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# Validity and reliability of a single-beam sensor for assessment of jump performance

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**Abstract**

This study aimed to establish the validity and reliability of a single-beam sensor for assessment of jump performance. Thirty-four male and female university students (age: 21.47 ± 0.98 years; height: 173.97 ± 9.32 cm; weight: 70.03 ± 10.63 kg) executed three trials of countermovement jump (CMJ) and three trials of squat jump (SJ), respectively. CMJ and SJ were simultaneously recorded using a force platform (reference) and single-beam jump sensor (Jump Pro). The flight time (FT) and jump height (JH) for both jumps were utilized for analyses. Results revealed the following for FT in CMJ performance: 1) Pearson's correlation coefficient (r) with lower limit (LL) and upper limit (UL) = 0.90 (0.82, 0.94); 2) Typical error of estimate (TEE) with LL and UL = 0.03 (0.01, 0.02); 3) Bland-Altman estimate = 0.05; and 4) Intraclass correlation coefficient (ICC) = 0.80. On the other hand, JH in CMJ posted: 1) r = 0.96 (0.94, 0.98); 2) TEE = 2.07 (1.73, 2.62); 3) Bland-Altman estimate = 4.00; and 4) ICC = 0.71. In regards to FT in SJ, r = 0.96 (0.94, 0.98), TEE = 0.02 (0.01, 0.02), Bland-Altman estimate = 0.03, and, ICC = 0.88. Further, JH in SJ exhibited r = 0.96 (0.94 – 0.98), TEE = 1.84 (1.53, 2.32), Bland-Altman estimate = 3.55, and ICC = 0.86. These findings support Jump Pro as a valid and reliable tool for measurement of CMJ and SJ performances.

***Keywords:*** *testing equipment, fitness assessment, anaerobic power, stretch-shortening cycle*

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## Introduction

Vertical jump (VJ) tests are common for assessment of the stretch-shortening cycle (SSC) capability, playing a crucial role in athletic performance (Secomb et al., 2015; Sheppard et al., 2008). The SSC is a natural muscle function wherein concentric action of a muscle is preceded by eccentric contraction (Nicol, Avela, & Komi, 2006). An efficient SSC demonstrates powerful propulsive force from concentric action (Flanagan & Comyns, 2008). Researchers identified VJ as a discriminating factor among elite vs. non-elite athletes (Trecroci, Milanović, Frontini, Iaia, & Alberti, 2018), starters vs. non-starters (Magrini et al., 2018; Sell et al., 2018), sprint vs. endurance athletes (Lewis, Young, Knapstein, Lavender, & Talpey, 2022), and fast vs. slow sprinters (Washif and Kok, 2022). Additionally, the utility of VJ has been extended to monitoring fatigue (Gathercole, Stellingwerff, & Sporer, 2015; Watkins et al., 2017) and training adaptations (Pagaduan, Schoenfeld, & Pojskić, 2019). The countermove-

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ment jump (CMJ) and squat jump (SJ) are usual tests for VJ. The CMJ measures the slow component of SSC (Laffaye & Wagner, 2013), while the SJ quantifies concentric-only muscle contraction (McBride, Kirby, Haines, & Skinner, 2010). The CMJ produces greater vertical jump compared to SJ due to the utilization SSC, contributing to greater work output (Bobbert & Cassius, 2005; Flanagan & Comyns, 2008). The ratio between CMJ and SJ referred to as eccentric utilization ratiois a practical insight of slow SSC ability (McGuigan et al., 2006).

Different tools are used to measure VJ. The force platform (FP) is considered as the gold standard for measurement of VJ. However, the FP is costly, requires technical expertise, and burdensome to transport. In the recent decade, there has been an emergence of low-cost tools for assessment of jump performance. Some of these include accelerometers (Choukou, Laffaye, & Taiar, 2014; Lake et al., 2018), contact mats (Leard et al., 2007; Pueo, Lipinska, Jiménez-Olmedo, Zmijewski, & Hopkins, 2017), optical timing systems (Bosquet, Berryman, & Dupuy, 2009; Castagna et al., 2013) and video-based mobile applications (Balsalobre-Fernández, Glaister, & Lockey, 2015; Haynes, Bishop, Antrobus, & Brazier, 2019; Montalvo, Gonzalez, Dietze-Hermosa, Eggleston, & Dorgo, 2021; Stanton, Wintour, & Kean, 2017). The availability of these technologies has increased the convenience of measuring jump performance, useful for making informed decisions in physical preparation.

In addition to the aforementioned multi-beam optical systems for jump measurement, a tool using a single-beam sensor (Jump Pro, Mobi Pro, Philippines) has been developed. However, there is no available study in terms of validity and reliability of such device. Such information may increase the confidence of practitioners for using the single-beam sensor. Therefore, this study aimed to identify the validity and reliability of a single-beam sensor in measurement of jump performance.

