

Article

Developing the Five-Target Test (FTT) for the technical performance analysis in boccia

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Abstract: This study aimed to create a new throwing test for assessing technical performance (accuracy) in boccia among female international players with cerebral palsy. Five international athletes (100% of a National Team) representing different functional classes participated. The test, conducted twice over two days, involved throwing 8 or 12 balls at five ground targets. Time to complete the test was recorded, along with average radial error (ARE) and constant errors (CE) in the X and Y axes for each throwing zone and the total test. Results indicated consistent performance between repetitions but decreased execution time. Reliability indicators showed acceptable consistency (ICC = 0.44 to 0.71; SEM = 1.23 to 3.19; MDC = 2.44 to 6.33). This novel test demonstrates validity and reliability for evaluating technical proficiency in boccia BC1, BC2, and BC3 classes, offering practical implications for coaches in designing training programs.

Keywords: Paralympics, physical disabilities, brain injury.

1. Introduction

Boccia is a precision and strategic sport with its origins traced back to ancient Greece (Abellán and Sáez-Gallego, 2021). Over time, it has evolved into an adapted discipline catering to individuals with severe physical disabilities, including cerebral palsy (CP). Boccia players are considered by the International Paralympic Committee as Athletes with High Support Needs (AHSN), requiring more intensive and specialized

support at competitions (e.g. coaching, special equipment, etc.) (IPC, 2015). These AHSN continue to encounter obstacles to engage in sports (Perdue and Howe, 2013), portraying the most excluded group within the Paralympic Games, attracting minimal societal attention and, consequently, amplifying the dropout rate among these athletes (Brittain, 2016). However, since its inclusion as an official Paralympic sport at the New York Games in 1984, boccia has



gained worldwide recognition and has been the subject of interest in various scientific research studies (Reina et al., 2018; Gontara & Doewes 2023; Doewes et al., 2020; Kataoka et al., 2020; Lapresa et al., 2017). It is for this reason that Boccia technical teams increasingly seek to improve their training processes and performance assessment.

The sport of Boccia involves throwing balls (red or blue) from a seated position towards a target ball (white or Jack) over a series of rounds, with the aim of getting them as close as possible to the target ball (BISFed, 2021). Additionally, a Boccia match can involve individual (6 balls), pairs (3 balls), or team competition (2 balls) (BISFed, 2021). To participate in Boccia it is necessary to meet the minimum impairment criteria, and players are classified into four sport classes (BC1 to BC4), according to the impact that the impairment has on the motor actions (movements) of the game (e.g. throwing, grasping, wheelchair manipulation, etc.) (Tweedy et al., 2018). Specifically for people with CP, players can only be classified into three of these four sport classes (BC1, BC2 and BC3). In Boccia, unlike other para sports, the sport class that accommodates athletes with the most severe impairments is not the class with the lowest number, but rather class BC3. In this class, it is welcoming individuals whose impairment in all four limbs is so severe that they are unable to throw the Boccia ball onto the court with direction and purpose (BISFed, 2021). Consequently, they play with support aids known as a ramp, assistant, and, if applicable, also with a pointer. The sport class BC1, includes players with severe impairment, who may throw the ball into the court with their hand or with their foot.

Category BC2 includes athletes with less limitation than BC1 and BC3, capable of throwing the ball with their hands (BISFed, 2021).

Performance in boccia is delineated by the athletes' proficiency in positioning their ball as closest to the Jack, which may be positioned anywhere on the court measuring 10 meters in length by 6 meters in width. Therefore, boccia inherently encompasses a substantial tactical and strategic element, where an individual's performance is predominantly dictated by accuracy, contingent upon the direction of the throw and the force regulation (Reina et al., 2018). Additionally, the sport demands a high degree of trunk stability and fine motor coordination to execute precise throws, particularly for athletes with severe impairments who rely heavily on these physical skills (Roldan et al., 2020). The ability to adapt throws to varying distances and court positions further emphasizes the importance of force regulation and directional accuracy, both of which are essential for successful gameplay. Furthermore, athletes must continually make strategic decisions, such as choosing whether to prioritize offensive or defensive throws, while also considering the positioning of both their own balls and their opponents' balls. These technical and strategic demands are compounded by competition patterns, such as the impact of prolonged gameplay on fatigue and the influence of equipment properties, like the rolling friction and stiffness of boccia balls, on performance outcomes (Dickson et al., 2010).

