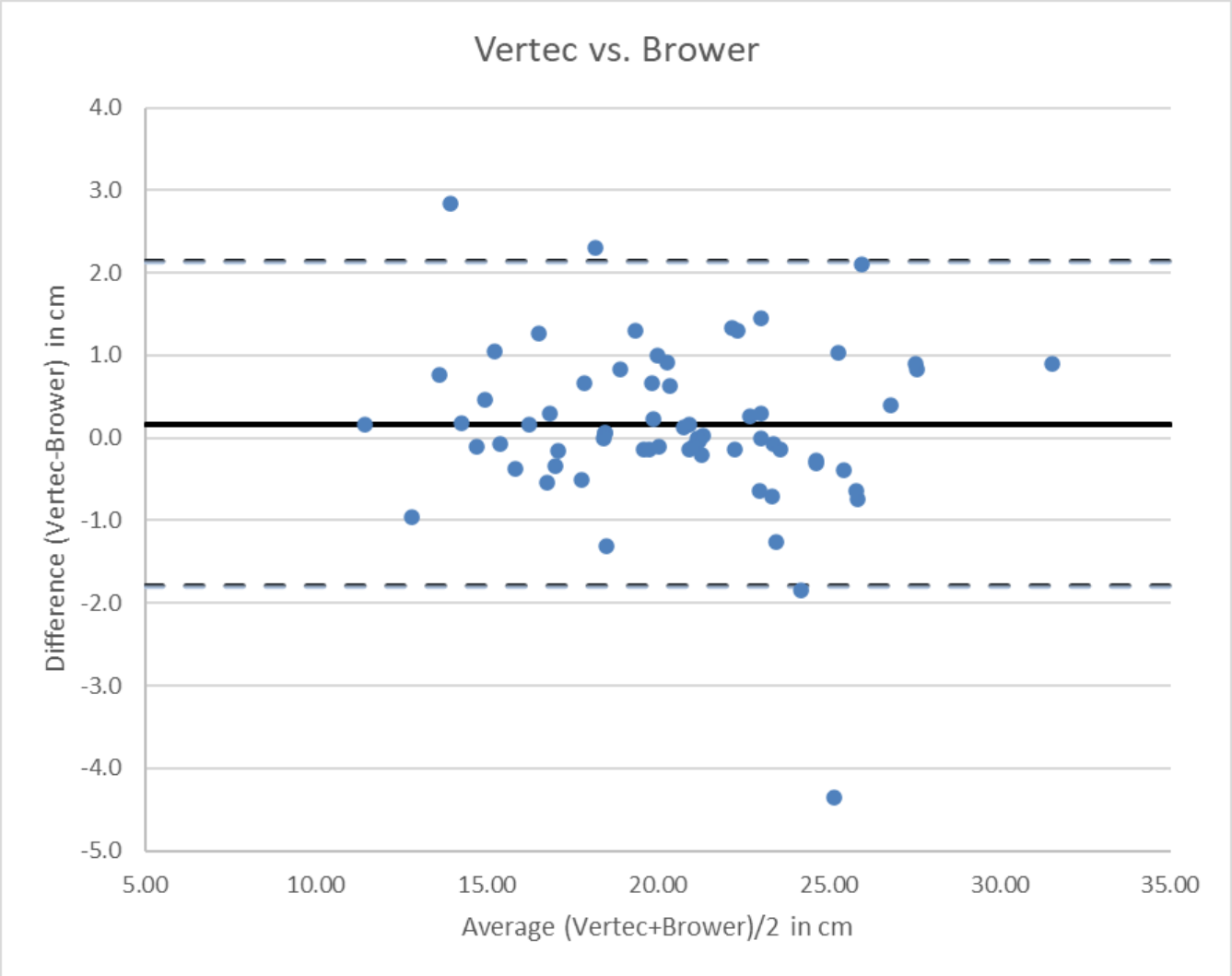

Figure 4. Bland-Altman plot illustrating the bias, upper limits of agreement, and lower limits of agreement between the Vertec and Brower vertical jump tools. Dashed lines represent the upper and lower limits of agreement while the solid line represents the bias.

While the results of this study demonstrate no significant differences between the Vertec and Brower systems, others have reported the Vertec is less accurate than other methods of measuring vertical jump (3, 7, 9) and that a constant device should be used rather than interchanging between different devices (11, 18). Buckthorpe et al. found the Vertec significantly under reported vertical jump when compared to a force plate which served as the criterion measure (3). That study used a group of forty participants that performed countermovement jumps in a counterbalanced order among a belt mat, contact mat, portable force plate, Vertec, and a laboratory force plate which served as the criterion measure. The Vertec measured -2.4 ± 6.6 cm which was considered significantly different from the laboratory force plate. They concluded that the portable force plate and belt mat were valid tools for measuring vertical jump height. In a group of 39 college students, Leard et al. (9) found that the Vertec had a significantly high correlation (r=0.906) with video analysis but significantly under reported vertical jump height. Hutchinson and Stone (7) also reported a significant relationship and a significantly

