Validity and Reliability of a Mobile App to Measure Vertical Jumps in Older Women

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ABSTRACT

The use of technology to approximate science to practice has been receiving attention, especially related to low-cost and portable devices. Thus, the present study aimed to investigate the validity and reproducibility of the Jumpo® application to measure vertical jump performance in older adults. 52 older women were invited to the survey. The evaluation consisted of the simultaneous application of countermovement and squat jumps through the contact mat and the application (Jumpo®). The results showed excellent correlation and inter-instrument agreement for the countermovement jump (ICC = 0.97; p <0.001; R2 = 0.0057) and squat jump (ICC = 0.95; p <0.001; R2 = 0.0006). The analysis intra-rater (ICC = 0.98, p <0.001), (ICC = 0.94, p <0.001) showed high values of reproducibility. As for inter-rater, they presented high reproducibility for

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countermovement jump and squat jump (ICC = 0.92, p <0.001), respectively (ICC = 0.94, p <0.001). Therefore, it is concluded that the Jumpo® application is a reliable tool for verifying maximum height in vertical jumps for the older adult population.

Keywords: Software validations, Mobile application, Physical Capacity, Older Adults

INTRODUCTION

Muscle contraction at high velocity is fundamental to the functional performance of older adults (Dias et al., 2020a). In particular, vertical jump performance (VJ) is associated with muscle strength and power, being important factors in the decrease in the number of falls in frail elderly people (Fragala et al., 2019). Besides, VJ variables are important in tracking sarcopenia and functional status in this population (Clémençon et al., 2008; Runge et al., 2004; Singh et al., 2014). Also, jump height is positively correlated with overall physical performance like gait speed and concentric isokinetic tests, thus it is an important measure to be considered in the training scenario when attempting to assess physical performance and monitoring age-related loss of muscle in older women (Santos et al., 2022). However, common instruments to measure the VJ performance presents some disadvantages like high prices, high demand for calibration time, and low practice application (Balsalobre-Fernández et al., 2015).

In this sense, it is interesting the validation of instruments with low-cost, portable, and good practical applications to the measurement and analyses of VJ, as mobile applications (apps) for smartphones and tablets (Coswig et al., 2019). Indeed, the use of apps become a relevant tool for measuring and analyzing maximum jump performance (Yingling et al., 2018). Also, the body of scientific knowledge about the validation and reproducibility of this type of tool is increasing in the rehabilitation and sports sciences (Awatani et al., 2018; Kemler et al., 2018).

Concerning the use of the apps to measure VJ in the older adult population, only *My Jump2®* has been considered reliable to measure the countermovement jump performance (CMJ) (Cruvinel-Cabral et al., 2018a). However, *My Jump2®* reproducibility has not been evaluated to inter-rater and intra-rater, and squat jump performance (SJ) to this public, factors that are essential to the validation of apps to measure the VJ (Azevedo et al., 2019a).

Indeed, other mobile apps, such as "*Jumpo®"*, could help health professionals to evaluate jump ability at healthcare units, hospitals, and even in patients' houses. Besides, coaches and trainers at the gym should also be encouraged to add those app-based measures to improve training control, prescription, and monitoring (Azevedo et al., 2019b). Therefore, this study aimed to test the validity and reliability of the *Jumpo®* to measure jump performance in older women. The initial hypothesis is that Jumpo® shows high values of reliability compared to contact matt and high values of reproducibility inter and intra-rater.

MATERIALS AND METHODS

Participants

Fifty-two older women were categorized as "postmenopausal" (45 to 59 years; n=3), grade 1 aging (65 to 74 years; n=40), grade 2 aging (75 to 84 years; n=9) (10,21), with a mean age of 62.8 ± 7.7 years old., 1.6 ± 0.1 m of height and body mass of 64.6 ± 9.1 kg. As inclusion criteria, participants should be 45 years or more, be engaged in physical activity programs, be listed in the Social Support Center, and not have joint or muscle injuries or limitations that could limit jump performance. Those who reported joint discomfort or did not conclude one of the tests were excluded from the analysis.