Several studies have proposed different throwing tests to assess accuracy in this sport. For example, Kataoka et al. (2020)

proposed a test designed to assess the ability to generate force for achieving the longest possible distances on the field. In this test, participants aimed to throw balls to the lowest point on the court reachable by each individual, providing valuable insights into their maximal throwing capacity. Morris and Wittmannová (2010) considered assessing accuracy by establishing three key distances on the field (3m, 5m, and 9m) and throwing twelve balls at each distance. In this study, the investigation of accuracy through force modulation was the primary objective, as having the three targets in a straight line in front of the athlete meant that direction did not serve as a constraint to accuracy. Similarly, Reina et al. (2018) aimed to evaluate accuracy, focusing on force regulation rather than throw direction by aligning the three targets in a straight line. In contrast to Morris and Wittmannová (2010), Reina et al., (2018) identified the peak of the V at 1.5m as the primary performance point, with the other distances set at 3m and 5m. Researchers like Oliveira et al., (2021) endorsed the distances proposed by Morris and Wittmannová (2010), but they introduced direction as an additional dimension of accuracy ability. In this scenario, players are required to throw different balls to three distinct distances positioned to the players' right and left. Lastly, Gontara and Doewes (2023) introduced an innovative test that integrates both dimensions: distance and direction, employing various distances from previous studies and covering different areas of the court, thereby designing a more realistic and transferable test to a Boccia competition.

However, complex and lengthy tests may pose limitations when assessing Boccia

players, as fatigue can arise during the performance (Fong et al., 2012). Furthermore, scoring systems based on categories determined by the distance to the target (e.g., awarding one point if the ball lands between 0.5 and 1m from the target) may have low sensitivity in detecting performance changes (e.g., an improvement of up to 0.5m going unnoticed), as well as providing limited information to the coach regarding the direction in which systematic errors are occurring. Therefore, the aim of this study was to develop a new assessment tool, called “the five-target test” (FTT), for systematic assessment of technical performance (accuracy) in Boccia. The objective is to create a simple and rapid test to allow Boccia coaches to efficiently assess technical performance, with low time investment and ease of preparation and implementation, facilitating regular use in training sessions and camps. This new test addresses the two fundamental dimensions for assessing accuracy and incorporates the reference distances from previous studies, such as 3m and 5m (Gontara and Doewes, 2023). In contrast to earlier works, it introduces a target at 7m, considering that few players consistently reach the 9m distance on the field. Verifying the reliability of the test will be essential to ensure that coaches can determine whether variations in measurements primarily stem from changes in athletes' performance or are influenced by external factors such as surface conditions, equipment variability, or environmental conditions (Dickson et al., 2010).

2. Materials and Methods

Participants– Five female Boccia players with CP participated in the study.

Descriptive data for each player are shown in table 1. All participants were active licensed members of the Spanish Federation of Sports for People with CP (FEDPC). The players included in the sample were those selected by the national team for a training camp, representing a group of international players with experience at both the national and international levels. Additionally, the players had a weekly training volume of 10 hours (± 2 hours).

This study was approved by the Office of Research Integrity of the hosting institution (AUT.DCD.IPG.231106). All participants provided informed consent prior to participation in the study, according to the Declaration of Helsinki (2013).

Table 1. Descriptive data for the participants.

P	SC	N E (y)	IE (y)	t R1 (min)	t R2 (min)	ARE_R 1 (cm)	ARE_R 2 (cm)	ARE_Tot (cm)
P1	BC1	20	6	58	54	45.12	42.8	43.96
P2	BC2	2	1	55	54	52.76	39.8	46.28
P3	BC1	12	8	57	52	61.86	50.6	56.23
P4	BC3	4	1	43	28	17.28	27.4	22.34
P5	BC3	2	0	70	57	47.5	53.6	50.55

¹ P: player; SC: Sport class; NE: National experience; IE: International experience; t: time; R1: Repetition 1; R2: Repetition 2; ARE: Average radial error.

Materials— The materials needed to carry out the FTT procedure are: (1) Adhesive tape to make the 4 necessary marks on the floor. The fifth mark corresponds to the central cross of the court, already marked on the court. The arrangement of each mark, as well as the distances at which they should be placed, are specified in Figure 1; (2) a handheld meter or measuring tape, to assess the distance from each ball to the target mark; (3) a stopwatch, to assess the time taken to complete the test; and (4) the specific Boccia

equipment (e.g., balls or ramp if necessary) for each player.

