Validation of split jump and the side-stepping jump coordination tests for cerebral palsy football athletes
Validación de las pruebas de coordinación split jump y side-stepping jump para atletas de fútbol con parálisis cerebral

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Abstract: Background: Football for athletes with cerebral palsy (CP) also involves the functional classification of players based upon the degree and form of the athlete's physical functionality. The aims of the cross-sectional study were: (a) to evaluate the validity of the side-stepping jump and split jump tests in CP football athletes and; (b) to analyse the differences in this ability between current functional classes; Methods: 60 Brazilian elite CP football athletes participated in this study. Each participant was eligible by the International Federation of Cerebral Palsy Football classes as: FT1, FT2 and FT3. In a test-retest design, the athletes performed the side-stepping jump and the split jump twice per session and were assessed by three different evaluators; Results: Both side-stepping and split jumps tests presented excellent objectivity, reproducibility and internal consistency with correlation values ranging from .83 to .96 (p<.001). The one-way ANOVA evidenced differences among the Classification groups for both tests: split jump (p= .019) and side-stepping jump (p= .004); Conclusions: These tests can be used in the new functional classification, contributing to an evidence-based classification of football for athletes with cerebral palsy.
Keywords: Classification; Paralympics; Evaluation; Reliability.

Resumen: Antecedentes: El fútbol para deportistas con parálisis cerebral (PC) también implica la clasificación funcional de los jugadores en función del grado y forma de la funcionalidad física del deportista. Los objetivos del estudio transversal fueron: (a) evaluar la validez de las pruebas de salto lateral y salto dividido en atletas de fútbol CP y; (b) analizar las diferencias en esta capacidad entre las clases funcionales actuales; Métodos: Participaron en este estudio 60 atletas brasileños de fútbol CP de élite. Cada participante fue elegible por la Federación Internacional de Fútbol para Parálisis Cerebral como clases: FT1, FT2 y FT3. En un diseño test-retest, los atletas realizaron el salto lateral y el salto dividido dos veces por sesión y fueron evaluados por tres evaluadores diferentes; Resultados: Tanto el test de paso lateral como el de split jumps presentaron excelente objetividad, reproducibilidad y consistencia interna con valores de correlación que oscilaron entre .83 y .96 (p<.001). El ANOVA de una vía evidenció diferencias entre los grupos de Clasificación para ambas pruebas: split jump (p= .019) y side-stepping jump (p= .004); Conclusiones: Estas pruebas pueden ser utilizadas en la nueva clasificación funcional, contribuyendo a una clasificación del fútbol basada en la evidencia para deportistas con parálisis cerebral.
Palabras Clave: Clasificación; Juegos Paralímpicos; Evaluación; Fiabilidad.

Introduction

According to the International Federation of Cerebral Palsy Football (CP Football Competition Rules, 2022), the football for athletes with cerebral palsy (CP) is a format of game played under the rules of the Football with some modifications. The CP Football is a 7-a-side game with two 30 minutes' halves, the field and the goals are smaller and it is played without off-sides (Cámara et al., 2013; CP Football Competition Rules, 2022; Kloyiam et al., 2011; Reina et al., 2016). As with all Paralympic sports, CP Football also involves the functional classification of players based upon the degree and form of the athlete's physical functionality (Reina, 2014; Reina et al., 2016). The classification system permits the inclusion of a spectrum of CP athletes induced

impairments and other acquired brain injury such as cerebral strokes or head injuries, which commonly lead to neuromuscular dysfunction. So, in the classification system based on the IFCPF the classes are namely FT1, FT2 and FT3 (IFCP Classification Rules, 2018). Each team must always field at least one class FT1 player on the field of play during a match, or the team will play with one less player and may always have a maximum of one class FT3 player on the field of play during a match. If the class FT3 player is dismissed, it is not allowed to replace a player in the field of play for a class FT3 player. In this respect, the IFCPF classification system influences the structure and effective performance of the team. This functional classification system makes the modality inclusive and maintain the fair play. The IFCPF classification is based upon the neurological impairment of the player.