Protocol

The participants were recruited from community centers of social support. Participants were informed about risks and benefits right before signing the informed consent statement, which followed the recommended ethical standard procedures of the ethical committee. All procedures were approved by the local Ethics Committee (protocol number CAAE 98870718.3.0000.0018). After that, jump performance was evaluated by the CMJ and the SJ tests, which were simultaneously measured by the contact mat and the Jumpo®. The test occurred in a circuit order and each participant performed three attempts for each jump type, reaching a total of 312 jumps adding for all participants and only the highest value was considered for analysis. For intra and inter-rater reliability, recorded videos were analyzed by two evaluators (inter) and one of them repeated the procedure after 1 week (intra) (Coswig et al., 2019).

Contact Mat

The contact mat (Jump System Pro®, Cefise, Brazil) (Azevedo et al., 2019b), was used as the reference instrument. The mat had 1000 x 600 x 8 mm. The contact mat was connected to a notebook was the Jump System 1.0 software was installed. This instrument is widely applied in sports science and sports medicine and has an intraclass correlation coefficient (ICC) of 0.96 (Farias et al., 2013a).

Jumpo® app

The Jumpo® (E-sporte SE, Brasília, Brazil) was installed in a Samsung Galaxy Tablet A (Samsung, South Corea, Frame Rate 60 fps, Android 7.0 system operating), it flashes through algorithm software with the program Java. The Jumpo® is your platform of access in *Playstore* with an algorithm developed in java language. For all jumps, the maximal height was calculated by flight time. The Jumpo®. App analyzes are based on recorded video and the algorithm is based on previously suggested equations (Samozino et al., 2008), according to the manufacturer. To measure that, the rater indicates in the app feature both take-off and landing moments, which were defined as the moment when the foot loses contact and returns to the ground, respectively (Figure 1) (Azevedo et al., 2019b).

Jumpo® Height (m)= $\frac{1}{8}gt^2_A$ gravity=9.81 m/s^2 $t^2_{A=}$ Aerial time

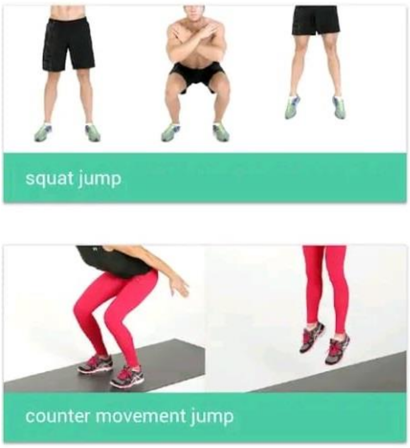


Figure 1 - Jumpo Layout

Countermovement Jump (CMJ) and Squat Jump (SJ)

To perform the CMJ, participants were asked to maintain an orthostatic position at the initial phase. After verbal signal subjects should perform knee (~90º) and hip flexion (~120º). Then, participants should perform explosive knee and hip extensions to achieve the highest height possible. Knees remain in the extension position during the flying phase until the landing (Hassani et al., 2014). For the SJ, the same procedure was held. The only difference was that after the first flexion, subjects were asked to hold the squat position for 2-3s (Van Hooren & Zolotarjova, 2017). In total, three measures were realized for the CMJ and SJ. Only the maximum height measurement was utilized for the analysis of each participant, to avoid a possible measurement error due to intra-individual variation (Claudino et al., 2017).

The appraisers position a 1.5 m distance of platform contact and 30 cm height of the ground and capture images were established plant front second recommendations of the study previous (Azevedo et al., 2019b).

