Validity of the MyJump2™ app for measuring different jumps in professional CP Football Players

Abstract

Background: Vertical jumps can be used to assess neuromuscular status in sports performance. This is particularly important in CP Football because the players are exposed to high injury risk, but it may be complicated because the gold standard to assess jump performance is scarce in field evaluation. In this case, field techniques such as mobile apps have been analysed to solve this problem.

Objectives: The present study aims to evaluate the reliability of the measures of the MyJump2™ app to assess vertical jump performance in professional CP Football.

Methods: We assessed 40 male CP Football athletes (28.1 ± 1.4 years, 72.5 ± 6.2 kg and 176 ± 4.2 cm) through the countermovement jump (CMJ) and squat jump (SJ) using a contact mat. At the same time, we assessed the athletes using the MyJump2™ application.

Results: There were no significant differences between the instruments in the SJ height (P = .12) and flight time (P = .15). Additionally, there were no significant differences between the instruments for CMJ in the jump height (P = .16) and flight time (P = .13). In addition, it was observed that there were significant and strong intraclass correlations in all SJ variables varying from .84 to 0.89 (P < .05), which was classified as “almost perfect”. Similar results were observed in all variables from the CMJ, varying from .91 to 0.92 (P ≤ .05).

Conclusions: We conclude that the MyJump2™ app presents high validity and reliability to measure jump height and flight time of the squat jump and the countermovement jump in CP Football athletes.

Keywords: Jump performance; Mobile Application for health, Paralympic Sport, CP Football.

Introduction

Cerebral Palsy Football (CP Football) is a Paralympic sport played exclusively by athletes with central neurological injuries, such as cerebral palsy (CP), traumatic brain injuries or stroke. Athletes of this sport may have ataxia, hypertonia or dystonia and are divided into classes based on their functional profile levels [1]. The sport is very similar to conventional soccer, except for the use of 7 players, smaller field measurements, shorter duration of matches (30 minutes per time) and the lack of the offside rule [1]. Regarding the physical demands, CP Football has the same characteristics as conventional soccer; for example, tactical, psychological and physical demands in which strength and power are the fundamental factors [2,3], much due to the intermittent characteristic of the sport, and the fact that moments of high intensity are decisive in the game [4].

Similar to conventional soccer, CP Football shows a relatively high injury rate. For example, Willick et al. [5], presented similar incidences of injury rates in CP Football (11.2 / 1000 athletes days) as in all sports (12.7 / 1000 athletes days) in the Paralympic Games of London 2012. This is quite similar to the injury rates for CP Football in the
Paralympic Games of Rio 2016 (10.2 / 1000 athletes days) [6], in which it is noted that injuries by overuse are the third highest prevalence (7.1%), as well as higher injury rates during competition (64%). Since there are high injury rates in CP Football and strength and power seem to be determinant for CP Football, it is important to establish reliable options to measure and analyse this variable. In this way, vertical jumps are an ecological alternative that provide an assessment near the athletes’ practice. Furthermore, vertical jumps have been used as an important parameter for injury prevention [7,8], which is already demonstrated to be a relevant factor in CP Football [6].

To evaluate vertical jumps, accurate and expensive instruments are often needed, such as force platforms [9] and contact mats [10,11]. In this way, the demand for evaluation methods using hands-free and mobile devices has increased. In addition to the technological advancement of smartphones, apps have been developed for sports measuring purposes, something that was reported as a trend by the American College of Sports Medicine [12]. In this sense, the MyJump2™ app becomes a viable option that evaluates the height of the jump. This app provides the data acquisition quickly and immediately, allowing easy monitoring in almost any environment [13], with a high reliability and reproducibility in vertical jumps [14-16]. However, it is necessary to validate this app in different populations and sports, which justifies the present study that aims to evaluate the reliability of the measures of the MyJump2™ app to assess vertical jumps in professional CP Football.