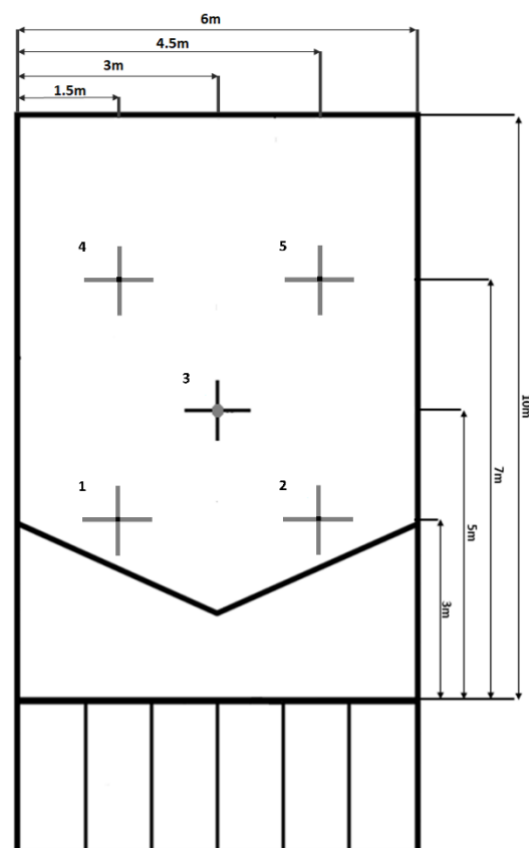


Figure 1. Graphical representation of the five-target test structure.

Procedure— Two repetitions (R1 and R2) of the FTT were conducted on two consecutive days for all members selected for a training camp of the Spanish National Boccia Team. Both measurements were taken at the same location (same court) and with the same equipment (individual equipment of each athlete). Prior to test execution, a standard warm-up consisting of ten throws to each mark, in the order preferred by the athletes, was conducted. In each test, the time taken to complete the test was recorded, as well as the distance in centimetres from each thrown ball to the target mark, along with the horizontal distance to the X-axis and the vertical distance to the Y-axis. Thus, for each throw, the researcher had to record 3

distances before removing the ball to avoid hindering the next throw. Figure 2 illustrates an example of the 3 distances that the researcher must measure for each throw. Athletes classified as BC1 and BC2 performed a total of 12 throws at each of the 5 marks, having to throw each type and colour of ball twice. Athletes classified as BC3 (with more significant disability impact) performed 8 throws at each of the five marks (also having to use all available balls at least once at each mark). According to Huang et al. (2014), players with more severe disabilities exhibited significantly longer movement durations during throws (mainly because smaller amplitude of elbow movement, greater amplitudes of shoulder abduction and flexion, slower maximal velocity of torso flexion and lower linear velocity of moving the wrist joint forward), which justified the reduction in the number of throws for BC3 athletes to ensure that the test remains efficient and practical for coaches.

Test Design— Five marks were made on the Boccia court: (1) in the lower left quadrant, 3m from the throwing area and 1.5m from the left sideline; (2) in the lower right quadrant, 3m from the throwing area and 1.5m from the right sideline; (3) right at the centre of the Boccia court (this mark may not be made if the court already has the centre marked), 5m from the throwing area and 3m from both sidelines; (4) in the upper left quadrant, 7m from the throwing area and 1.5m from the left sideline; and (5) in the upper right quadrant, 7m from the throwing area and 1.5m from the right sideline. For further information, please refer to Figure 1.

Development— Once the warm-up phase concluded, the athlete assumed position within the central box. After the researcher's

elucidation of the test protocol, the athlete prepared to execute his/her first throw. At this juncture, the researcher initiated the stopwatch. The sequencing of throws at each mark, as well as the order of ball types thrown within each target mark, was randomized to mitigate potential fatigue-induced effects on the test outcome. The examination reached completion once all players had thrown all their allocated balls (ranging from 8 to 12, contingent upon their sport class) at the five designated target marks.

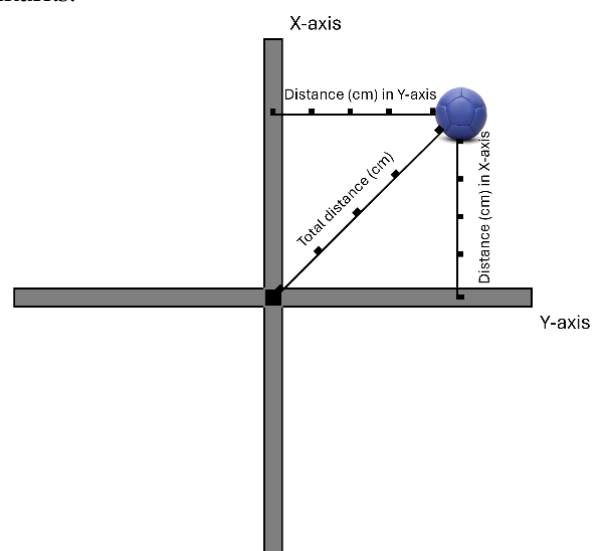


Figure 2. Graphical representation of the three distances measured (in cm) after each throw, for each field zone in the five-target test.

