Validation of the VERT wearable jump monitor device in elite youth volleyball players

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ABSTRACT: This technical report aims to determine the validity and the accuracy of the VERT Wearable Jump Monitor. The participants of this study were all experienced volleyball players from the U18 category from the Brazilian National team. To assess jump performance, the VERT scores were compared to the VERTEC (jump and reach device). Each athlete performed 3 attack and 3 block jumps in a random, counterbalanced order, and the average score was registered. In the attack jumps, the VERTEC and VERT mean ± SD scores were 70.9±8.2 and 76.3±7.5 cm, respectively, and the typical error of the estimate (TEE) as a coefficient of variation (CV) was 7.8% (90% CL 7.0 to 8.9%). VERTEC and VERT devices presented a *very large* Pearson's correlation for attack jumps (r=0.75; 90% CL 0.68 to 0.81). In addition, the mean±SD block jumps were 53.7±6.1 and 58.5±5.7 cm for the VERTEC and VERT, respectively and the TEE as a CV was 7.9% (90% CL 7.1 to 8.9%). Pearson's correlation coefficient was *very large* for block jumps (r=0.75; 90% CL 0.67 to 0.81). The VERT device was found to be a very practical tool to quantify jump performance in volleyball players.

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INTRODUCTION

Volleyball matches require players to perform short bursts of running, positioning, jumping, and blocking [1]. In addition, the match develops around a net of 243 and 224 cm high for men and women, respectively [2]. As a result, jumping ability plays a key role in volleyball and, therefore, the training of this physical attribute must receive attention from coaching staff [2,3]. In fact, professional volleyball players jump approximately 60 jumps per hour, whereas female players perform 78 jumps on average, after introduction of the new rally rule [4,5]. As the training process helps athletes to achieve sport-specific adaptations that lead to competitive success [6], coaches and sport scientists need to accurately quantify training-related variables in order to objectively monitor how athletes adapt and respond to training [7,8]. As such, systematic assessment of training loads, fitness, and fatigue guides those professionals involved with athletes to detect beneficial changes in those variables and physical performance [9,10]. Therefore, it is imperative that every tool used during the training process is valid and accurate [11].

Volleyball players usually train on court, with several athletes training at the same time, which can often make it difficult to take all squad members to laboratories for routine assessment. Moreover, testing athletes using traditional tests and recording the results on paper sheets, one athlete at a time, requires time and dedicated staff to compile and present the data to the coaching staff. Furthermore, the assessment and validation of standard vertical jumping tests have been extensively performed [12-14] and may also present a time-consuming method for volleyball player assessment. For example, using motion-capture methods may provide accurate outcomes and be considered as the gold standard, but this method is time consuming and requires technical expertise and complex camera set up, as well as high equipment costs [15]. Instead, the use of valid, simple, low cost tools, such as the VERTEC (which is basically a ruler), is appealing once it overcomes most of the shortcomings of motion capture [16]. Unfortunately, however, the VERTEC requires a specific set up that only permits its use during certain training sessions.

The use of wearable microtechnology is appealing as a way that coaching staff could monitor the athletes in real time during both training and official matches when athletes perform specific jump ability. This would provide important information on the external load performed by the athletes and help in the interpretation of the dynamics of the internal training loads. The VERT system has been investigated using 3- to 12-year old children in unspecific tasks [17] and junior elite athletes performing volleyball tasks [15]. However, highly specific tasks of volleyball, such as attack and block jumps, have yet to be examined. Therefore, this study aimed to determine the concurrent validity and the accuracy of the VERT Wearable Jump Monitor compared to a standard wall ruler (VERTEC) for measuring attack and block jump performance [2]. It was hypothesized that the VERT Wearable Jump Monitor would have an acceptable measurement error, which allows its use during training and competition.