**Methods**

**Experimental design**

To evaluate the reliability of the app, professional CP Football athletes were recruited, and the data collection occurred in one session. The session was held during the 2017 Brazilian CP Football Championship. The athletes performed the countermovement and the squat jump and were assessed by two instruments simultaneously (a contact mat and MyJump2™). Each participant performed three repetitions of each jump, and the highest height values were used in the analyses. The order of the participants for each load was randomized.

Before data collection, subjects performed a specific warm-up for five minutes, which involved the execution of vertical jumps similar to those applied in the evaluations, in order to learn how the jump would be executed and with stimulation of slow and fast cycles of stretching and shortening. After the specific warm-up period, participants were instructed to perform three countermovement jumps with their hands fixed at the waist, performing the jump at the highest possible height [17].

**Sample**

A sample size calculation from an earlier investigation indicated that 7 participants would be needed, considering a $P = .001$ and a power of 90% [14]. Thus, for this study, 40 male athletes (28.1 ± 1.4 y, 72.5 ± 6.2 kg and 176 ± 4.2 cm) without presenting acute or chronic conditions that prevented them from performing the jump protocol were included. Inclusion criteria required that participants have neurologic injuries at the central nervous system, be engaged in official professional CP Football competitions and have prior experience in the vertical jumping exercise. Participants were informed about possible risks, benefits and discomforts that the protocol could cause.
Procedures

Countermovement Jump (CMJ)
In the CMJ, the individual starts in an orthostatic position with the hands fixed at the waist and, at the evaluators’ command, performs a squat until the knees reach an angle of 90°, then the participant extends the hips and the knees to project the body vertically with the greatest speed and strength possible to reach the maximum possible height. Participants were instructed to not flex the knee or dorsiflex the ankle during the flight phase. All participants received verbal stimuli for a better performance. A period between each jump was set as a 30-second rest interval.

Squat Jump (SJ)
In the SJ, the individual starts in an orthostatic position and, at the evaluator’s command, performs a squat until the knees reach a 90° angle. This position is maintained in isometric contraction for three seconds, after which the individual extends the hips and knees to project the body and the load vertically at the highest possible speed and strength; that is, to achieve maximum power during the execution.

Contact Mat
The Jump System Pro® Contact Mat (CEFISE, Nova Odessa, Brazil) evaluates the power output through flight time. The output data were collected by the Jump System Pro® Software, version 1.0 (CEFISE, Nova Odessa, Brazil). The contact map showed a high reliability for jump height, with an intraclass correlation coefficient (ICC) of 0.91 and a coefficient of variation (CV) of 10% [18].

MyJump2 ™ application
The application for the iOS operating system (Apple Inc.) was developed using the software (XCode0.5 for Mac OS X 10.9.2, Apple Inc., USA) and installed on the iPhone 6s (Apple Inc). The evaluation required a high-speed camera (120 Hz) with a minimal resolution of 720p. The application analysed the height of the vertical jumps by calculating the time between two frames (in ms) selected by the evaluator and corresponding to the loss of contact to the ground and the return of the contact to the ground. For this instrument, the same evaluator performed all the collections and was always in the same position (at the front) and at the same distance (1.5 m) from the material being evaluated. For inter- and intra-evaluator reliability, recorded videos were analysed by two evaluators (inter) and one of them repeated the procedure after one week (intra).

Statistical analysis
The data are presented in mean ± standard deviation. The Shapiro-Wilk test was used to assess normality, and the paired t-test was used to compare instruments. For the reproducibility of the test measurements, the intraclass correlation coefficient (ICC), standard error of measurement (SEM= sd(√1-ICC)) and minimal detectable change (MDC= SEM(√2)) were applied (19). The Pearson correlation coefficient was applied for the correlations, and Bland-Altman plots were applied to test level of agreement between instruments. All analyses were performed using SPSS software (22.0). For all variables, statistical significance was set at \( P \leq .05 \).
Results