Traditionally, regardless of skill level, the desire to develop consistency within complex motor skills remains a

priority for coaches. In this sense, the classification based on scientific evidence presents the same concept, mainly in the need to establish clear and concrete test validation procedures that can truly express the real motor characteristic of the Paralympic athlete. Classification systems are an integral part of Paralympic sport and are used to determine eligibility and control the impact of eligible types of disability on the outcome of competition. Valid ranking systems facilitate competition in the sense that successful athletes are not simply those who have less severe disabilities than their opponents, but those who have the most favorable combination of sporting attributes and have improved them to the best effect (Hoskins-Burney & Carrington, 2014). According to Beckman et al., 2014 «Classification that is not valid or that is not considered valid represents a significant threat to Paralympic sport. At the elite level, the legitimacy of an individual's competitive success or athletic performance can be significantly diminished by the perception that they are in the wrong class, with the potential for considerable personal and financial cost, as well as discrediting the sport. Paralympics as a whole. At the grassroots level, a rating system that is considered unfair will discourage participation among people with disabilities, rather than achieving the goal of increasing it.» To avoid subjectivity in CP Football classification system is essential to develop an evidence-based system of classification (Tweedy & Vanlandewijck, 2011). Although evidence-based methods in classification must use valid and reliable measures of disability, such measures cannot be the sole basis for the classification process (Beckman & Tweedy, 2009). Even if eligible impairments are permanent, they could be responsive to training.

So, the idea is to provide a classification system able to identify the athlete's functionality based on his motor ability, i.e. the motor coordination. Motor Coordination is believed to be an important physical component necessary for successful performance in Football. Age and maturity are related with differences in motor coordination among male elite youth soccer players (Rommers et al., 2019). Coordination is defined by the relative movements between segments of one limb (intra-segment coordination) or different limbs (inter-segment coordination), or between limb segments and an object to intercept (Newell, 1985). Football is a dynamic game in which many of the important skills to master are interceptive actions, such as kicking with the lower limb, heading and, in the case of the goalkeeper, catching and punching the ball (Bangsbo, 2014).

This study proposes 2 motor coordination tests which could improve the evidence-based classification system for CP Football: the lateral displacement jump or SIDE-STEPPING (Figure 1a (Dintiman & Ward, 1997)) and the anterior-posterior displacement jump or SPLIT JUMP (Figure 1b (Dintiman & Ward, 1997)). The goal of both tests is to evaluate the motor coordination in symmetrical lateral jumps (Dintiman & Ward, 1997). So, the aims of the present study were: (a) to evaluate the objectivity, reproducibility and internal consistency of the side-stepping jump and split jump tests in football players with CP; (b) to analyse the differences in the side-stepping jump and split jump tests among the CP athletes' functional classes. Our hypothesis is that differences in the motor coordination among functional classes can be found due to the different CP motor alterations.
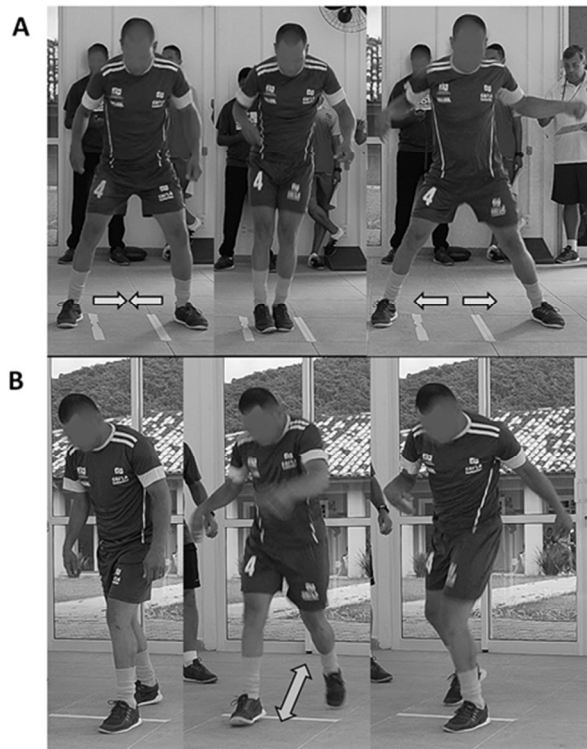

Figure 1. Jump tests analyzed in this study: A, side stepping test; B, split jump test.