MATERIALS AND METHODS

Study design

This study compared, in a random, counterbalanced design, the jump height scores presented by the VERT Wearable Jump Monitor (VERT Wearable Jump Monitor, USA) (VERT) and a device called VERTEC (VERTEC – Sports Imports, USA). Swivel vanes are attached to a metal pole and measure jump height. The specific block jump (BJ) and attack jump (AJ) in experienced volleyball players from the U18 category from the Brazilian National team were used for measurements. All the athletes were participating in a tournament trial for national team representation (n = 128, age 17.8±1.1 years, body mass 81.9±12.2 kg, and stature 191.1±8.3 cm). After a thorough outlier search (see statistical procedures section), the final data analysis was done on the scores of 112 athletes. The procedures, risks, and benefits of this study were cleared before the beginning of the study. All procedures were cleared by local ethics committee and informed consent was signed by all participants and their parents or legal representatives.

Testing procedures

All the testing was conducted on the same standard, ventilated volleyball court, with temperature ranging from 22 to 24°C in the morning (between 9:00 and 11:00 am) during 3 consecutive days. Athletes were randomly assigned to 1 of the 40 athletes' group and instructed to refrain from heavy exercise the day before testing and to be well hydrated. After arriving at the court, each athlete had their stature and body mass measured and registered. A wooden stadiometer with 0.1 cm and a calibrated scale with 0.1 kg precision were used. Before testing, a 6-minute warm-up on a stationary bicycle and a light hamstring stretch were done. Each athlete performed 3 trials in a random, counterbalanced order, and the average score was registered. Athletes performed all jumps wearing the VERT and using the VERTEC at the same time. The interval between trials was defined to be from 3 to 5 minutes. These procedures have been applied elsewhere [2].

The VERT device was placed at the iliac crest height, close to the upper edge of the sacrum, and was kept fixed with a firm band. Under the VERTEC, the athletes extended both arms and reached as high as possible, with heels touching the floor. The highest achievement during jumping actions was then subtracted from standing height in the VERTEC and registered as a score for jumping performance.

Attack jump (AJ) and block jump (BJ)

Jump performance was assessed by a specific volleyball jump, in order to verify equipment validity and accuracy under the specific conditions players face on a daily basis. Therefore, the athletes performed the attack jump (AJ) and the block jump (BJ). In the AJ, the athlete uses a 2–3 step approach and performs a half-drop jump followed by a countermovement arm swing and an eccentric action. Finally, this maximal vertical jump is linked to a strong backward arm swing. On the other hand, to perform the BJ, the player starts from a stable position, with slightly bent knees, jumping as quickly as possible, with hands in front of the chest [2].

Statistical analyses

Data were log-transformed to reduce non-uniform error and back-transformed and presented as mean ±SD unless otherwise stated.