lower vertical jump as reported by the Vertec in a group of active undergraduate students. Leard et al. suggest a lower measurement of jump height occurs due to "miss-time" when attempting to swat the vanes, meaning they strike the vanes after peak height has been achieved and the participant is on their way down (9). This same phenomenon was confirmed by Hutchinson and Stone in a group of regularly active undergraduate students (7). For this study, the Brower laser system was mounted next to the Vertec so both jump heights could be measured simultaneously. With this set up we found no significant difference between the two measures. It is possible that the miss-time event did not occur in our population. It is also possible that both measures were accurate, and the Brower system is a valid tool for measuring vertical jump height. To determine this, we suggest the Brower be tested against video analysis systems and force plates. This would determine if a miss time even does occur and provide validation against video analysis.

The current study also examined within session reliability. The results of this data demonstrate a high correlation between the two highest measures obtained. However, the data also showed a significant difference between the two highest jumps. We suspect this is the result of a learning curve, meaning the more jumps a participant performed the better the scores. It is possible there were not enough practice and trial sessions to assess reliability well.

Overhead goal (4) has been reported as a potential motivator for participants in reaching a maximal vertical height. Ford et al. (4) suggest that an overhead goal results in increased vertical jump due to altered lower extremity biomechanics. Although we did not measure lower extremity biomechanics, we did utilize an overhead goal. The Vertec has an overhead goal built into the device organically, where the Brower device does not. Anecdotally our lab placed an overhead goal (small stuffed animal) on the top of the Brower device and participants reported it more motivating when performing the vertical jump. Future research and validation of the overhead goal and enhanced vertical height should be assessed.

The high throughput capacity from the Brower system may be advantageous and pragmatic to coaches, strength and conditioning coaches, sports scientists, and clinicians that regularly and consistently collect large amounts of vertical jump height data. The Brower system calculates vertical height and averages if desired, it also requires minimal between participant set-up. These factors should minimize potential errors of data collection. The potential cons of the Brower device may be technology, battery-powered, and novelty in this industry is sometimes not looked on favorably. The Vertec and Brower devices can be essentially used interchangeably, which may serve to enhance data transfer from teams, labs, or clinics.

Potential limitations for this study may be the unequal number of men and women that were recruited. Previous reports show differences in sex and vertical jump performance (18). This current study did not evaluate intersession reliability between testing sessions. The potential sex difference should be explored. It is suggested the difference is mainly due to learning effects or a higher level of coordination and motor patterns with the countermovement jump. Validity and reliability of the Vertec and Brower systems should be performed and compared again to other tools such as video analysis for the vertical jump height.

Additional work to overcome some of the current reported issues between vertical jump height analysis tools should be pursued. Like Moir's work on presenting three different methods of calculating vertical jump height (10, 15) potential regression analysis could be applied to bridge the gap between different systems for field application and training/coaching implementation.

There are several instruments used to assess vertical jump, an obstacle of collecting any performance measure is the cost and time associated with data collection. Computation and implementation time for performance data can often dictate the frequency of analysis for performance tracking and training modifications. The ability to quickly and accurately assess several athletes decreases resistance for data collection and may provide more opportunities to collect performance measures to more often guide training needs.

The Brower Vertical Laser device is a novel tool that can test many athletes in a short amount of time. This current study has successfully validated the Brower vertical jump tool with the Vertec jump system. The Brower device can be added to the array of vertical jump height tools that provide an estimate of lower body muscular power. Based upon our findings, strength and conditioning coaches and researchers can use the Brower vertical jump system and obtain similar results as the Vertec vertical jump system.

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PURPOSE

The purpose of this study is to assess the validity and reliability of a novel vertical jump height tool designed by Brower Timing Systems.

KEY FINDINGS

- There is no difference in vertical jump as measured by the Vertec and Brower laser system.
- A strong relationship was found between the Vertec and Browser laser system.
- A strong relationship was found between the two highest vertical jumps for each participant.
- The within session reliability saw statistically significant differences between the two highest jumps for each participant.

RATIONALE

Vertical jump is used to measure lower body power by assessing the height jumped. Traditionally, a Vertec has been used for the measurement. Newer types of devices such as motion capture labs and vertical jump maps have also been used to measure vertical jump. A novel device from Brower uses lasers to measure vertical jump. To determine if it is accurate it was tested against the commonly used Vertec device.

THE STUDY

Fifty-one males and nineteen females (n = 70; mean age = 22.8 +/- 5.7 years; mean height = 69.9 +/- 3.5 inches; mean body mass = 174.5 +/- 35.8 pounds) students from the Salt Lake Community College were recruited to participate. Testing was conducted during a single visit to the testing site. A Brower system was mounted to a basketball backboard with a Vertec nearby. The participant performed three jumps hitting the swivels of the Vertec while simultaneously being measured by the Brower. The highest jump recorded for each participant was used for analysis. Furthermore, we examined if the two highest jumps were significantly different.