Statistical Analysis

After Shapiro-Wilk's test for normality, data are presented by the mean and standard deviation (SD). A Paired t-test and Pearson correlation coefficient (ICC) were used to compare the instruments (Koo & Li, 2016). Besides, correlations and Cohen's d was used to estimate effect sizes (ES), which were classified as trivial (<0.20), small (0.20 to 0.30), medium (0.40 to 0.70), or large (>0.80) (Lakens, 2013). The Mean absolute error (MEA), Root mean squared error (RMSE), and the visual analysis of the Bland-Altman plot was performed for validation and assessment of the predictive ability, according to the study of the (23). For the reproducibility of intra and inter-rater analysis of the test measurements, the ICC, the standard error of measurement (SEM) was calculated by the following equation: SEM= SD x $\sqrt{(1 - ICC)}$; and minimal detectable change (MDC) was calculated as follows: MDC = SEM x 1.96 x ($\sqrt{2}$). All statistical analysis was performed by the SPSS package, version 22.0, and statistical significance was determined when $p<0.05$.

RESULTS

Performance in jump tests measured by both instruments is presented in Table 1, where high correlation and agreement inter-instruments are presented. Also, no differences were found between jumps and instruments. This showed that the Jumpo® is an app reliable to measure VJ when compared to the contact mat.

Table 1. Inter-instrument evaluation agreement.

Jump	CM Mean±SD	Jumpo® Mean±SD	95%CI	t(p)	ES	ICC(p)	RMSE	MAE
CMJ (cm)	6.7±2.9	6.9±2.9	6.25 to 7.35	-1.40 (0.166)	0.20	0.97 (<0.001)	0.75	0.58
SJ (cm)	7.0±2.7	7.2±2.8	6.58 to 7.62	-1.42 (0.160)	0.17	0.95 (<0.001)	0.88	0.70

CMJ: Countermovement Jump; SJ: Squat Jump; CM: contact mat; ES: Effect size; ICC: intraclass correlation coefficient; CI: Confidence interval; RMSE: Root mean squared error; MAE: Mean absolute error.

Table 2 presents intra-rater agreement values for the Jumpo®, and the results present high values of ICC and low values of SEM and MDC. Also, no differences were found between the means. Table 3 shows the inter-rater analysis performed by the two evaluators. Data suggest high values of agreement, with no statistical differences between them. These results confirmed that the Jumpo® has high values of reproducibility when the measures are realized by the same individual and individuals differently.

Table 2. Intra-evaluator agreement for the *Jumpo® app*.

Jump	Analysis 1st	Analysis 2st	95%CI	t(p)	ES	ICC(p)	SEM	MDC

	Mean±SD	Mean±SD						
CMJ (cm)	6.9±3.0	6.9±2.9	6.36 to 7.48	-0.294 (0.770)	0.03	0.98 (<0.001)	0.40	1.09
SJ (cm)	7.2±2.7	7.1±2.8	6.66 to 7.73	0.257 (0.798)	0.03	0.94 (<0.001)	0.67	1.80

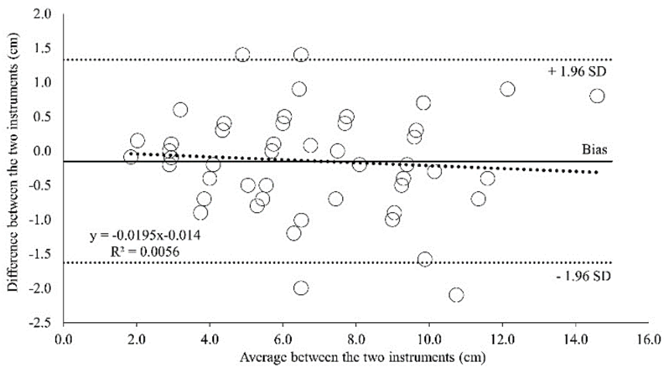
CMJ: Countermovement Jump; SJ: Squat Jump; ES: Effect size; ICC: intraclass correlation coefficient; CI: Confidence interval: CV: coefficient of variation; SEM; standard error of measurement; MDC: Minimum detectable change.