Assessment of Each Attempt— Following each throw, the researcher assessed the attempt and removed the ball. In each attempt, the researcher assessed the distance from the athlete's thrown ball to the centre of the target mark using the measuring tape. The measurement was recorded in centimetres and with two decimal places. The distance to the centre of the mark on the X and Y axes was also recorded, considering that the values on each axis can be positive or negative (see Figure 2 again). It is worth

noting that measurements were taken from the exact point corresponding to the centre of the mark made on the ground to the nearest point of the thrown ball. The three distances obtained in each attempt were recorded in the Excel spreadsheet as follows: (1) Distance from the ball to the centre of the mark; (2) distance from the ball to the Y-axis line (vertical measurement) to assess the distance in the X-axis; and (3) distance from the ball to the X-axis line (horizontal measurement) to assess the distance in the Y-axis.

Statistical Analysis– The time taken to complete each repetition of the test was recorded in minutes. Once the 3 distances (total distance to the centre of the mark, distance to the X-axis, and distance to the Y-axis) of each throw were recorded, the Average Radial Error (ARE), Constant Error (CE) on the X-axis, and CE on the Y-axis were calculated for each of the 5 throwing zones using the Excel spreadsheet. The ARE was calculated as the average of the distances between the throws made in each throwing zone and the target mark of that zone, in centimetres, resulting in one ARE for each throwing zone (ARE_Z1, ARE_Z2, ARE_Z3, ARE_Z4, ARE_Z5). Similarly, the CE on each axis was calculated as the average of the distances (considering that these could be positive or negative) with respect to each axis (X and Y), in centimetres, for each of the throwing zones, resulting in one CE on each axis for each throwing zone (CE_X_Z1, CE_Y_Z1, CE_X_Z2, CE_Y_Z2, CE_X_Z3, CE_Y_Z3, CE_X_Z4, CE_Y_Z4, CE_X_Z5, CE_Y_Z5). All these error measures were obtained in each of the two repetitions of the test carried out by the athletes (R1 and R2).

A Shapiro-Wilk test was used to check the normality of the data sets used for

subsequent analyses. A paired samples t-test was performed to check the differences between ARE, CE_X, and CE_Y of R1 compared to R2. Paired samples t-test was also used to check the differences between the times taken in R1 and R2. The standardized differences or effect sizes (ES) at 95%CI between sport classes were expressed in Cohen's d units to assess the magnitude of the differences between R1 and R2, and between t1 and t2, and they were interpreted as trivial (<0.19), small (0.20–0.49), moderate (0.50–0.79), and large (>0.80) (Cohen, 1992).

The relative reliability of the test was assessed using the Intraclass Correlation Coefficient (ICC) obtained by comparing ARE, CE_X, and CE_Y between R1 and R2. The ICC was interpreted as low (ICC<0.40), moderate (0.40> ICC <0.75), or high (ICC >0.75) (Fleiss, 2011). Additionally, the standard error of the measurement (SEM) and the minimal detectable change (MDC) were calculated to complete the interpretation of the test's reliability. The SEM was calculated as the standard deviation divided by the square root of the sample size, and the MDC was calculated using the following formula: $MDC = SEM \cdot \sqrt{2 \cdot 1.9628}$

All data analyses were performed using Microsoft Excel® and JASP software (JASP Team, Version 0.17.3) and the level of significance was set at $p < .05$.

3. Results

The Shapiro-Wilk test revealed a normal distribution for all datasets used in the statistical analyses. The paired t-test indicated a significant reduction in the time taken to complete the test in R2 compared to

R1 (R1 [min] = 56.6 ± 9.61 ; R2 [min] = 49.0 ± 11.87 ; $t = 2.80$; $p = 0.049$; ES (95%CI) = $1.25 [0.06; 2.43]$). However, no statistical differences were found in ARE, CE_X, and CE_Y between R1 and R2 (see Table 2 and Figure 3). Effect sizes suggest a low difference in the test outcome between R1 and R2 with trivial or small ES. Reliability analyses are also included in Table 1. These showed moderate relative reliability, with ICC values between 0.40 and 0.75, while demonstrating acceptable standard error of measurement and minimal detectable change.