Methods

Participants

A sample of 60 Brazilian elite athletes (26.2±1.66 years old, 1.75±3.52m, 70.78±7.04kg) of CP Football from the 8 clubs participating in the XVIII Brazilian CP Football Championship. The participants were classified according to the International Federation of Cerebral Palsy Football Classification Manual (Classification Rulebook, 2018) as: FT1 (n = 4), FT2 (n = 29) and FT3 (n = 27) classes. These differences between groups have occurred due the functional classification system characteristics and are reflecting the profile of the Championship's participants. All the sample athletes had, some type of CNS injury, such as Cerebral Palsy, Traumatic Brain Injury and/or Stroke. The Table 1 presents the sample characteristics.

Regarding the ethical aspects of the research, all subjects signed the Free and Informed Consent Form. The study was approved by the Ethics Committee in Research Involving Human Beings at UNICAMP (State University of Campinas) under the number 2.361.952.

Table 1.
Sample characteristics and differences among IFCPF functional classes.

Independent Variables	Total Sample	IFCPF Functional Classes		
		FT1	FT2	FT3
N	60	4	29	27
Height [m]	1.75±3.52	1.72±9.32	1.76±5.53	1.74±8.16
Weight [kg]	70.78±7.04	70.9±13.66	70.93±11.85	70.59±11.98
BMI [kg*m^{-2}]	23.04±3.52	23.68±2.61	22.90±4	23.1±3.18
Dependent Variables				
Split Jump [s]	22.58±9.11	29.47±16.49	23.42±7.63	20.66±9.07
Side-Stepping Jump [s]	20.83±8.36	23.91±9.12	21.96±7.81	19.18±8.81

Experimental Procedures

The data acquisition was held at the Paralympic Training Centre, in the city of São Paulo, Brazil. The data collection was obtained when the athletes were on training and/or playing in the championship.

To evaluate the Side Stepping test is necessary to position on the floor two parallel tapes measuring 50 cm length with a distance of 40 cm between them. The athlete is placed within the tapes space. At the evaluator's signal, the athlete starts to jump performing legs' parallel opening with the feet outside the tapes and then inwards forming a cycle (as illustrated in Figure 1a). The Split Jump test consists of positioning one tape with 50 cm length on the floor (Figure 1b). The athlete left foot is positioned in front of the tape and the right foot behind the tape. At the evaluator's sign, the athlete starts to perform simultaneous jumps changing the feet position and returning to the initial position, then a cycle is computed (as illustrated in Figure 1b). In both tests the subject must complete 25 cycles in the shortest time as possible. Lower is the time to complete the tests better is the athlete coordination.

Measurements

The participants were evaluated in two moments (test and retest), by three well-trained evaluators, with a time difference of forty-eight hours between test and retest. It allowed the analysis of the objectivity, reproducibility and internal consistency of the jump tests. Initially, the objectivity of the tests was evaluated by the comparison of the measurements done by the three evaluators. If these results did not reveal significant differences so we could assume consistent results when the jump tests are applied by different evaluators. Then, the measurements were also compared at two different times (test and re-test) and between the different attempts at the same time of application. In this way, reliability (ability to produce consistent measures in different tests for the same subject) and internal consistency (intra-test reliability) were tested.

Statistical analysis

For the data analysis, descriptive statistics were used, through the R software for Windows. When performing the tests, it was possible to observe the analysis of objectivity, reproducibility and internal consistency of the instrument. The one-way ANOVA for independent measures (parametric) was used to assess objectivity. Reproducibility and internal consistency were assessed using Pearson's (parametric) intraclass correlation coefficient.

