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Abstract

This study aimed to analyse the influence of classification on the performance of Boccia in international-level events. The official results of the 2012 and 2016 Boccia Paralympic Games (PG), 2017 European Championships (EC), and 2018 World Championships (WC) were considered for analysis, a total of 3.962 partials, which represent 47.544 ball throws by players. We found a growing trend of participation when comparing the PG editions and the 2017 EC and 2018 WC, and the majority of partials were adjusted (in the region of 75%, 1-2 balls difference), . Differences based on the Boccia classification and the type of partial were only observed in individual BC3 and teams BC1 & BC2. These results highlight the need to further and deeper study these classes, characterized by rules related to teams´ constitution and game dynamics that differentiate them from other classes. This is relevant in the perspective of assurance of similar conditions for performance based in specific functional capacity and correct classification, guaranteeing that practice is attractive and motivating to improve the quality of life, opportunities for inclusion in society, and setting an example for other citizens with and without disabilities to get involved in playing Boccia.

Keywords: adapted sport; ability; strategy; inclusion; wellbeing.

Resumen

Este estudio tiene como objetivo analizar la influencia de la clasificación en el rendimiento de Bocha en eventos de nivel internacional. Se consideraron para el análisis los resultados oficiales de los Juegos Paralímpicos (JP) de Bocha de 2012 y 2016, los Campeonatos de Europa (CE) de 2017 y los Campeonatos del Mundo (CM) de 2018, un total de 3.962 parciales, que representan 47.544 lanzamientos de pelota por parte de los jugadores. Encontramos una tendencia creciente de participación al comparar las ediciones de JP y los CE 2017 y CM 2018, y la mayoría de los parciales fueron ajustados (en la región del 75%, 1-2 bolas de diferencia). Las diferencias basadas en la clasificación Bocha y el tipo de parcial sólo se observaron en BC3 individual y equipos BC1 & BC2. Estos resultados ponen de manifiesto la necesidad de profundizar en el estudio de estas clases, caracterizadas por reglas relacionadas con la constitución de los equipos y la dinámica de juego que las diferencian de las demás clases. Esto es relevante en la perspectiva de asegurar condiciones similares para el rendimiento basadas en la capacidad funcional específica y la clasificación correcta, garantizando que la práctica sea atractiva y motivadora para mejorar la calidad de vida, las oportunidades de inclusión en la sociedad, y sirviendo de ejemplo para que otros ciudadanos con y sin discapacidad se involucren en la práctica de la Bocha.

Palabras Clave: deporte adaptado; capacidad; estrategia; inclusión; bienestar.

Introduction

Participation in sports has shown many benefits for the mental and physical health of individuals with disabilities (Khoo *et al.*, 2018). In this respect, older individuals and children with physical and intellectual disabilities also benefit from regular physical activity (PA), which is associated with immediate improvements in aerobic capacity, physical and cognition function, and physical development, as well as longer-term benefits on functional abilities and quality of life (Blick *et al.*, 2015; Ash *et al.*, 2017; Lai *et al.*, 2020). In this particular, adapted sports make use of adapted equipment or rules to make sports accessible to individuals with disabilities (Swartz *et al.*, 2019). Also, of note, that publications of manuscripts related to sports for people with disabilities have increased by 49% since 2006 (Gamonales *et al.*, 2023). Cerebral Palsy (CP) is categorized under physical disability and refers to posture and a group of movement disorders generally associated with behavioral and emotional difficulties, epilepsy, intellectual disability, communication, and language issues (Ying *et al.*, 2021).

Although primarily classified as a motor disorder, CP is often accompanied by sensation, perception, cognition, communication, and behavior disturbances. Activity limitations are presumed to result from these combined factors. Much of the treatment offered is targeted towards the dimension of neuromuscular body function, whereas the goal is to improve activity (Braendvik *et al.*, 2010). Studies have shown that individuals with CP who possess higher levels of emotional intelligence tend to experience better social relationships, greater self-esteem, and improved coping abilities in the face of challenges associated with their condition (Wang *et al.*, 2020; Papoutsi *et al.*, 2022). It is a non-progressive disorder that affects muscle tone, strength, coordination, and motor skills during human development (Woollacott *et al.*, 2005). Based on different studies, it is estimated that the prevalence of CP in developed countries is 2.11 children with CP per 1.000 live births (Oskoui *et al.*, 2013; Sadowska *et al.*, 2020). In addition, CP is a non-progressive neuromotor disorder that affects the developing fetal or infant brain (Oskoui *et al.*, 2013), and can cause different types of neurodevelopmental disorders, such as muscle weakness, selective voluntary motor control, reduced coordination, contracture, and spasticity (Gormley, 2001).