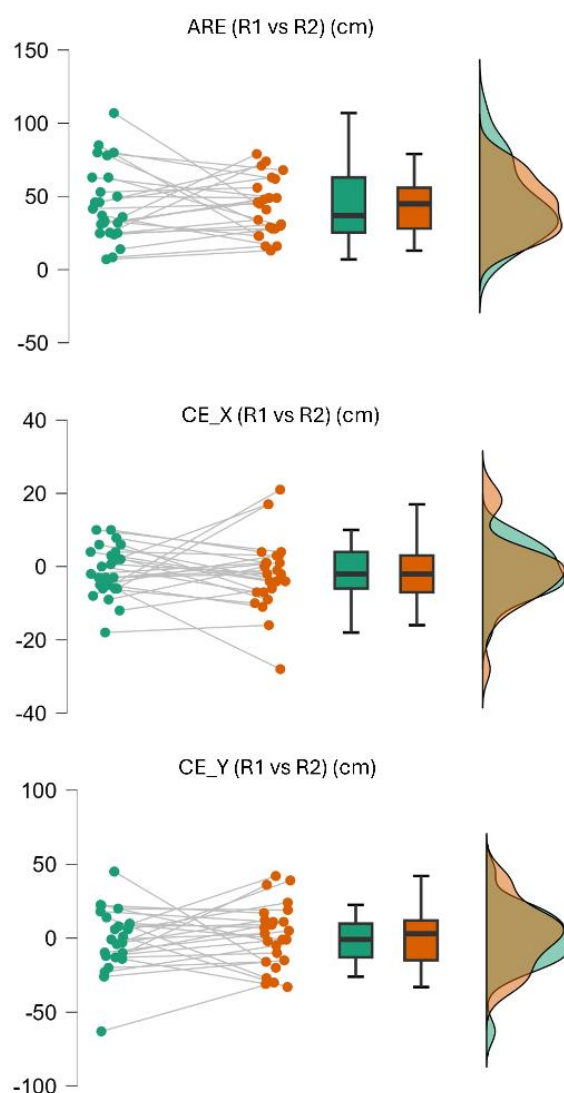


Figure 3. Individual data and averages for the whole test in in Average Radial Error, Constant Error in X axis, and Constant Error in Y axis, between Repetition 1 and Repetition 2.

4. Discussion

The aim of this study was to develop a new assessment tool, called “the five-target test” (FTT), for systematic assessment of technical performance (accuracy) in Bocchia. The main novelty of this study is that the FTT provides quantitative measures of throwing error, including Average Radial Error (ARE) and Constant Errors (CE) on the X and Y axes. This approach offers deeper insights into the magnitude and directionality of errors, enabling coaches to identify specific technical deficiencies, such as force control or systematic directional deviations. The FTT also demonstrates versatility by being applicable across different functional classes (BC1, BC2, BC3) and practicality through its low-cost, time-efficient design, making it a valuable tool for performance monitoring and training adjustments in Bocchia.

Similarly to Gontara and Doewes (2023), the use of five throwing zones in the FTT implies a challenge for the athlete, as they are positioned at 3 different distances from the throwing box (3, 5 and 7m) and at three different widths, enhancing the assessment's versatility and depth. Including marks at different distances is a positive aspect, as long-distance throws are directly related to overall performance in Bocchia (Fong et al., 2012).

The FTT yielded valid and reliable results. The test exhibits construct validity stemming from content validity and face validity. No statistical differences were found in ARE, CE_X, and CE_Y between R1 and R2, indicating consistency in the test

results. The internal consistency observed in the test indicates its validity, reliability, and reproducibility as a measure for Boccia. However, the duration required to complete the test was shorter in R2 compared to R1, suggesting a potential learning effect in the procedure might be influencing the speed of the test, though not its outcome. The authors suggest that the reduction in time between R2 and R1 could be attributed to enhanced efficiency on the part of the researchers in measuring distances during each throw, rather than the speed at which athletes execute their throws. The ICC, SEM, and MDC data also indicate that, despite the inherent variability in the athlete's ability to execute a throw to a specific point, the results across each throwing zone tend to be consistent between R1 and R2, with moderate reliability values. While group comparison analyses show low differences between R1 and R2, indicating good test consistency, it is worth noting that data dispersion appears large in both test repetitions, potentially leading to substantial individual changes between R1 and R2 (Figure 3). Therefore, the favourable reliability results should be interpreted with caution. This variability could stem from both athlete-specific factors, such as skill level and familiarity with the test, and external influences, including surface conditions or equipment changes (Dickson et al., 2010). Such variability underscores the importance of interpreting FTT results cautiously, particularly when making intra-athlete comparisons over time or evaluating the effects of training. To mitigate this, it is recommended that coaches use multiple test sessions to establish a reliable baseline for each athlete and complement quantitative data with

qualitative observations to better understand the sources of error. By addressing individual variability in this way, the FTT can provide more actionable insights for tailoring training programs and monitoring progress.