Still the Shapiro-Wilk test and Levene's statistics were used to test data normality and variance homogeneity, respectively. Parametric statistics were applied by means of a one-way ANOVA for independent measures, aiming to compare the differences among the classification groups (FT1, FT2 and FT3). Tukey tests were applied to account for multiple outcomes. The power of the analysis and the partial eta squared (partial η2) value was calculated to verify the practical relevance of the main effects and interactions. As proposed by Richardson (Richardson, 2011) in this study, partial η2 values >0.01 were categorized as low, >0.06 as medium, and >0.14 as high. The level of significance for all tests was set at α <0.05.

Results

The classification groups (FT1, FT2 and FT3) displayed similar baseline demographic and clinical characteristics (Table 1): Height (F = 0.734; p= 0.485), Weight (F = 0.006; p= 0.994) and BMI (F = 0.09; p= 0.914).

Both side-stepping and split jumps tests presented excellent objectivity, that is, the tests demonstrated that they have the ability to objectively measure a variable, providing similar results even when performed by different evaluators. The tests also showed good reproducibility, which means that the test has a high degree of consistency or agreement of results when the measurement is repeated under identical conditions. In addition, these tests also showed excellent internal consistency, demonstrating that the tests really evaluate what they are intended to evaluate. All results of the Intra-Class Correlation as presented in Table 2, and the concordance analysis with the Bland-Altman test in figure 2. The one-way ANOVA evidenced no differences among the Classification groups for both tests: split jump (F = 1.928; p= 0.155; power = 0.402) and side-stepping jump (F = 1.068; p= 0.351; power = 0.238). For both comparisons, the partial η2 value shows that the relevance of this effect was medium: split (Partial η2 = 0.063) and side (Partial η2 = 0.036). The Table 1 presents these results.

Table 2.
Intra-Class Correlation (rICC (IC95%)) to determine internal consistency and reproducibility, and one-way analysis of variance for objectivity assessment.