Table 1 shows the values of the absolute comparison and intraclass correlation coefficient between the instruments for the jump height and flight time of SJ and the CMJ. There were no significant differences between the instruments in the jump height variables ($P = .12$) and flight time ($P = .15$). The effect size of the two variables was trivial for jump height and flight time, according to Cohen’s classification (20). There were no significant differences between the instruments for CMJ in the jump height variables ($P = .16$) and flight time ($P = .13$). The effect size of the two variables was also trivial for jump height. In addition, it was observed that there were significant intraclass correlations in all squat jump variables ($P < .05$). Strong correlations were found at jump height and flight time (ICC = .84 for both, respectively), being classified as “almost perfect” (20). Similar significant intraclass correlations were observed in all variables from the countermovement jump ($P \leq .05$), where jump height and flight time presented excellent levels varying from .91 to .92, classified as “near perfect” (20).

Table 1. Mean and standard deviation of jump height and flight time of squat jump and countermovement jump assessed by MyJump2TM and a contact mat in 40 male CP Football athletes.

<table>
<thead>
<tr>
<th></th>
<th>MyJump2™</th>
<th>Contact Mat</th>
<th>T</th>
<th>P-value</th>
<th>ES</th>
<th>r_{icc}</th>
<th>$P_{icc}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Squat jump</strong></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Jump Height (cm)</strong></td>
<td>25.1±7.4</td>
<td>26.2±6.2</td>
<td>-1.59</td>
<td>.12</td>
<td>.17</td>
<td>.84</td>
<td>&lt;.001</td>
</tr>
<tr>
<td><strong>Flight Time (ms)</strong></td>
<td>452.5±66.0</td>
<td>458.5±55.6</td>
<td>-1.47</td>
<td>.15</td>
<td>.17</td>
<td>.84</td>
<td>&lt;.001</td>
</tr>
<tr>
<td><strong>Countermovement Jump</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Jump Height (cm)</strong></td>
<td>28.4±6.5</td>
<td>27.8±6.1</td>
<td>1.42</td>
<td>.16</td>
<td>.09</td>
<td>.91</td>
<td>&lt;.001</td>
</tr>
<tr>
<td><strong>Flight Time (ms)</strong></td>
<td>477.7±56.1</td>
<td>473.2±52.5</td>
<td>1.56</td>
<td>.13</td>
<td>.02</td>
<td>.92</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Legend: ES – Cohen d effect size. $r_{icc}$ – Intraclass correlation coefficient. $P_{icc}$ – Level of significance of r_{icc}. Level of significance was set in $P \leq .05$.

Table 2 presented reliability data between evaluators, while Table 3 presented values between test and re-test. For both, high values of intraclass correlation and very low values of standard error of measurements and minimal detectable changes were found. Bland-Altman (Panel A) and correlations (Panel B) analysis are presented in figures 1 and 2 for SJ and CMJ, respectively. For both jumps, high levels of agreement were found, and the differences were similar for all ranges of heights.
### Table 2. Inter-evaluator intraclass correlation coefficient of squat jump and countermovement jump measurements in MyJump2TM App in 40 CP Football athletes.

<table>
<thead>
<tr>
<th></th>
<th>Evaluator 1</th>
<th>Evaluator 2</th>
<th>ICC</th>
<th>P-value</th>
<th>SEM</th>
<th>MDC (%)</th>
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<tr>
<td><strong>Squat Jump</strong></td>
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<tr>
<td>Jump Height (cm)</td>
<td>25.5±7.0</td>
<td>23.3±7.1</td>
<td>.93</td>
<td>&lt;.001</td>
<td>0.56</td>
<td>0.79 (3.09)</td>
</tr>
<tr>
<td>Flight Time (ms)</td>
<td>452.5±66.0</td>
<td>442.5±83.5</td>
<td>.90</td>
<td>&lt;.001</td>
<td>7.45</td>
<td>10.53 (2.33)</td>
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<tr>
<td><strong>Countermovement Jump</strong></td>
<td></td>
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<tr>
<td>Jump Height (cm)</td>
<td>28.4±6.7</td>
<td>27.1±7.8</td>
<td>.95</td>
<td>&lt;.001</td>
<td>0.36</td>
<td>0.51 (1.81)</td>
</tr>
<tr>
<td>Flight Time (ms)</td>
<td>477.7±57.5</td>
<td>468.7±71.3</td>
<td>.92</td>
<td>&lt;.001</td>
<td>5.12</td>
<td>7.24 (1.51)</td>
</tr>
</tbody>
</table>