Table 3. Inter-rater agreement for the *Jumpo® app.*

Jump	Evaluator 1 Mean±SD	Evaluator 2 Mean±SD	95%CI	t(p)	ES	ICC(p)	SEM	MDC
CMJ (cm)	6.9±3.0	6.8±2.8	6.31 to 7.42	0.555 (0.581)	0.07	0.92 (<0.001)	0.84	2.30
SJ (cm)	7.2±2.8	7.1±2.7	6.63 to 7.67	1.153 (0.254)	0.14	0.94 (<0.001)	0.72	1.97

CMJ: Countermovement Jump; SJ: Squat Jump; ES: Effect size: ICC: Intraclass correlation coefficient; CI: Confidence interval; CV: Coefficient of variation. SEM: Standard error of measurement; MDC: Minimum detectable change.

Bland-Altman plots are presented in Figures 2 and 3 for CMJ and SJ, respectively. The strong agreement is evidenced by visual analysis and low values of R^2. Figure 4 showed intra (Panels A and B) and inter-rater (Panels C and D) correlations for CMJ (Panels A and C) and SJ (Panels B and D) tests. For all of them, high correlations were evidenced. Thus, high values of reproducibility inter and intra-rater were found, showing that the Jumpo® has valid measures for the measurement of maximum jump height at different moments of analysis.