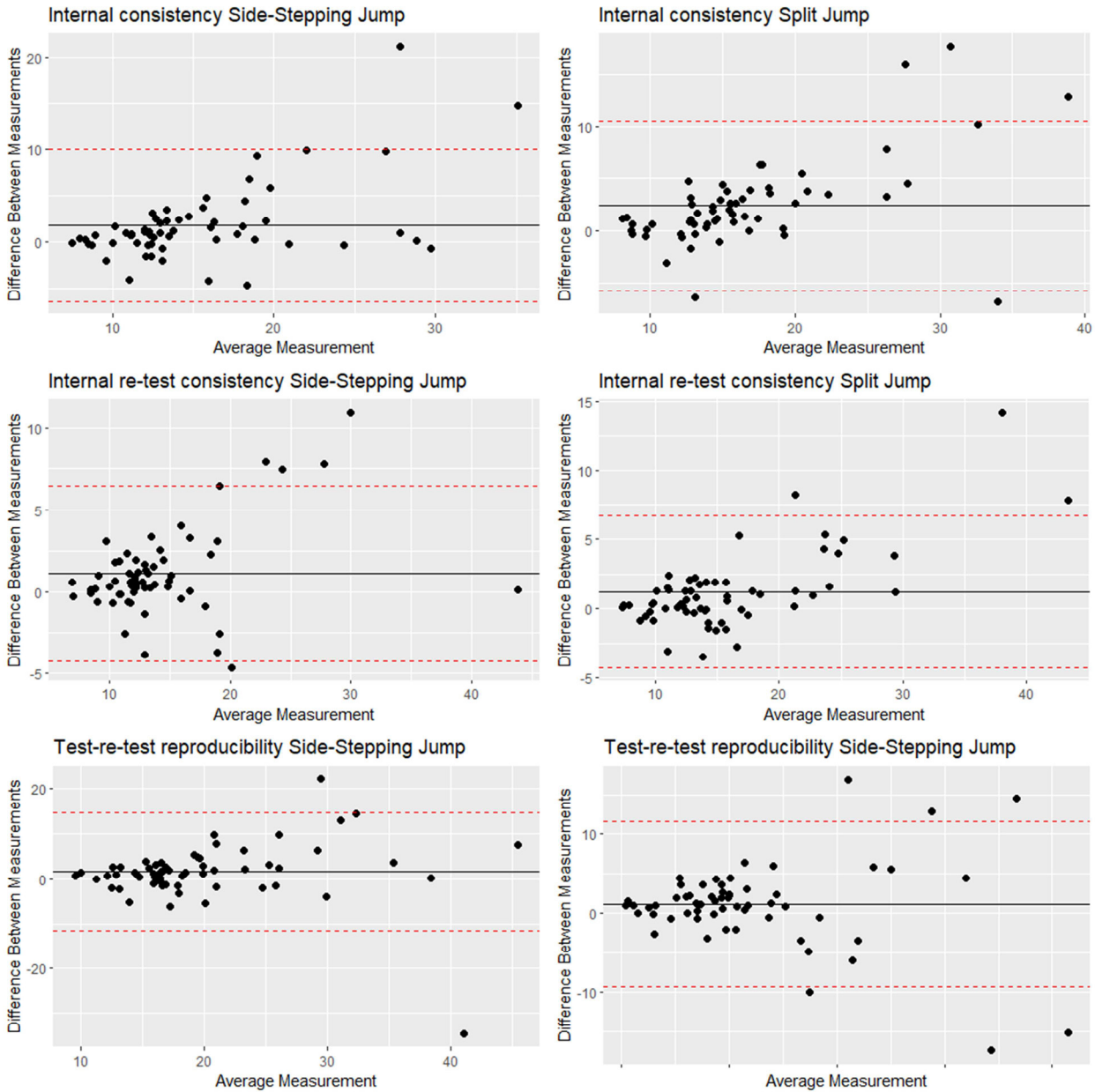| ICC	Side-Stepping Jump [s]			P-value	Split Jump [s]			P-value
Internal consistency test	0.82			< .001	0.83			< .001
Internal re-test consistency	0.93			< .001	0.94			< .001
Test-re-test reproducibility	0.66			< .001	0.83			< .001
	Evaluator 1	Evaluator 2	Evaluator 3	-	Evaluator 1	Evaluator 2	Evaluator 3	-
Objectivity	20.83±8.36	20.72±8.39	20.77±8.40	.997	22.58±9.11	22.44±9.09	22.49±9.34	.996

Figure 2. The concordance analysis with the Bland-Altman test

Discussion

The first aim of this study was to evaluate the objectivity, reproducibility and internal consistency of the side-stepping and split jump tests in CP Football players. Both tests showed strong to very strong values in objec-

tivity, reproducibility and internal consistency, except for Side-stepping in test reproducibility which was moderate. Once, no differences were observed in the measurements done by different evaluators (ANOVA one-way, with p > .90 for all the comparisons). The tests presented internal consistency values (r_{icc} = .82 and .93 for Side-stepping in

test and re-test, r_{icc} = .83 and .94 for Split in test and re-test) are excellent values and reproducibility (r_{icc} = .66 for Side-stepping and r_{icc} = .83 for Split jump) that can be considered as strong to very strong correlation values (Safrit, 1981).

The need to create valid tests that can be used in the evidence-based classification in Paralympic Sports is a relatively new topic and it presents an essential field to guarantee the legitimacy of the decisions made in the evaluation process of the athletes (Tweedy & Vanlandewijck, 2011). The motor coordination tests, applied in this study, emphasized an essential motor characteristic which is influenced by the functional classes of the athletes. In this sense, an accurate and reliable assessment can be important to the evidence-based classification system. Still, with these tests application is possible to quantify the motor coordination performance in legs displacement movements in antero-posterior (split jump) and lateral (side-stepping jump) directions. Generally speaking, standard validation of tests for individuals with disabilities is a relatively common practice. Spathis et al. 2015, in a study to validate the identification of sports talent, used conventional motor tests in twenty-eight individuals, obtaining mean correlation values r= 0.89, indicating that talent identification tests can be used to validly identify individuals with limitations motors. Other studies such as Javier et al., 2014 and Coswig et al., 2019 demonstrated that convectional tests can be used to validate test in Paralympic Sports.