Players with CP tend to present highly affected neuromuscular functions related to muscle tone, agonist and antagonist muscle synergies and/or the range of motion of the impaired limbs, causing limitations in upper limb movements (Van Thiel *et al*., 2000) and hand function Braendvik et al. (2010). For example, players with hypertonia present spastic flexor muscles that will affect elbow extension during the throwing action (Purohit *et al.*, 1998), leading to greater variability in throwing. According to Darainy & Ostry (2008), and Silva *et al.* (2009), stiffness modulation is assumed to vary with different tasks and environmental constraints. Granata *et al.* (2000). also stated that the electromechanical delay could be affected by muscle stiffness, especially in spastic muscles, and the mixed pictures of hypertonia with/without athetosis and/or dystonia usually presented by BC1 and BC2 Boccia players could influence the performance variability (e.g. release the ball). It was previously found that children with diplegic CP are characterized by impairment of motor control more severe in the lower extremity than in the upper extremity, presenting limited postural adjustment of the lower extremities in certain external perturbation conditions (Burtner *et al.*, 2007). Further, children with less motor ability had a more curved hand path (Ju *et al.*, 2010), and hand reach performance and postural control ability are significantly positively correlated in children; the better a child's postural control ability is, the more coordinated and efficient the child's hand reach performance will be (Ju *et al.*, 2010). Regarding this evidence, more recently, it was indicated that PA can help reduce some of the secondary conditions in individuals with CP and improve balance, muscle tone, and posture (Cho *et al.*, 2020).

Reina *et al.* (2015), stated that Boccia is a sport of precision, consisting of a series of rounds in which players must try to place the game balls (in red or blue color) as close as possible to the target ball, the jack (in white color)**.** It is a strategic game that demands high coordination and control of movement to achieve accuracy (Reina *et al.*, 2016), requiring a high degree of muscle control, coordination, accuracy, concentration, the ability to strategize, emotional control, interaction with others, and tactical awareness (Fong *et al.*, 2021). The colored balls are allowed to be thrown by hand, kicked by feet, or, if the competitor's disability is severe, launched with an assistive device, specifically in athletes with BC3 classification. At the end of each round or end, the referee measures the distance of the colored balls closest to the jack and awards points accordingly. The team/player with the highest number of points at the end of the game is the

winner, all events feature individual, pair, and team competitions. Depending on their physical and functional abilities, Boccia athletes are assigned to one of the four sports classes, BC1-BC4 in this parasport, which involves complexity (Ferreira *et al.*, 2023).

People with different eligible impairments practice Boccia, including hypertonia, athetosis, ataxia, impaired passive range of movement, impaired muscle power, or limb deficiency (International Paralympic Committee, 2015a), and the sport is always played in a wheelchair. The main objective of classification in Boccia is to group athletes in different sports classes to ensure that sports performance is only determined by an athlete's sporting excellence (International Paralympic Committee, 2015b). Boccia is a popular adapted sport, originally designed for individuals with CP but is now played by athletes with other severe disabilities affecting motor skills. Sports classification for people with CP has been in use for several years, nevertheless, it is still complicated to fit these players into classification systems that are appropriate for other health conditions or disabilities (Khalili, 2004). Therefore, it is important to analyze the influence of functional classification (FC) in sports for people with disabilities to promote competitive balance (Gamonales *et al.*, 2021).

The Boccia classification system itself has undergone regular modifications over time. In 1983, the Cerebral Palsy International Sports and Recreation Association (CPISRA) was responsible for the classification of competitors in Boccia. By the early 1990s, Boccia classification had moved away from a medically based system to a FC system, and in 1992, the International Paralympic Committee (IPC) formally took control of governance for many disability sports. Because of issues in objectively identifying functionality that plagued the post-Barcelona Paralympic Games (PG), the IPC unveiled plans to develop a new classification system in 2003, which went into effect in 2007 and defined ten different disability types that were eligible to participate on the Paralympic level. Afterward, the Boccia International Sports Federation (BISFED) introduced the 2nd edition of the Boccia Classification Rules in 2013, the 3rd in 2017, the 4th in 2018 and lastly, the 5th in 2021, which is the current version for classification.