The FTT has proven its effectiveness as a test for assessing technical performance, particularly accuracy, in Boccia. It facilitates the establishment of initial values for comparative analysis among athletes and enables the observation of improvements or deteriorations in test results, thus aiding in the assessment of athletes' adaptation to the training process. In this line, it is necessary to correctly interpret the values of ARE, CE_X, and CE_Y presented in this study. The results shown by the FTT are based on the amount and direction of the player's throwing error. This strategy for calculating test performance has only been used in the previous study by Reina et al. (2018), as most tests in this field usually employ a scoring system based on different categories of distances from the target where the thrown ball lands (Morris and Wittmannová, 2010; Oliveira et al., 2021; Doewes et al., 2022; Gontara and Doewes, 2023). These scoring system tests utilize an evaluation system (total test score) that is based on the allocation of points, contingent upon the distance from which the coloured ball is thrown in relation to the target (which may be either the target ball or a mark on the ground). For example, in the Morris and Wittmannová (2010) test, scoring was based on 1, 2, and 3 points, depending on the distance between the coloured ball and the target ball (<9.0 cm; >9.0 cm - <18.0 cm; >18.0 cm - < 27.0 cm, respectively). This same scoring category system has recently been utilized in the Sebelasmaret Boccia Throw Test by Gontara and Doewes (2023).

Table 2. Descriptive data (mean $\pm$ standard deviation) for five-target test results in Repetition 1 and Repetition 2, including paired t-test comparison and reliability data.

	R1 (M $\pm$ SD)	R2 (M $\pm$ SD)	t (p)	ES (95%CI)	ICC	SEM	MDC
ARE (cm)	44.90 $\pm$ 25.76	42.84 $\pm$ 19.30	0.37 (.72)	0.07 (-0.32; 0.47)	0.71	3.19	6.33
CE_X (cm)	-1.23 $\pm$ 6.91	-1.56 $\pm$ 10.30	0.15 (.88)	0.03 (-0.36; 0.42)	0.44	1.23	2.44
CE_Y (cm)	-1.20 $\pm$ 21.11	1.76 $\pm$ 21.38	0.57 (.58)	0.11 (-0.28; 0.51)	0.61	2.98	5.91

R1: Repetition 1; R2: Repetition 2; ES: Effect size; CI: Confidence intervals; ICC: Intraclass correlation coefficient; SEM: Standard error of the measurement; MDC: Minimal detectable change; ARE: Average radial error; CE_X: Constant error in X-axis; CE_Y: Constant error in Y-axis.

The present study highlights the potential limitations of scoring systems based on point attribution regarding distance categories, as observed in Oliveira et al. (2021) and Doewes et al. (2022). These systems may lack sensitivity to detect subtle performance improvements or declines, particularly when athletes achieve small yet meaningful changes in accuracy. For instance, if a player consistently improves by a few centimeters within a distance category, the scoring system may fail to reflect this progress, thereby limiting its utility in monitoring gradual performance adaptations.

Furthermore, a significant drawback of these categorical scoring systems is that they do not provide information about the directionality of the error. For example, neither the athlete nor the coach can determine whether a low score is due to consistently overshooting or undershooting the target, or due to deviations to the left or right. Without this critical information, it becomes challenging for athletes and coaches to identify the root cause of errors and implement targeted corrective strategies to improve performance. This lack of detailed

feedback restricts the ability to tailor training interventions effectively.

Comparatively, other studies in para-sports have also reported challenges with categorical scoring systems. For example, Morris and Wittmannová (2010) observed similar issues in boccia scoring, where static point ranges did not adequately capture performance variability. These findings align with the present study's emphasis on using quantitative measures, such as ARE and CE, to provide more nuanced feedback on athletes' precision and directionality.

Additionally, studies like Reina et al. (2018) have demonstrated the value of quantitative metrics for assessing technical performance in para-sports. Their approach aligns with the current findings, underscoring that a detailed, quantitative evaluation can enhance test sensitivity and provide actionable insights for coaches and athletes. This is particularly critical in boccia, where performance is highly influenced by small, precise adjustments in throwing technique.

By addressing these limitations, the FTT offers a more advanced assessment approach, enabling athletes and coaches to not only track performance changes more

sensitively but also understand the direction and magnitude of errors. This capability allows for targeted training adjustments, such as focusing on correcting systematic overshooting or lateral deviations, ultimately leading to improved performance outcomes. The FTT's design thus represents a significant step forward in addressing the gaps identified in traditional scoring systems for para-sports.

Specifically, a positive value on the X and Y axes in the present test indicates that the athlete tends to consistently overshoot the target area (on average) and tends to deviate to the right in throws to that target, respectively. Negative values on the X and Y axes indicate that the player tends to consistently fall short and deviate to the left, respectively, in throws to that target. For better comprehension, the CE on the X and Y axes can be plotted in each zone (see an example of this in Figure 4), enabling coaches to assess if their athletes tend to make long/short throws or deviations to the right/left (and the magnitude of those errors) for each throwing zone.