## Methods

*Experimental Approach*

In this study, the researchers examined the validity, agreement, and reliability of flight time (FT) and jump height (JH) from the CMJ and SJ performances using a single-beam sensor (Jump Pro). Participants were asked to perform CMJ and SJ on a force platform (gold standard), while simultaneously measured from the Jump Pro. The Jump Pro displays FT and JH values via a developed mobile application. On the other hand, the FT from the force platform was used to estimate JH. Data from both equipment were examined using the Hopkins' validity and reliability spreadsheets (Hopkins, 2014, 2015).

*Subjects*

Thirty-four healthy male and female university students (age: 21.47 ± 0.98 years; height: 173.97 ± 9.32 cm; weight: 70.03 ± 10.63 kg) volunteered to participate in this study. Participants have no physical limitations or any injury that affected their ability to perform the jump trials. A signed consent form was obtained prior to further participation. The participants were asked to refrain from any strenuous activity 24 hrs before experimentation and maintain regular dietary habits. The study was approved by the Faculty of Physical Culture Ethics Committee of Palacký University Olomouc (reference number: 21/2023). The study was conducted in accordance with the Ethical principles of the 1964 Declaration of Helsinki and its later amendments.

*Procedures*

The study involved a single experimentation session between 1000 am – 1200 pm at a fitness room in the Technical University of Liberec. Upon arrival, measurement of height (Leicester Height Measure Mk II) and weight (Xiaomi Mi Body Composition Scale 2) were administered. Then, participants performed a standardized warm-up that consisted of light jogging (5 minutes), dynamic stretching exercises (squat, lunge and reach, reverse lunge and twist, leg swing to toe touch, and knee hug to quadstretch) for 2 sets of 5 repetitions, and 20 jumping jacks. This was followed by a 3-minute active rest (walking/moving to the next activity). After, participants proceeded with CMJ and SJ testing. Twenty-four hours before the testing session, the protocol of the study was explained to the participants, followed by familiarization of CMJ and SJ tests.

*Measures*

Countermovement Jump. Participants assumed a static position with hands on waist and feet shoulder-width apart. After, participants executed a countermovement, succeeded by vertical jump. Three trials were administered, with intratrial rest of 30 seconds. However, the tester administered additional trial/s upon assessment of faulty jump execution. The FT and JH of the best trial were utilized for validity analysis. A three-minute rest ensued after CMJ testing.

Squat Jump. Participants assumed a similar starting position with CMJ. Then, participants positioned the knees at approximately 90-degrees for 3 seconds. This was followed by a vertical jump, with hands kept on the waist in the entire duration of the jump. The trial with highest FT and JH was used for analysis.

*Equipment*

Jump Pro. The Jump Pro (Mobi Pro, Philippines) is portable jump measurement tool that utilize a single-beam laser to detect flight time. The emitter (E3F12-30DN1-5V M12 30m sensing DC 5V NPN NO laser, Finglai Electric, China) and receiver (controller: nRF5282, Nordic Semiconductor ASA, Norway)were set at 1 m apart, powered by a portable charger. To minimize error, participants were asked to jump/land on a designated marker, wherein the fifth hallux approximately in line with the laser beam (6). After each jump trial, the FT and JH are displayed on a mobile application developed for Jump Pro. The JH was estimated using the flight time formula (H = 0.5g x t2), where H refers to height of the jump, g is the acceleration due to gravity, and t as the time from take-off to peak of the jump (Bosco, Luhtanen, & Komi, 1983; Moir, 2008)

Force platform. A commercial force platform Quattro Jump (Kistler, Switzerland) was used as the reference criterion. The force platform was connected to a software (Quattro Jump Software, Kistler, Switzerland) at a sampling rate of 1000 Hz. The raw data was extracted to an excel spreadsheet, and used to determine FT, wherein start and stop of FT was computed immediately after zero force and resumption of force measurement, respectively. Then, estimation of JH was performed using similar formula employed in Jump Pro. Figure 2 exhibits the equipment set-up for this study.

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**Figure 1.** Jump Pro Device.

*Statistical Analysis*

Descriptive statistics are presented as mean ± standard deviation. Criterion validity was investigated using the Pearson's correlation coefficient (r) interpreted as very weak (<.20), weak (.20-.40), moderate (.40-.70), strong (.70-.90), and very strong (>.90) (Learner and Goodman, 1996). Also, the typical error of estimate (TEE) was used to determine the threshold of disagreement, interpreted as trivial (0.00–0.10), small (0.11–0.30), moderate (0.31–0.60), large (0.61–1.00), very large (1.01–2.00), or impractical (>2.00). The Bland-Altman estimate was also utilised to establish the agreement between the force platform and Jump Pro (Bland and Altman, 1986). The intraclass correlation coefficient (ICC) was utilized to determine intratrial reliability, with ICC values referred as trivial (<0.10), small (0.10–0.30), moderate (0.30–0.50), high (0.5–0.70), very high (0.70–0.90), and practically perfect (>0.90) (Banyard, Banyard, Nosaka, & Haff, 2017). The Hopkins' validity and reliability spreadsheets were utilized in this study (Hopkins, 2014, 2015).

