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# Validity of an Electronic Based System (*Training Tester*™) to Measure Vertical Jump Performance

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**Abstract** The aim of this study was to determine the validity of an electronic based system (*Training Tester*™) to measure vertical jump performance. As reference criterion a force plate was used. Fifteen male elite junior team handball players performed, after a standardized warm-up program, five counter movement jumps. The result of the best trial was used for further data analysis. Vertical jump performance was assessed simultaneously with *Training Tester*™ and force plate. Subjects achieved significantly ($t$ = 19.195, $p$ < .001) greater jump heights with the *Training Tester*™ (13.29 ± 2.68 cm). Pearson correlation coefficient between both measurement methods was high ($r$ = .922, $p$ < .001). Consequently, criterion-related validity of the *Training Tester*™ could be demonstrated. In conclusion, this electronic measurement system provides a portable, cost-effective and time-saving tool to evaluate vertical jump performance and can be seen as well-proven alternative for testing in field situations.

**Keywords** Counter Movement Jump, Field Test, Jump Measurement System, Jump Test

## 1. Introduction

The ability to jump as high as possible is crucial in many sports[3, 6, 9, 18]. Hence, the vertical jump performance of an athlete has been measured for several purposes in field and laboratory settings[7, 14, 19, 22]. For this a lot of different methods and tools can be used[9,18]. These include force plates[13, 25], jump and reach devices like Vertec™ [4,17] and Yardstick™[15,21], switch mats[5,24], and video analysis[1,12].

Force plates and video analysis are accepted as gold standards to assess vertical jump performance[9,10,11]. However, these methods are expensive and inappropriate for field situations[3,6,18]. In contrast, jump and reach devices are easy and convenient to use, so that they are especially popular among athletes and coaches[6]. Nevertheless, conventional jump and reach devices have some disadvantages. For instance, they are based on vanes and it is necessary to adjust them after every jump. Moreover, the test result must be calculated manually. A new innovative jump and reach device is the *Training Tester*™ (BZ Hi-Tech S.r.l., San Martino di Venezze, RO, Italy) which is shown in Figure 1. The *Training Tester*™ is an electronic device based on optical sensors equipped with infrared technology and displays maximal reach height in real time with intervals of 1 cm in a range between 211 cm and 389 cm. This electronic based system allows immediate jump tests and could be an alternative to classical jump and reach devices like Vertec™ and Yardstick™.

**Figure 1.** Jump measurement system *Training Tester*™

However, the validity of the *Training Tester*™ to measure vertical jump performance has not been examined to our knowledge. Before using the *Training Tester*™ in practice, the criterion-related validity should be demonstrated.

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Criterion-related validity is based on the comparison between a new method and a recognized gold standard, which is called the criterion measure[16,20]. The aim of this study was to assess the criterion validity of the *Training Tester*™ to measure vertical jump performance by comparing the *Training Tester*™ with the gold standard force plate.

# 2. Methods

## 2.1. Experimental Approach to the Problem

The criterion-related validity of the *Training Tester*™ to measure vertical jump performance was determined by comparing results of the *Training Tester*™ with data obtained simultaneously from a force plate.

## 2.2. Subjects

Fifteen male team handball players participated voluntarily in this study and gave their written informed consent. They had an average age of 16.0 ± 1.3 years, an average height of 182.7 ± 8.3 cm, and an average body mass of 72.4 ± 10.6 kg. Without exception, all subjects played in the supreme German junior league. The procedures undertaken in this study were approved by the local ethics committee and are in compliance with the Helsinki Declaration.

## 2.3. Procedures

At first, the subjects performed a standardized warm-up program consisting of 5 min moderate cycling with 1 W per kilogram body weight at 60-80 rpm and five submaximal counter movement jumps. Afterwards, subjects standing reach height was measured flat-footed. To accomplish this, the subjects stood in an upright shoulder-width stand at a marked line 10 cm in front of the measuring zone of the *Training Tester*™. Then, the subjects were instructed to extend their dominant throwing arm as high as possible and to move it at the highest point forward through the measuring zone. Subsequently, the height of the *Training Tester*™ was adjusted dependent on the subject's standing reach height. The subjects were not familiarized with the counter movement jump, so that the number of sample trials was flexible. After several sample trials with feedback, the subjects performed five test trials with a break duration of 30 s. The counter movement jump technique was conveyed via verbal instruction and a video demonstration. Following positioning at the marked line in an upright shoulder-width manner, the subjects performed maximal counter movement jumps with both legs. The subjects were again asked to extend the dominant throwing arm as high as possible and to move it at the highest point forward through the measuring zone. Each subject was tested separately and requested to achieve maximal performance. The jumps were executed on the force plate AMTI BP400600 (Advanced Mechanical Technology Inc., Watertown, MA, USA). Force data were recorded with Vicon Nexus™ version 1.7 (Vicon® Motion Systems Ltd., Oxford, UK) at a sampling frequency of 1000 Hz. A custom-designed Matlab® (The MathWorks Inc., Natick, MA, USA) force plate analysis program was used to compute vertical force. The take-off impulse method[23] was applied to determine jump displacement. Body mass was recorded over a 1 s period of standing still before starting to jump. All jumps were simultaneously measured with the *Training Tester*™ which was placed immediately next to the force plate. The jump height revealed by the *Training Tester*™ was defined as the difference between jumping reach height and standing reach height.

## 2.4. Statistical Analyses

All statistical analyses were carried out using the statistical software IBM® SPSS® Statistics version 21 (IBM® Corp., Armonk, NY, USA). Results are shown as means ± standard deviation from the best of five trials. The normal distribution of the variables was tested by a Kolmogorov-Smirnov test. Student's t-test for paired data was carried out to analyze whether differences existed between means of the two methods. The Pearson product moment correlation coefficient was used to determine correlation between the methods. Furthermore, a Bland Altman plot was created to examine measuring agreement[2]. An alpha of 5 % was accepted as statistically significant.