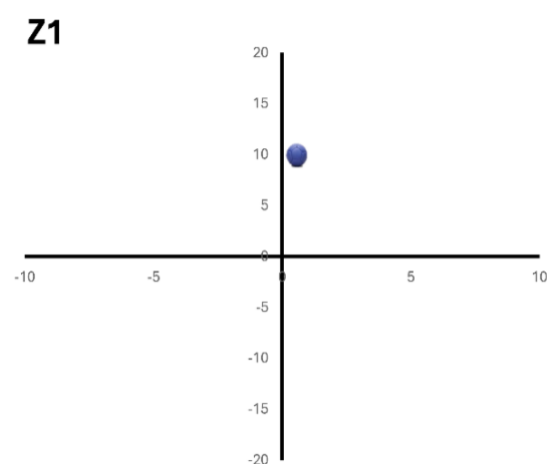


Figure 4. Example of graphical representation of Constant Error on X and Y axes across throwing zones.

Another contribution of the FTT is its potential to assess different types of errors associated with the throws accumulated in five specific areas of the Boccia court. Through the ARE, athletes and coaches can determine the "amount of error" accumulated in that zone, on average. This information is basically quantitative and may be more sensitive than the information provided by the previously described tests through a scoring system. In contrast to tests where higher performance correlates with a higher test score, in the FTT, enhanced performance is associated with a decrease in the value of ARE. Additionally, this test assesses CE on the X and Y axes and, consequently, athletes and their coaches can ascertain whether errors primarily stem from excessive or insufficient force in throws to each zone or, if there is a deviation in the throw pattern to the right or left at each mark. Armed with this information, coaches can determine whether athletes should concentrate their training on force control and/or rectifying systematic errors in throw directionality. Moreover, these decisions may vary across different throwing zones (see examples in Figure 5). Figure 5 presents the results of a player in the FTT, comparing them to the average performance of the evaluated group (this average may represent a team, a group of monitored players, etc.) for each throwing zone. This comparison allows for the identification of the player's strengths and weaknesses in specific zones, providing valuable insights for decision-making. For example, it can guide efforts to improve precision in certain areas of the field or inform strategic choices about which zones to target during gameplay to optimize performance in competition. This enables

high-level Boccia players to tailor their training regimen differently for various throwing zones and monitor performance over time (see Figure 6).

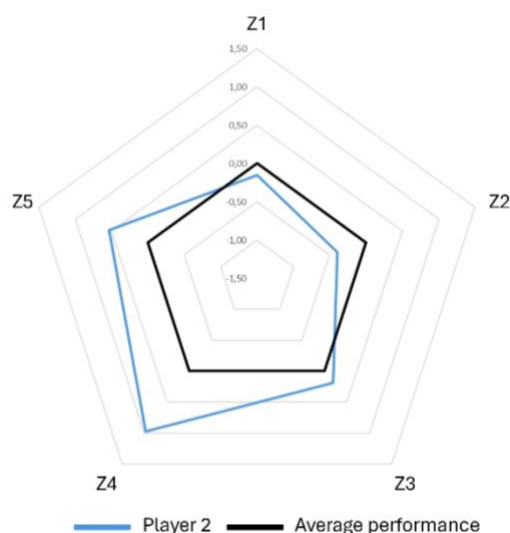


Figure 5. Example of graphical representation of a player's Average Radial Error across different throwing zones of the test, comparing to the group average.

Lastly, another important aspect to highlight regarding the TFF is its versatility for use with players with diverse functional profiles. Currently, in the literature, there is a scarcity of studies conducted with players who have the highest physical limitations, such as

Boccia players in class BC3. The few studies conducted with this sports class have designed assessment tests that can only be used by them, such as analysing the use of the ramp and assistant relationship (Lapresa et al., 2017; Alves et al., 2018). The FTT enables coaches to assess the entire team collectively, regardless of their sport class, in a short amount of time, which is an important aspect to consider when choosing assessment tests.

An aspect that has been considered for the design of the FTT is that it had to be an efficient test in terms of time and use of materials, to avoid that the implementation of the test throughout the athletes' training process implies a significant reduction in the time spent in training. It is also very important that it does not imply an additional cost, economically, since Boccia athletes and clubs and federations already have high economic expenses in the acquisition of specific sports equipment. Finally, this test also meets conditions of efficiency and simplicity in setting up and recording data