The second aim of this study was to analyse the differences in this ability among different IFCPF functional classes. The results were the opposite of our hypothesis, once the performance in both tests was expected to be proportional to the CP Football athletes' classification level: the more functional the athlete, the better his results in the coordination tests. However, when the functional classes were compared, no significant differences were found corroborating with the study by Reina et. al. (2021). The FT1 class athletes are the ones who have more possibilities of limitation in these motor coordination tests. Most of them have severe involvement either by spasticity or dystonia in high degrees. Dystonia is a movement disorder characterized by persistent and intermittent muscle contractions that cause involuntary repetitive movements, and that can lead to abnormal posture in affected parts of the body that may leave to motor problems (Randby et al., 2018). Moreover, the abnormal dystonic movements can also be related with balance problems affecting the athlete's gait (Barbosa & Warner, 2018) and consequently influencing in the performance of the side-stepping and split jump tests. On the other hand, the FT2 (moderate involvement) and FT3 (light involvement) classification athletes, presented no differences when compared with FT1. By the CP Football

rules, each team must always field at least one (1) class FT1 player on the field of play during a match, or the team will play with one (1) less player. Each team may always have a maximum of one (1) class FT3 player on the field of play during a match, and, taking into consideration that mostly teams have a smaller number of FT1/FT3 athletes in the team (IFCP Classification Rules, 2018).

In Paralympic sport, an evidence-based classification system has a clear purpose and the methods used to classify athletes will achieve the stated purpose (Tweedy & Vanlandewijck, 2011). Even if the evidence-based classification process is based on valid and reliable measures of disability, the classification cannot be based solely on these measures (Beckman & Tweedy, 2009). In this sense, it is noteworthy that although eligible disabilities are permanent, many types of disabilities can respond to training. Thus, current practice calls for classification panels to assign a certain class, considering the results of the disability assessment in association with three other forms of assessment (*World Para Athletics Classification Rules and Regulations*, 2018): (a) novel motor tasks, which are tasks that are unlikely to have been practiced by the athlete in the usual course of training for his or her sport; (b) sport-specific activities that are likely to have been frequently practiced by athletes training for the sport; and (c) a detailed training history and other personal and environmental factors likely to affect sports proficiency.

Since the velocity training potential may influence the performance of the jump tests, it would be important to consider other parameters to be evaluated in these coordination tests, as: height, velocity, and time of each of the 25 jumps. Future studies will be designed to develop tools based on inertial measurement units (IMUs), which will be able to quantify not only the time to perform the 25 jumps in split and side tests, but also to quantify the jumps height, velocity, and time.

Our results suggests that both tests showed strong to excellent values of objectivity, reproducibility and internal consistency, except for Side-stepping in the test reproducibility which was moderate. Thus, these tests can be used in the new functional classification, contributing to an evidence-based classification of football for athletes with cerebral palsy.

Perspectives

The tests had a high index of scientific authenticity and could be used safely in the application of the same in the specific group of the study. It is understood, therefore, that the validation of tests for the new functional classification is fundamental, as one of the parameters to be used for the interpretation of the impact of the deficiency in the sport,

facilitating the allocation of the athlete in functional classes closer to its reality in terms of performance. Although complementary studies to the new CP Football class system is needed, it is expected that these tests will give more support to the classifiers for their making-decision as one of the parameters in the functional classification in the CP Football.

Funding

Acknowledgments

Conflicts of Interest

The authors declare no conflict of interest.

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