**Figure 2.** Equipment Set-up.

## Results

Table 1 displays the validity and reliability values of CMJ and SJ using the single-beam sensor.

Results revealed that the FT of CMJ in Jump Pro demonstrated r = 0.90 (0.82, 0.94), TEE = 0.03 (0.01, 0.02), and Bland-Altman estimate of 0.05. The ICC of jump trials for FT of CMJ in Jump Pro was 0.80. In regards to JH of CMJ, the r = 0.96 (0.94, 0.98), TEE = 2.07 (1.73, 2.62), and Bland-Altman estimate = 4.00, with ICC = 0.71.

The FT for SJ posted the following: 1) r = 0.96 (0.94, 0.98); 2) TEE = 0.02 (0.01, 0.02), 3) Bland-Altman estimate = 0.03; and, 4) ICC = 0.88. On the other hand, JH of SJ showed: 1) r = 0.96 (0.94 – 0.98); 2) TEE = 1.84 (1.53, 2.32), Bland-Altman estimate = 3.55; and 4) ICC = 0.86.

**Table 1.** Validity and reliability of CMJ and SJ indices in Jump Pro.

| | Flight Time | | | | | Jump Height | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Time (ms) | ICC | *r* (LL, UL) | TEE (LL, UL) | Bland-Altman Estimate | Height (cm) | ICC | *r* (LL, UL) | TEE (LL, UL) | Bland-Altman Estimate |
| *CMJ* | | | | | | | | | | |
| Jump Pro | 0.521 ± 0.054 | 0.80 | 0.90 (0.82, 0.94) | 0.03 (0.01, 0.02) | 0.05 | 33.09 ± 7.50 | 0.71 | 0.96 (0.94, 0.98) | 2.07 (1.73, 2.62) | 4.00 |
| Force Platform | 0.501 ± 0.062 | 0.97 | | | | 31.26 ± 7.72 | 0.92 | | | |
| *SJ* | | | | | | | | | | |
| Jump Pro | 0.494 ± 0.055 | 0.88 | 0.96 (0.94, 0.98) | 0.02 (0.01, 0.02) | 0.03 | 30.13 ± 6.61 | 0.86 | 0.96 (0.94, 0.98) | 1.84 (1.53, 2.32) | 3.55 |
| Force Platform | 0.482 ± 0.057 | 0.92 | | | | 28.84 ± 6.77 | 0.92 | | | |

-ICC – intraclass correlation coefficient; LL – lower limit; UP – upper limit; TEE – typical error of estimate

## Discussion

This study aimed to establish the validity and reliability of a single-beam sensor for measuring CMJ and SJ jump performances. Results revealed that Jump Pro demonstrated valid FT and JH values in CMJ and SJ. Additionally, the reliability for both the FT and JH from the CMJ and SJ in Jump Pro were acceptable.

Indeed, the CMJ and SJ indices from Jump Pro demonstrated valid outcomes. These results are in line with previous studies that measured CMJ and SJ using optical timing systems (Lewis et al., 2022; Leard et al., 2007). Further, the Bland-Altman estimates and TEE values of all CMJ and SJ indices posted in acceptable agreement between Jump Pro and force platform. On the other hand, the results of the JH of CMJ in Jump Pro contrasted the findings from JH of CMJ (Parmar, Keenan, & Barry, 2021; Watkins, Maunder, van den Tillaar, & Oranchuk, 2020) and JH of SJ (Watkins et al., 2020) from a similar technology using a single-beam sensor. The overestimation from the previous technology may be due to forward displacement during landing and/or sensor position. The validity results of Jump Pro suggest the practicality of such a tool as an alternative equipment to a force platform.

In this study, the FT and JH values in CMJ and SJ in Jump Pro exhibited acceptable reliability. The reliability of JH values from CMJ and SJ in Jump Pro are in accordance with the results posted by Watkins et al., 2020. Therefore, CMJ and SJ can be measured consistently in Jump Pro.

Limitations of this current study are acknowledged. First, only CMJ and SJ tests were used in this study, restricting utility for assessment of SSC function. Future studies should employ jump tests (e.g. drop jump) that may help elucidate information on other lower body contractile properties. Second, the hands-on-waist procedure was administered in this study to reduce the influence of arm swing on performance (Lees, Vanrenterghem, & De Clercq, 2004). Establishing the validity of other protocols that facilitate maximal jumps, providing more value for practical inference should be warranted. Lastly, only intraday reliability was assessed in this study. Conducting additional test-retest reliability studies with Jump Pro may help identify potential systematic bias or random error of such equipment (Atkinson and Nevill, 1998).

## Conclusion

In summary, the results in this study suggest that Jump Pro is a valid and reliable tool for measuring FT and JH in both CMJ and SJ tests. With this, the Jump Pro can be used interchangeably with the force platform for acquisition of similar indices.

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## Conflicts of Interest

The first author of the article is the co-developer of the single-beam sensor and co-designer of the mobile application.

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