Nowadays, people with CP can compete in classes BC1, BC2 or BC3. According to BISFed (2021), the basic differences between these three classes are: firstly, BC1 class is for athletes who are diagnosed "with a Neurological Impairment affecting the central nervous system - CNS; Spastic hypertonic quadriplegia or athetosis or who may have a mixed picture including those with severe ataxia"; secondly, BC2, athletes who are diagnosed "with a neurological impairment affecting the CNS; Spastic hypertonic quadriplegia or dyskinesia (athetosis/dystonia) or who may have a mixed picture including those with ataxia.", and thirdly, individuals classified in the BC3 class are "athletes who are diagnosed with a neurological impairment affecting the CNS; Spastic hypertonic quadriplegia or dyskineisa (athetosis/dystonia) or who may have a mixed picture including those with ataxia, or athletes who are diagnosed with an impairment of non-cerebral origin (not affecting the CNS)." Finally, BC4 is associated to "athletes who are diagnosed with an Impairment of non-neurological origin not affecting the CNS and who do not present with tonal change or spasticity as their primary impairment. BISFed acknowledge that athletes with spinal cord Injury may have spinal spasticity as part of their physical presentation, but this must not be the primary impairment, and athletes must meet the minimum impairment criteria as detailed below".

In Boccia classification, the physical profiles and the minimum impairment are considered, associated with the physical assessment/technical assessment components. It was previously stated that to achieve fair competition, sports classification aims to cluster athletes into sports classes in which the least impaired athletes still have the best chances to win (International Paralympic Committee, 2015a,b). However, a major limitation in some adapted sports is the lack of evidence-based assessment methods to assess the degree of impairment and its effect on sports proficiency (Tweedy *et al.*, 2014). Despite its more than 30 years of playing history, and the observation that this parasport requires in-depth study (Ferreira *et al.*, 2022), very little research has reported scientific evidence related to Boccia classification. Most studies focus on the technical, biomechanical, and learning aspects of Boccia throwing (Dickson *et al.,* 2010; Morriss & Wittmannová, 2011; Huang *et al.*, 2014), but to our best knowledge, until now no study focused on the relationship between the classification and performance in Boccia. Hence, the aim of this study was to analyse the influence of classification on the performance of Boccia in international-level events.

Materials & Methods

Study design

The design of this study presents a descriptive and associative strategy (Ato *et al.*, 2013), to identify whether there are differences between two or more study variables. For this purpose, the official results of the 2012 and 2016 Boccia PG editions, European Championships (EC), and World Championships (WC) (2017 and 2018, respectively) were retrieved from the official competition websites and worldboccia.com.

For analysis, partials from the preliminary phase to the finals were considered. Games decided by tie-break were excluded from the analysis. These events were selected because results from partials were available, contrary for example to Tokyo 2020, in which only game results were available, as in the case of the 2013 EC, and 2014 WC.

Variables

The definition of each study variable and its categories were proposed in previous research involving a group of experts in sports for people with disability (Gamonales *et al.*, 2018a,b; Muñoz-Jiménez *et al.*, 2018). These variables used for the analysis of performance indicators were based on previous research methodology (O'Donoghue, 2015). All were categorized numerically, to facilitate their registration and subsequent statistical analysis

Since there is no previous research on this specific research topic of the game in Boccia, we codified the variables related to the results in the game partials and game results (Agresti & Finlay, 2009; Field, 2009). Table 1 shows the variables' type of partial nomenclature and respective point intervals.

Table 1. Classification of type of partials considering the number of ball differences.

	Type of partial
Adjusted	(1-2 ball difference)
Balanced	(3-4 ball difference)
Unbalanced	(5-6 ball difference)

The considered variables for analysis were: 1) Classification: BC1, BC2; BC3, BC4; 2) Competitions: PG 2012, PG 2016, EC 2017, and WC 2018 and; 3) Type of partial: adjusted, balanced, unbalanced.