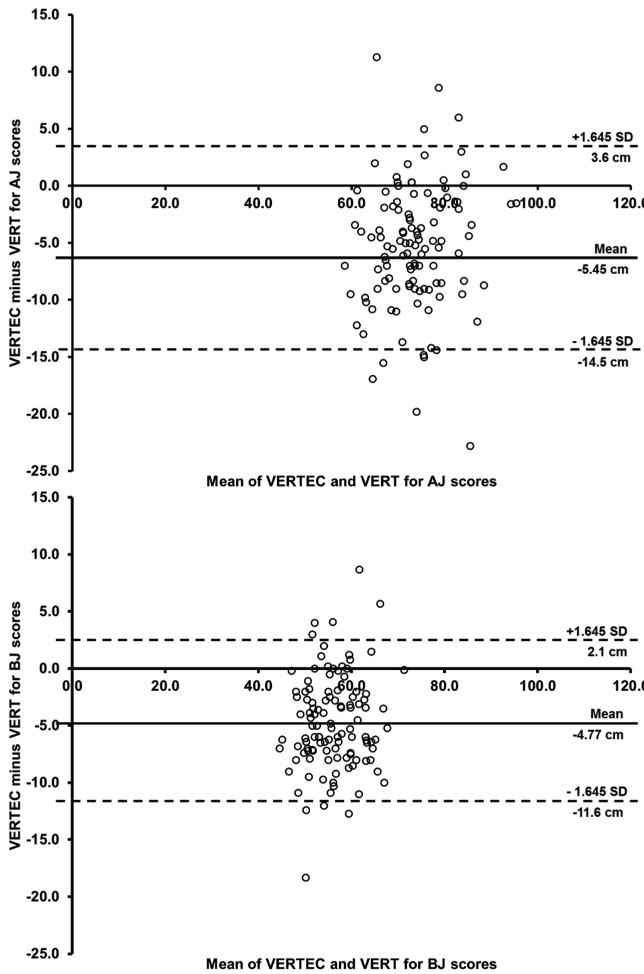

FIG 1. Bland and Altman plot (n = 112) of: A (upper panel) VERTEC and VERT jump height performance for the attack jump (AJ). Mean 90% confidence interval from -5.38 cm to -5.51 cm; SD = 5.47 and; B (lower panel) VERTEC and VERT jump height performance for the block jump (BJ). Mean 90% confidence interval from -4.72 cm to -4.82 cm; SD = 4.14.

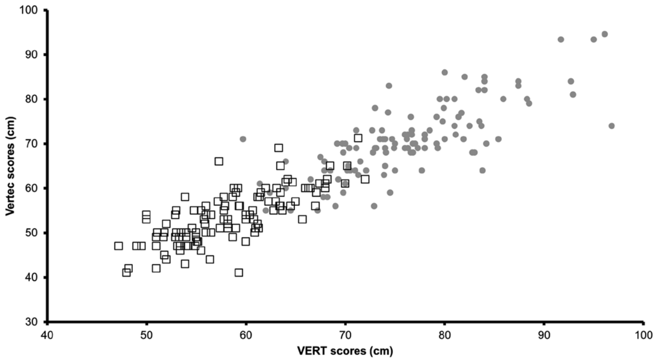

FIG 2. Relationship between the VERT and the VERTEC scores for the attack (grey filled circles) and block (open black squares) jumps.

Outliers were considered to be 1.5 times the interquartile range of the difference between criterion (ruler) and practical (VERT) devices. The concurrent validity was determined by linear regression, using a bespoke spreadsheet (Microsoft Excel, USA) [18]. Calculations compared the scores registered for the criterion and practical devices. Bland and Altman statistics were calculated in order to detect systematic bias ± random error into the sample [19]. Typical error of the estimate (TEE) was presented as a coefficient of variation (%) and raw (cm) units. The magnitude of the standardized TEE was interpreted as <0.2 – *trivial*, 0.2-0.6 – *small*; >0.6-1.2 – *moderate*; >1.2-2.0 – *large*; >2.0 – *very large*. Pearson's correlation coefficient was calculated between criterion and practical variables, and the magnitude of effects was evaluated according to Hopkins [20]. The 90% confidence limits (90% CL) were calculated for all these measures. The smallest worthwhile change was calculated as 0.2 times the between-subjects standard deviation [11].

RESULTS

In the attack jump performance, the VERTEC and the VERT mean ±SD scores were 70.9 ±8.2 and 76.3 ±7.5 cm, respectively. Typical error of the estimate (TEE) as a coefficient of variation (CV) was 7.8% (90% CL 7.0 to 8.9%). The VERTEC and VERT devices presented a *very large* correlation (r=0.75; 90% CL 0.68 to 0.81). The raw TEE was 5.3 cm (90% CL 4.8 to 6.0 cm), whereas the standardized TEE presented a *moderate* ES for both raw (0.65) and CV (0.66) calculations. The smallest worthwhile change in the attack jump for the VERT was 6.8 cm (9.9%). The mean ±SD block jump performances were 53.7±6.1 and 58.5±5.7 cm for the VERTEC and the VERT, respectively. TEE as a CV was 7.9% (90% CL 7.1 to 8.9 %). Pearson's correlation coefficient was *very large* – r=0.75 (90% CL 0.67 to 0.81), whilst raw TEE was 4.0 cm (90% CL 3.6 to 4.5 cm. Standardized TEE was *moderate* for both raw (0.67) and CV (0.66). The smallest worthwhile change in block jump performance for the VERT was 5.1 cm (9.9%).