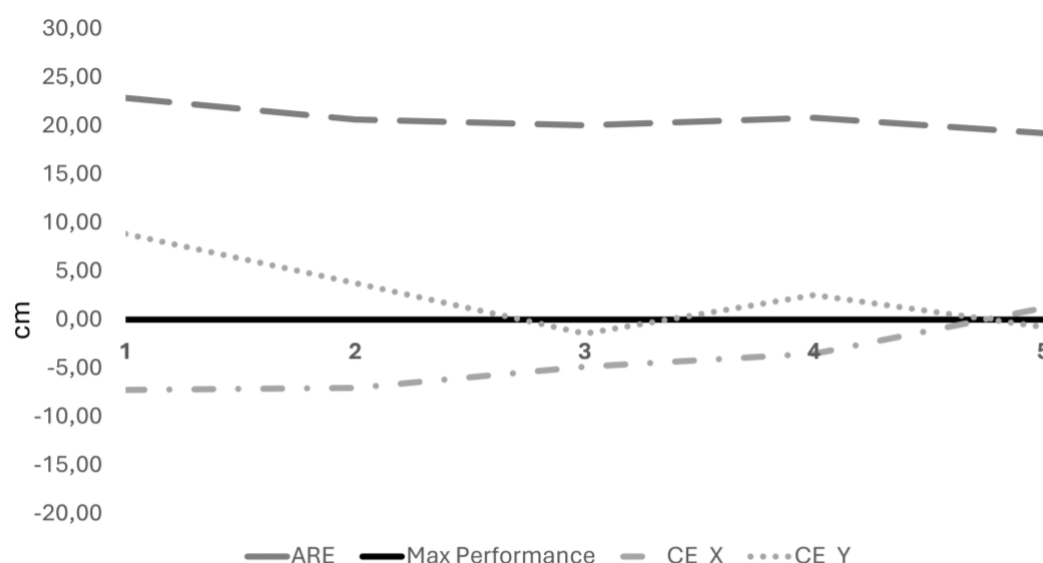


Figure 6. Example of graphical representation of various errors (ARE and CE) over time as a measure of athlete's technical performance monitoring.

FTT limitations– The FTT is a test designed to assess throwing accuracy in Boccia, understanding that throwing accuracy is closely linked to the technical performance of Boccia players. This test does not consider other performance parameters that may be equally important in Boccia, such as strategy, decision-making during competition (tactics) or athletes' communication skills (i.e. BC3). Therefore, it would be necessary for coaches to complement this test with other assessments related to other performance parameters in Boccia in order to gain a comprehensive understanding of the athlete's sporting performance. Furthermore, this study presents certain methodological limitations that should be taken into consideration when interpreting the results. The study has been conducted with a very small sample size ($n=5$), which, although representative (athletes belonging to the Spanish national team), entails a limitation when generalizing the results obtained. Future research with larger sample sizes could provide new data on the validity, reliability, and utility of the FTT for Boccia. Moreover, the reliability of the test is moderate, and aspects such as changing the playing surface, changing sports equipment (e.g., balls), etc., could negatively influence the reliability of the test. For this reason, it is recommended that coaches include qualitative aspects in their assessments of the FTT, such as whether there has been a change in the playing surface or equipment compared to the last test conducted, as this could partially bias the results. On the other hand, these sources of variability are inherent to the sport modality and influence performance in competition, so being able to assess the change in technical performance due to the influence of these contextual factors can be a positive element in preparing for competition.

5. Practical Applications.

The development of the FTT offers significant practical applications for Boccia, particularly for athletes with CP. It enables coaches to design targeted training programs by identifying specific areas for improvement, such as force control or directional accuracy, based on precise data from average radial error (ARE) and constant errors (CE) in the X and Y axes. The FTT provides an objective, reliable, and valid measure of technical proficiency, facilitating both intra- and inter-subject comparisons, and allowing for efficient tracking of athlete progress. Its simple and quick administration minimizes time and resource requirements, making it easily integrable into regular training sessions. Additionally, the FTT's versatility ensures applicability across different sport classes (BC1, BC2, and BC3), promoting fairness in performance evaluations. Real-time feedback enables immediate performance assessment and timely training adjustments. Furthermore, the FTT contributes valuable data to sports science research, enhancing the understanding of performance dynamics and advancing training methodologies in Boccia. Overall, the FTT supports the development of athletes with CP in achieving their highest potential in the sport.

6. Conclusions

The FTT is presented as a developing test for assessing technical performance (precision) in Boccia. Initial results suggest that it is a valid, reliable, useful, and efficient test. This test positions itself as a low-cost and equipment-free assessment, leading to a significant reduction in the time required for its administration, and its ease of use allows it to be implemented at various points throughout the Boccia players' season to evaluate the impact of training on their technical performance. Results of this test display the average radial error of players in

5 zones of the field at different distances, as well as the average constant error at each distance on the X and Y axes. With this information, coaches can understand the magnitude of the error associated with each athlete's throws in each zone of the field, as well as the directionality of that error. Through the systematic application of this test in performance groups over time, inter-subject comparisons (comparison with the group) as well as intra-subject comparisons (individual technical performance evolution over time) can be made, allowing the effects of training programs to be assessed.

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