Procedures

The authors C.C.F. and M.C.E. retrieved the data. Inter-observer reliability was analyzed to guarantee the quality and validity of the data collection for subsequent statistical analysis and to ensure that relevant conclusions could be drawn. This process was previously used in scientific literature in different sports contexts, such as grassroots football (Gamonales *et al.*, 2019). In detail, two external observers were previously trained to categorize the data. The observer training process was divided into four stages: the preparatory stage; the coder selection stage; the observer training stage; and finally, the reliability stage. Inter-coder reliability was measured using the Multirater Kappa free index (Randolph, 2005), obtaining a minimum value of 0.85 for all the variables analyzed.

A total of 3.962 Boccia game partials were analysed, representing 47.544 ball throws by Boccia players. Every player throws the ball six times in each partial, and three times in pairs games, to sum the same six throws by each team in a single partial. In teams' games, the number of partials is higher (six), and the dynamic of the throws is different because teams are composed of three players, resulting in two ball throws by each player in a single partial. The number of partial distributions considering the different Boccia classifications is presented in Table 2.

Table 2. Boccia partials distribution considering the classification in the studied international-level competitive events (*n*=3.962 partials).

Classification	London (PG - 2012)	Rio de Janeiro (PG - 2016)	Póvoa do Varzim (EC - 2017)	Liverpool (WC - 2018)	Total
BC1	84	127	137	252	600
BC2	124	124	211	252	711
BC3	104	127	263	250	744
BC4	72	125	209	247	653
Pairs BC3	64	63	93	127	347
Pairs BC4	64	63	92	125	344
Teams BC1 & BC2	120	112	142	189	563
Total	632	741	1.147	1.442	3.962

PG: Paralympic Games; EC: European Championships; WC: World Championships.

The schematic representation of all individual, teams, and pairs classes in the four international-level studied Boccia events is shown in Figure 1.

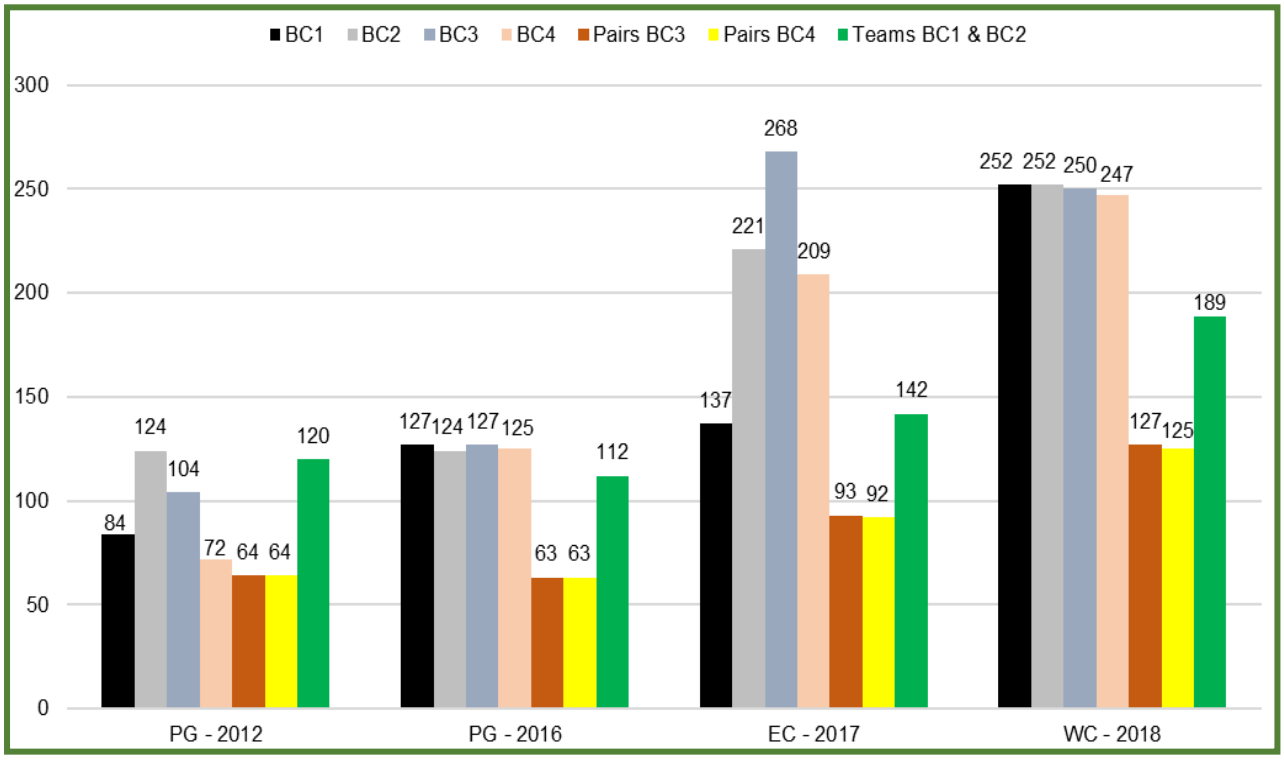

Figure 1. Schematic representation of game partials associated with classification in four international-level Boccia events.