Figure 1 shows systematic bias between the scores for the VERTEC and the VERT for attack jump performance (-5.45 ± 5.47 cm, 90% CL -5.38 to -5.51 cm) (Figure 1A) and block jump performance (-4.47 ± 4.14 cm, 90% CL -4.72 to -4.82 cm) (Figure 1B).

Figure 2 presents the relationship between both systems (VERTEC and VERT) for the AJ and BJ.

DISCUSSION

Jumping ability for volleyball players highlights physical performance status [2]. Therefore, the accurate quantification of this ability may be useful for both training and competition. Whilst laboratory-based tests may present limitations, wearable technology seems appealing to be used in the field. Moreover, the implementation of specific tests evaluates players performing their actual routines, instead of simulated ones [11,13,14]. The main findings of this study were that the VERT presented an acceptable CV for both the AJ (7.8%) and BJ (7.9%), with a *moderate* TEE for both AJ and BJ performance. The correlations between the criterion and practical variables were *very large* for both AJ and BJ. The VERT systematically overestimated the scores of both AJ and BJ performance, compared to the ruler. This is the first study to test the VERT for validity and accuracy in elite youth volleyball players.

The scores measured with the VERT overestimated the criterion variable in ~7.1% (AJ) and ~8.2% (BJ) (Figure 1). The VERT device was placed at the iliac crest height, close to the upper edge of the sacrum, and was kept fixed with a firm band. Both jumps require the athletes to flex their knees, just before they execute the actual jump. It appears that the VERT triggers the algorithm that calculates displacement when the athlete flexed their knees, positioning the VERT lower than when the athlete was standing. On the other hand, the ruler was at a fixed location and the athletes aimed to reach its highest position. The linear regression analysis showed that the VERT consistently overestimated the scores from the ruler, with a CV of 7.8% and 7.9% for the AJ and BJ, respectively, with a *moderate* TEE. Such results were confirmed by systematic bias for the AJ and BJ (figure 1A and 1B, respectively). These variations are possibly due to variations in jumping technique. Even though the performance registered by the VERT overestimated the criterion scores, there was a *very large* correlation for both AJ and BJ performances. Such a relationship increases the confidence in using the device to quantify jump performance in training and competition.

When comparing the 2 jump techniques, the AJ performance presented higher scores, compared to BJ performance, probably due to biomechanical aspects of the jump. For instance, to execute the AJ, the athlete increases velocity before jumping, with subsequent better jumping performance. In this study, the BJ performance was 23.3% lower than AJ. The jump performance for current sample was superior than the results of Sattler and colleagues [2]. In their study, the AJ and BJ performances were approximately 62.8 and 48.6 cm, respectively, while the scores measured by the criterion (ruler) and the practical (VERT) devices in this study were 70.9 and 53.7 cm and 76.3 and 58.5 cm, respectively. Moreover, the BJ performance in the present study was 23.3% smaller than AJ. Sattler et al. [2] found a 22.0% difference. These results suggest that high-level volleyball players consistently present similar differences between AJ and BJ performances.

A limitation of this study was that care should be taken in the generalization of these results. The athletes who performed the jumps in this study were of a high competitive level, which implies that they were experts in performing such jumps.

CONCLUSIONS

The VERT device was demonstrated to be a very practical tool to assess jump performance. Not only does it provide real-time information to coaches, via wireless communication, but it also can record the data for further analysis. It is a valid and accurate tool to quantify the volleyball attack and block jump performances in the field, with acceptable validity and accuracy for use during training and competition.

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