Legend: ICC – Intraclass correlation coefficient. P-value – Level of significance set in $P \leq .05$. SEM: Standard error of measurement. MDC: Minimal detectable change.

### Table 3. Intra-evaluator intraclass correlation coefficient of the MyJump2TM in 40 CP Football athletes in squat jump and countermovement jump.

<table>
<thead>
<tr>
<th></th>
<th>1st Analysis</th>
<th>2nd Analysis</th>
<th>ICC</th>
<th>P-value</th>
<th>SEM</th>
<th>MDC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Squat Jump</strong></td>
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<td></td>
</tr>
<tr>
<td>Jump Height (cm)</td>
<td>25.5±7.0</td>
<td>24.8±7.4</td>
<td>.99</td>
<td>&lt;.001</td>
<td>0.07</td>
<td>0.10 (0.39)</td>
</tr>
<tr>
<td>Flight Time (ms)</td>
<td>452.48±66.02</td>
<td>447.8±70.2</td>
<td>.95</td>
<td>&lt;.001</td>
<td>4.08</td>
<td>5.77 (1.27)</td>
</tr>
<tr>
<td><strong>Countermovement Jump</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Jump Height (cm)</td>
<td>28.4±6.7</td>
<td>28.1±6.6</td>
<td>.99</td>
<td>&lt;.001</td>
<td>0.04</td>
<td>0.06 (0.20)</td>
</tr>
<tr>
<td>Flight Time (ms)</td>
<td>477.7±57.5</td>
<td>477.4±56.1</td>
<td>.99</td>
<td>&lt;.001</td>
<td>0.06</td>
<td>0.08 (0.01)</td>
</tr>
</tbody>
</table>

Legend: ICC – Intraclass correlation coefficient. P-value – Level of significance set in $P \leq .05$. SEM: Standard error of measurement. MDC: Minimal detectable change.
Figure 1. Bland-Altman (Panel A) and correlations (Panel B) for agreement analysis of squat jump.
Discussion

Principal Results
The main objective of this study was to assess the reliability of a mobile application that measures jumping performance in CP Football athletes to establish a reliable field.
evaluation possibility for jump analysis. In this sense, we assessed 40 male, physically disabled players with the MyJump2™ app and with a contact mat at same time. Additionally, two evaluators made the measurements with the app, and one of them repeated the measurement one week later to analyse the inter- and intra-evaluator variability, respectively. Our main results are showing that MyJump2™ is a reliable and valid method compared with the contact mat when assessing jump height and flight time.

Comparison with Prior Work
MyJump2™ seems to be reliable to assess jump height and flying time in CP Football. Our results are in agreement with two other studies that investigated the MyJump™ reproducibility in vertical jumps [14,15]. For example, Balsalobre-Fernandez et al. [15] evaluated the app's validity to assess CMJ jump in 20 recreationally active healthy men compared to a force platform. They observed a near perfect correlation at jump height, which is pretty similar to that found in our results. Thus, the authors indicated that CMJ could be easily measured and was reliable and reproducible through application. It is important to note that the reference method used by Balsalobre-Fernandez et al. [15] is a more precise method, compared with a contact mat that we have used in this study.