# 3. Results

The mean values and standard deviations of jump heights and the Pearson product moment correlation coefficient for evaluating correlation between both measurement methods are presented in Table 1.

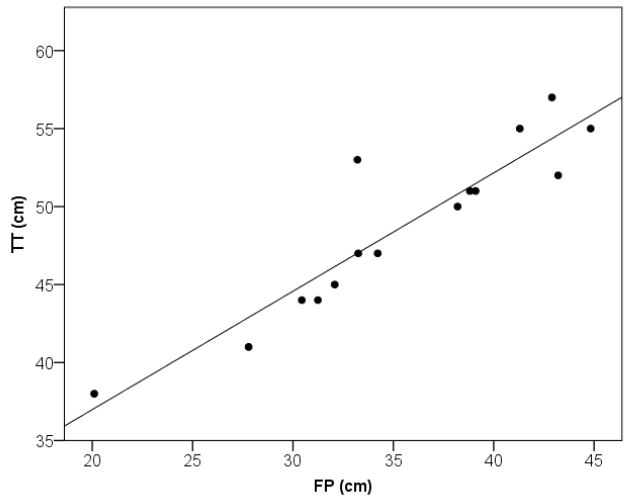


**Figure 2.** Correlation and linear regression for jump height with *Training Tester*™ (TT) and force plate (FP)

The *Training Tester*™ measured significantly ($t = 19.195$, $p < .001$) greater jump heights (13.29 ± 2.68 cm) compared to the force plate (Table 1). But, Pearson correlation coefficient for jump height was high ($r = .922$, $p < .001$). Figures 2 and 3 show the linear regression and Bland Altman plot for the studied variables.

**Table 1.** Values of mean jump height and standard deviation (*SD*) measured by *Training Tester*™ (TT) and force plate (FP). Pearson correlation coefficient (*r*) and paired sample Student's t-test (*t*) with *p*-values between methods

| | TT mean (*SD*) | FP mean (*SD*) | Pearson *r* (*p*-value) | Student's t-test *t* (*p*-value) |
|---|---|---|---|---|
| Jump height (cm) | 48.67 ± 5.52 | 35.38 ± 6.71 | .922 (< .001) | 19.195 (< .001) |

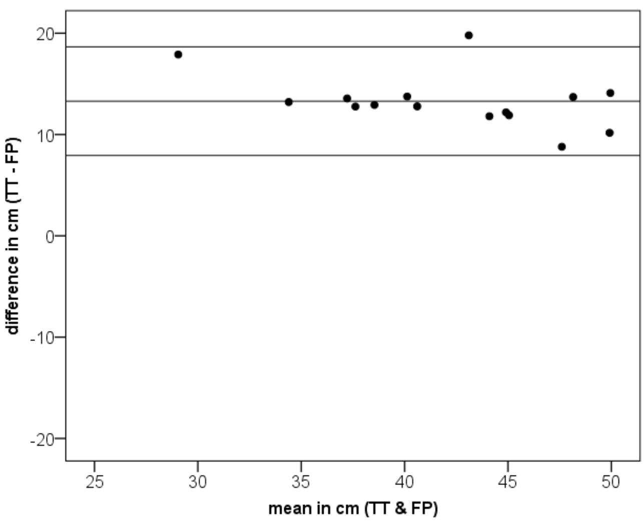


**Figure 3.** Bland Altman plot illustrating absolute differences of jump height between *Training Tester*™ (TT) and force plate (FP)

# 4. Discussion

For the measurement of vertical jump performance in field situations, mostly jump and reach devices are used[4,15,17,21]. These devices must be adjusted after every jump. This is time-consuming and not very user-friendly. Therefore, the purpose of this study was to determine the validity of the electronic jump measurement system *Training Tester*™ to assess vertical jump performance. This system can be described as a time-saving electronic jump and reach device which displays maximal reach height in real time. For evaluation of validity, a force plate as reference criterion was used.

The different jump heights between *Training Tester*™ and force plate are not surprising. The overestimation of jump height with *Training Tester*™ is systematic and can be explained through the applied flat-footed standing reach height method as force plates estimate vertical jump displacement beginning when toes leave the platform[8]. In addition, this difference is consistent with the results of Ferreira and colleagues[9]. These authors discovered very similar differences of approximately 13 cm between the traditional jump and reach device Vertec™ and a force plate. They also conducted a counter movement jump and determined standing reach height flat-footed with one hand, as we did. Nevertheless, we found a Pearson correlation coefficient greater than .90 for the measured variables. Therefore, the *Training Tester*™ jump measurement system can be considered valid. This is remarkable because the subjects did not have any experience with the counter movement jump technique. We suggest that using subjects who are familiarized with the testing procedures would result in higher agreement and correlation between measurement methods. However, in practical situations athletes are often tested for the first time, so that the validation of a new measurement method should also include inexperienced subjects. Yet, it would be a desirable outlook to repeat our study with counter movement jump experts.

# 5. Conclusions

Executing vertical jump tests with the *Training Tester*™ shows an overestimation of maximal vertical jump height in comparison to force plate data. The difference is systematic and can be explained through the applied flat-footed method for the determination of standing reach height. However, correlation between the measurement methods was found to be high. Consequently, the electronic based system *Training Tester*™ provides a portable, cost-effective and time-saving tool for the assessment of vertical jump performance and can be seen as well-proven alternative for testing in field situations.

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