Statistical Analysis

Data is presented as mean (M) and standard deviation (SD). The Chi-square (χ^2) was used (Newell *et al.*, 2014), to assess the level of association between the variables using Cramer's Phi coefficient (φc) (Crewson, 2006). The level of association was interpreted according to Crewson's proposal: Small (<0.100), Low (0.100–0.299), Moderate (0.300–0.499), and High (>0.500). For the interpretation of the degree of association of the variables studied, adjusted standardized residuals (ASR) were used (Field, 2013). The software used for the analysis was the Statistical Package of Social Science (v27, IBM Corp., Armonk, NY, USA). The significance level was set at $p < .05$.

Results

Table 3 shows the descriptive statistics of all classifications in the four international-level Boccia events, namely the PG of 2012 and 2016, the EC of 2017, and the WC of 2018.

Table 3. Descriptive analysis of the type of partials considering the different classifications in four international-level Boccia events.

Classification		Adjusted	%	Balanced	%	Unbalanced	%	Total
Individual	BC1	430	76.67	134	22.33	36	6.00	600
	BC2	517	72.71	157	22.08	37	5.20	711
	BC3	542	72.85	176	23.66	26	3.49	744
	BC4	488	74.73	139	21.29	26	3.98	653
Pairs	BC3	261	75.22	78	22.48	8	2.31	347
	BC4	258	75.00	73	21.22	13	3.78	344
Teams	BC1 & BC2	431	76.55	111	19.72	21	3.73	563

Mostly all partials in individual, pairs, and teams were adjusted (around 75%), only in BC1 and BC2, percentages between 5% and 6% were observed as unbalanced partials (in all other classes below 5%), and the balanced games were between 21% and 24%, exception for teams' partials (19.72%). Table 4 shows the relationship between the type of partials in four international-level events (*n*=3.962 partials) in all the Boccia classifications.

Table 4. Relationship between the type of partials in four international-level events (*n*=3.962 partials) in all the Boccia classifications.

Classification	Type of Partials						
	χ2	df	*P*	Φc	*p*	Association Level	Observations
BC1 (*n*=600)	8.025	6	.236	.082	>.05	-	No differences
BC2 (*n*=711)	3.729	6	.099	.051	>.05	-	No differences
BC3 (*n*=744)	13.950	6	.030	.097	<.05	Small	Differences
BC4 (*n*=653)	2.986	6	.811	.048	>.05	-	No differences
Pairs BC3 (*n*=347)	2.602	6	.857	.061	>.05	-	No differences
Pairs BC4 (*n*=344)	6.150	6	.407	.095	>.05	-	No differences
Teams BC1 & BC2 (*n*=563)	13.939	6	.030	.111	<.05	Low	Differences

χ2**:** Chi-square; df: degree of freedom; φc: Cramer's Phi coefficient; Association level according to Crewson's: Small (<.100), Low (.100–.299), Moderate (.300–.499), and High (>.500).

Differences were only found in individual BC3 (Cramer's Phi coefficient of .097, a small association strength), and teams BC1 & BC2 (Cramer's Phi coefficient of .111, a low association strength). Table 5 describes the analysis of the ASR, considering the individual BC3 and Teams BC1 & BC2, where differences were observed.

Table 5. Descriptive results and adjusted standardized residuals considering the type of partial in four international-level events in BC3 and Teams BC1 & BC2.