The other study on the theme [14] has analysed different jumps (drop jump, SJ and CMJ) in a sample of 21 male and female athletes, and the authors compared the app with a contact platform and a high speed video camera method. In all jumps, there was a strong and significant correlation between the instruments. Similarly, with our results, the CMJ has a strong correlation coefficient with the reference method in jump height (r = .95). Other relevant results are about the inter- and intra-evaluator variability. Our results show that the MyJump2™ is reproducible when used by different subjects and occasions. These results are in agreement with literature about MyJump2™ reproducibility [15].

Our findings point out the possibility of an accurate measurement of jump performance in CP Football athletes. The MyJump2™ validation makes possible the use of the app in field evaluations or in poorly equipped environments. Additionally, in competitive periods when it is not possible to use the gold standard equipment, the app seems a good alternative to evaluate athletes with neurologic damage, who should be constantly monitored [21,22] and who are also more susceptible to soft tissue lesions [23,24]. Given the portability and practicality of MyJump2™, smartphones can quickly become a standard method for assessing physical performance in the field with great precision in CP Football.

The comparison between MyJump2™ and other methods, such as force platforms [14–16] and the field method (Vertec) [25], is important to consolidate the app. This is justified by the use of few force platforms in field evaluations, which raises the importance of the comparison between MyJump2™ and other field methods [25]. In this regard, our study compares the app with one of the most used field techniques, the contact mat. Compared to the platform force, contact mats can be used in a wide variety of scenarios, and this can be considered a more ecologic option in agreement with the study that analysed a comparison between MyJump and Vertec [25]. Another factor that deserves further comments is the type of jumps assessed here. The CMJ and SJ are consistent with the current literature [14,16,17,26,27].

Another important aspect of the present study is that it appears as the first work using the application in a Paralympic sport, in which it is known that physical assessments are lacking and should be increased [28]. Another interesting characteristic of this paper concerns the sample. In the Paralympic context, it is particularly challenging to do
investigations with a large number of subjects, especially at higher competitive levels. Therefore, the present study used a significant Paralympic sample from a top national ranking team, which reinforces the originality and relevance of the present findings.

Limitations
The study has some potential limitations. Due the fact that data collection was conducted during a Brazilian CP Football Championship, it was not possible to use a better reference method, such as the force platform. Despite that, it could be considered as a methodological choice in order to raise ecological validity of our findings. With our study design, it was not possible to assess the use of the app in other conditions such as before and after the games to analyse applicability of the app, which we suggest for further studies.

Future directions
Since the MyJump2™ is a reliable method for assessing jump height in CP Football, future investigations may be designed in some topics differing from validation studies. With the limitations of laboratory methods, there is a trend to use small samples in investigations, and less field assessments are observed. Therefore, one possibility will be to assess a wide sample to establish reference values of jump height and flight time in CP Football, using a large sample as possible. Other possibilities may be to use the prospective assessments of the jump performance and the association with injury prevention parameters in this population. Regarding the validation studies, it seems to be an important possibility for the validation of MyJump2™ to assess other types of jumps, besides CMJ and SJ. For example, the asymmetry jump test, drop jump test and horizontal jump are three kinds of skills that can be used to assess jump performance and, until this date, do not have validation to CP Football evaluation.

Conclusions
Thus, we conclude that the MyJump2™ app presents high validity and reliability to measure the jump height and flight time of the squat jump and the countermovement jump in elite CP Football athletes and can be a very useful tool in the analysis of jump performance for the Paralympics. In addition, we believe that our findings could encourage trainers, coaches and athletes to monitor jump performance, which is relevant information to improve decision making in training control and prescription.

Acknowledgements
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Conflicts of Interest
"none declared"

Abbreviations
CMJ: Countermovement Jump
CP Football: Cerebral Palsy Football
CP: Cerebral Palsy
CV: Coefficient of Variation
ICC: Intraclass Correlation Coefficient
MDC: Minimal Detectable Change
SEM: Standard Error of Measurement
SJ: Squat Jump

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