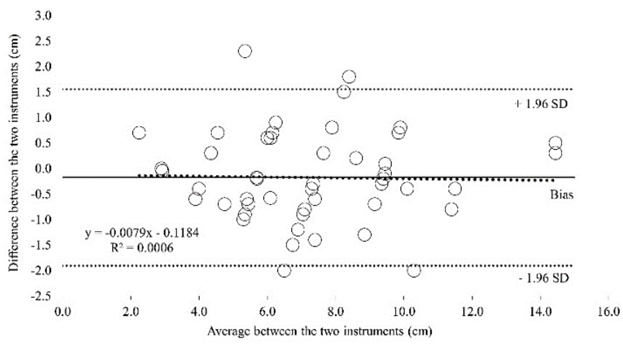


Figure 2 - Bland Altman Plots for CMJ

Figure 3 - Bland Altman Plots for SJ

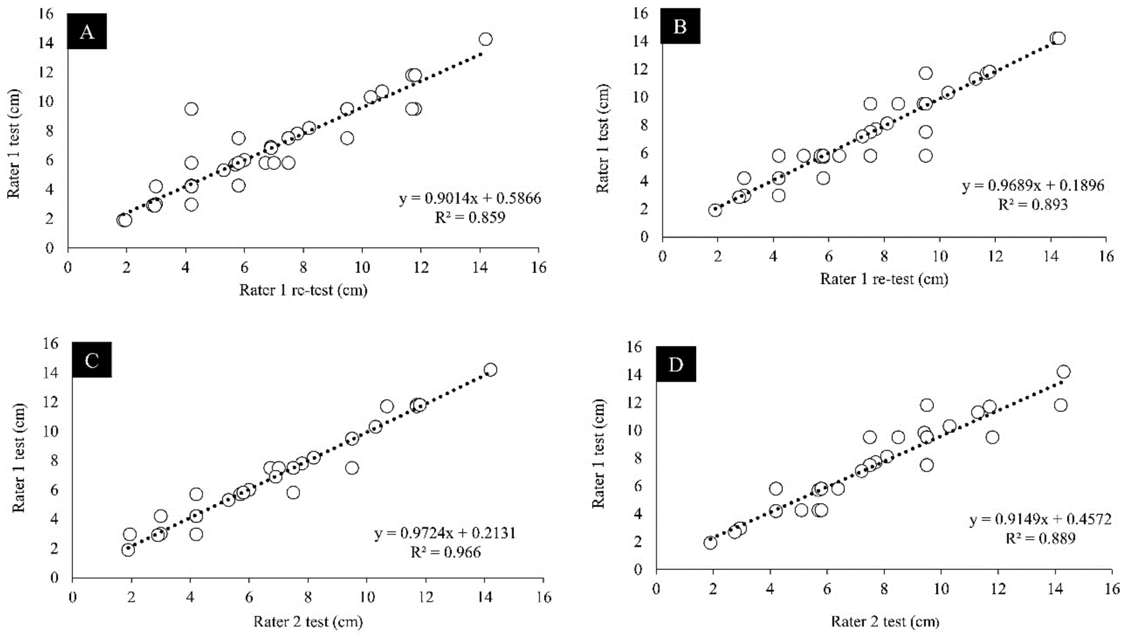


Figure 4 - Linear Regression correlations for CMJ and SJ

DISCUSSION

This study aimed to investigate the validity and reproducibility of the Jumpo® to measure vertical jump performance in female older adults. The main findings of this study were that this mobile app presented excellent validity and reproducibility to be used with this population.

To our knowledge, only the study of (9) analyzed the validity of the mobile app to this population, but only the measure of the CMJ performance was evaluated. This data showed an almost perfect correlation for analyses (ICC; 0.99), with a frame capture frequency rate of 240 fps, as well in other studies that utilized the My jump® (Balsalobre-Fernández et al., 2014; Coswig et al., 2019; Gallardo-Fuentes et al., 2016a). However, our findings showed high values of reliability between instruments (ICC; 0.97), with the average of lower jump height measurements in comparison to this study (My jump; 10.01 cm vs Jumpo; 6.9 cm). Besides, even with the lower frame rate captures (65 fps), it seems acceptable to confirm that this is the minimum frequency needed for a good measure of VJ. Therefore, these findings become consistent for measuring jump performance for this public, with increased portability and easy applicability.

Regarding jump performance, the study of (3), analyzed the jump height of amateur athletes of judo and karate, through Jumpo® and contact mat. The results demonstrated good values of reproducibility of CMJ (ICC=0.97; $p < 0.001$), SJ (ICC=0. 96; $p<0.001$) and drop jump (DJ) (ICC=0.94; $p < 0.001$). Thus, the jumpo® demonstrated good accuracy for the measure of jumps of ~30 cm. However, the validity of this app for older adults would become a challenge, due to the low jump height values expected in this population (less than ~ 20 cm), thus the signal-to-noise ratio could compromise the validity of these apps (Cruvinel-Cabral et al., 2018b). On the other hand, even with the variation of the jump performance between (~1.8 to 14 cm), due to the different functional capacity levels, expected by biological aspects associated with aging (Argaud et al., 2017), our results suggest that Jumpo® is a reliable tool to measure the maximum height of VJ regardless of elderly stage.

Besides CMJ measures have been widely applied, the SJ has also been suggested for monitoring training status and differs from the first by removing reducing the role of muscle elastic properties (Van Hooren & Zolotarjova, 2017). Again, My Jump2® was already tested against high-speed cameras and force platforms, ((13), where 21 subjects were investigated, and the inter-instruments agreement was very high (r=0.95). This pattern was also shown in the study by (8) on soccer athletes with neurological injury (ICC = 0.93). Notwithstanding, to the best of our knowledge, evidence of app-based SJ performance measurements is not frequent in special groups. In that sense, and based on our findings, the Jumpo® seems to be a promising strategy, at least for the older adults.

An important variable to be considered while using video-based apps is the smartphone/tablet camera frame rate. The general suggestion is to use high frame rates (~240 fps), however, our experiment used Jumpo® in equipment that achieved only 60 fps. However, even with low frame rates, the app was capable to achieve higher values of agreement with the contact mat and excellent reliability, which means that this instrument is not restricted to expensive equipment. It is our opinion that this finding is of interest to coaches and trainers since even low-quality smartphones can produce trustable data.