	Boccia International Events											
	PG 2012			PG 2016			EC 2017			WC 2018		
	n	%	ASR	*n*	%	ASR	*n*	%	ASR	*n*	%	ASR
BC3												
Adjusted	74	71.15%	-0.4	100	78.74%	1.6	189	71.76%	-0.4	179	71.60%	-0.5
Balanced	27	25.96%	0.6	25	19.69%	-1.2	57	21.57%	-0.9	67	26.80%	1.4
Unbalanced	3	2.88%	-0.4	2	1.57%	-1.3	17	6.46%	3.3	4	1.60%	-2.0
Teams BC1 & BC2												
Adjusted	85	70.83%	-1.7	84	75.00%	-0.4	121	85.21%	2.8	141	74.60%	-0.8
Balanced	26	21.67%	0.6	26	23.21%	1.0	19	13.38%	-2.2	40	21.16%	0.6
Unbalanced	9	7.50%	2.5	2	1.79%	-1.2	2	1.41%	-1.7	8	4.23%	0.4

n: frequency; %: percentage; ASR: Adjusted Standardized Residuals > |1.96|

In teams BC1 & BC2, we found a high probability of the Boccia partials to be considered unbalanced (5-6 ball difference) in London 2012 PG, and in contrast, a higher probability of adjusted partials in the 2017 EC (1-2 ball difference).

On the other side, in individual BC3, only a higher probability of unbalanced partials (5-6 ball difference) was found in 2017 EC and a lower probability in 2018 WC, which highlights that in this classification, in a two-year time frame and considering three international-level events (PG, EC, and WC), the tendency was always different in BC3. Table 6 shows the analysis of combining both BC1 and BC2, BC3 and BC4.

Table 6. Relationship between BC1 and BC2 combined (n= 1.311 partials) and BC3 and BC4 combined (1.397 partials) and the type of partials in 4 international-level Boccia events.

Classification	Type of Partials						
	χ2	**df**	***p***	**φc**	***p***	**Association Level**	**Observations**
BC1 & BC2	1.318	2	.517	.032	>.05	-	No differences
BC3 & BC4	4.801	2	.091	.059	>.05	-	No differences

χ2**:** Chi-square; df: degree of freedom; φc: Cramer's Phi coefficient; Association level according to Crewson's: Small (<.100), Low (.100–.299), Moderate (.300–.499), and High (>.500).

No differences were found when combining BC1 and BC2 (individual classes who play alone in the wheelchair and without a ramp, the throw is performed with the hand or foot) and BC3 and BC4 (also individual classes, BC3 characterized by the use of a ramp to perform the throw, with a sports assistant inside the box of game and BC4, classification associated to players with non-cerebral impairments). Table 7 shows the relationship between individual performance (2.708 partials) and pairs (691 partials) and the type of partials in 4 international-level Boccia events.

Table 7. Relationship between individual (2.708 partials) and pairs (691 partials) performance and the type of partials in four international-level Boccia events.

Classification	Type of Partials							
	χ2	**df**	***p***	**φc**	***p***	**Association Level**	**Observations**	**Observations**
BC1 to BC4	6.962	6	.324	.036	>.05	-	No differences	No differences
Pairs BC3 & BC4	1.360	2	.507	.044	>.05	-	No differences	No differences

χ2 Chi-square; df, degree of freedom; φc Cramer's Phi coefficient; Association level according to Crewson's: Small (<.100), Low (.100–.299), Moderate (.300–.499), and High (>.500).

Discussion

This study aimed to analyze the influence of classification on the performance of Boccia in international-level events. The main findings were: 1) Considering individual, teams, and pairs (3.962 partials and 47.544 ball throws), the majority of partials were adjusted (in the region of 75%, 1-2 balls difference); 2) Differences based in the Boccia classification and the type of partial were only observed in individual BC3 and teams BC1 & BC2; 3) No differences were found when combining BC1 and BC2 or BC3 and BC4; and 4) When combining individual BC1 to BC4 or Pairs BC3 & BC4, no differences were found. Therefore, the results indicate that globally, the classification system in Boccia leads to adjusted partials in international-level events, but suggest the need to further study a potential influence of the use of a ramp and assistant support in BC3 and to evaluate the team's constitution (BC1 & BC2).

Boccia, through its emphasis on strategy, teamwork, and social interaction, fosters emotional regulation, empathy, and interpersonal skills, contributing to the development of emotional intelligence (Barak *et al.*, 2016). Playing Boccia requires great tactical ability and concentration by players, an ability to analyze the game, and also good accuracy (Reina *et al.*, 2015). Moreover, the Boccia activity requires fitness components such as upper-body strength, dynamic stability, perceptual-motor awareness, and visual-motor coordination, which are important not only for sports but also for daily functioning (Barak *et al.*, 2016). This is particularly important, considering that regular involvement in PA can help offset physical decline and dementia (Perez & Cancela Carral, 2008).