Some limitations should be considered when interpreting our data. First, there is a subjective analysis when the evaluator manually indicates the take-off and landing points (as required by the app). However, our data indicate that even with a subjective component in the evaluation, levels of intra and inter-rater agreement were excellent. Second, our findings could be affected by the low experience and possible fear of the fall of this elderly sample with jumping. However, this fact reinforces our findings in the light of external validity and for the clinical approach. Finally, the reference equipment (contact mat) is not the gold standard (force platforms or high-speed cameras), however, it is widely applied in sports medicine science and the field and has been shown higher agreement with gold standard methods (Farias et al., 2013b).

CONCLUSION

The interest in mobile apps has been growing in sports and medical sciences. Also, infield, there is a gap between the need for portable and valid measures and the expensive nature of the available instruments. Here we evidenced that the Jumpo® seems to have this support, at least for use in the older women.

CONFLICTS OF INTEREST

The authors report no conflict of interest.

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Validity and Reliability of a Mobile App to Measure Vertical Jumps in Older Women

Validade e Reprodutibilidade De Um Aplicativo Móvel Para Medir Saltos Verticais em Mulheres Idosas

RESUMO

O uso da tecnologia para aproximar a ciência da prática tem recebido atenção, especialmente relacionado a dispositivos de baixo custo e portáteis. Assim, o presente estudo teve como objetivo investigar a validade e reprodutibilidade do aplicativo Jumpo® para medir o desempenho de salto vertical em idosos. 52 mulheres idosas foram convidadas para a pesquisa. A avaliação consistiu na aplicação simultânea de saltos com contramovimento e agachamento por meio do tapete de contato e do aplicativo (Jumpo®). Os resultados mostraram excelente correlação e concordância inter-instrumento para o salto com contramovimento (ICC = 0,97; p <0,001; R2 = 0,0057) e salto agachado (ICC = 0,95; p <0,001; R2 = 0,0006). A análise intra-avaliador (ICC = 0,98, p <0,001), (ICC = 0,94, p <0,001) mostrou altos valores de reprodutibilidade. Quanto à análise interavaliadores, apresentaram alta reprodutibilidade para salto com contramovimento e salto agachado (ICC = 0,92, p <0,001), respectivamente (ICC = 0,94, p <0,001). Portanto, conclui-se que o aplicativo Jumpo® é uma ferramenta confiável para verificar a altura máxima em saltos verticais para a população idosa.

Palavras-chave: Validação de Software, Aplicativo Móvel, Capacidade Física, Idosos.

Validez y Confiabilidad De Una Aplicación Móvil Para Medir Saltos Verticales en Mujeres Mayores

RESUMEN

El uso de la tecnología para aproximar la ciencia a la práctica ha estado recibiendo atención, especialmente en relación a dispositivos portátiles y de bajo costo. Por lo tanto, el presente estudio tuvo como objetivo investigar la validez y reproducibilidad de la aplicación Jumpo® para medir el rendimiento en el salto vertical en adultos mayores. Se invitaron a participar en el estudio 52 mujeres mayores. La evaluación consistió en la aplicación simultánea de saltos con contramovimiento y sentadilla utilizando la plataforma de contacto y la aplicación (Jumpo®). Los resultados mostraron una excelente correlación y acuerdo interinstrumental para el salto con contramovimiento (ICC = 0,97; p <0,001; R2 = 0,0057) y para el salto de sentadilla (ICC = 0,95; p <0,001; R2 = 0,0006). El análisis intraevaluador (ICC = 0,98; p <0,001) y (ICC = 0,94; p <0,001) mostró valores elevados de reproducibilidad. En cuanto al análisis interevaluador, se presentaron valores elevados de reproducibilidad tanto para el salto con contramovimiento como para el salto de sentadilla (ICC = 0,92; p <0,001) y (ICC = 0,94; p <0,001), respectivamente. Por lo tanto, se concluye que la aplicación Jumpo® es una herramienta confiable para verificar la altura máxima en saltos verticales en la población de adultos mayores.

Palabras clave: Validaciones de software, Aplicación Móvil, Capacidad Física, Adultos Mayores