Our results, particularly the number of partials comparing the 2012 and 2016 PG and 2017 EC, and 2018 WC, highlight Boccia players' growing participation in international-level events, preventing sedentary lifestyles and promoting PA. Additionally, considering that reaching this international-level in Boccia signifies that many other athletes play the game in lower-level competitions and passed through qualifying stages, it is possible to project that many athletes now practice Boccia at a competitive level. Of note that in our study the majority of the partials were adjusts, revealing not only the high-level of these competitive events (EC, WC and PG), but also that the game in itself is a motivating factor for athletes to strive for good results and for the games to be well disputed. In this respect, Marszalek *et al.* (2015) stated that it is necessary to look for the relationship between performance, enjoyment, health, and technical-tactical factors. In elite sports, technical-tactical aspects are of great importance, as the aim is for the athlete to achieve optimal performance, which entails improving these factors during training, with the aim of achieving success during competition (Paulson & Goosey-Tolfrey, 2017).

Additionally, nowadays Boccia is played by people with disabilities in international-level events, but practiced by a significant portion of the population, from children in schools to the elderly, with social and rehabilitation objectives. Previously, Ferreira *et al*. (2022), has found that the number of athletes in Boccia has noticeably increased in PG context, nevertheless, our study reveal that the number in EC and WC are significantly higher compared to PG, the most prestigious competition worldwide, but associated to restrictions such as the time for the games to take place in the different phases of the competition, which limits the number of possible participants, even more so when athletes with disabilities often need more time for their individual performance and daily routines. This is particularly important because there is a correlation between adapted sports participation and quality of life and quality of social life (Diaz *et al.*, 2019). Participation in sports has shown many benefits for the mental and physical health of individuals with disabilities (Winnick & Porretta, 2016; Khoo *et al.*, 2018), this is especially important in Boccia because the activities in which persons with CP participate are relatively passive, mainly home-based, and require less variability (Shikako-Thomas *et al.*, 2008)

The results of this study, considering the BC1 and BC2 classes (1.311 partials, representing 7.866 ball throws), revealed no differences in the type of partial based on the 4 international-level competitions between 2012 and 2018. In BC1 and BC2, the players alternate the throw of balls depending on which ball is closest to the jack, the white ball (it can happen that after the first ball is thrown by one player, the next six are made by the other because the first player's ball is closest to the jack), and the ball throws are performed in box number 3 or 4 (the more centered, defined previously to game start by coin flip performed by the referee). The conditions are standardized in these individual classes, which from

our understanding leads to the games of Boccia to be closely disputed. We should also bear in mind that BC1 and BC2 players usually have activity limitations in hand function and follow-through, leading to coordination problems, usually presented in their upper limbs (Reina *et al.*, 2015). For example, in dystonic profiles, contractions are powerful and sustained and cause twisting or writhing of the affected areas, being the pattern highly variable, and contractions fast or slow (O'Sullivan, 2001). Moreover, results demonstrated that Boccia players tend to display intralimb limitations in comparison to individuals without CP (Roldan *et al*., 2017), it was previously indicated that Boccia players performed worse due to muscle weakness, impaired voluntary muscle activation, and problems regarding muscle coactivation, as has been found in similar studies on children with CP (Steenbergen & Meulenbroek, 2006; Huang *et al*., 2014).

Interestingly, we found differences when analysing the Teams BC1 & BC2 classification, which involves three players, at least one of whom must be a BC1. From our point of view, considering that the BC1 and BC2 classes have specific FC characteristics that lead athletes to be integrated into one class or another and that no differences were observed in the type of partials in individual games, the differences in Teams BC1 & BC2 should be associated with issues related to game strategy, which is less standardized in Teams BC1 & BC2 compared to individual BC1 and BC2. Teams can have one or more BC1 players, which immediately leads to potential differences in the team's composition, but in our opinion, the factor that most influences the differences in the dynamics of the game. In teams, the players are in fixed boxes (from 1 to 6, alternately), each player has only two balls to throw and the throwing sequence within each team is random, depending on the team's strategy and proximity to the jack, the target ball. These details condition the course of the game and confront players and teams with greater complexity from a tactical/strategic point of view, which in our perspective results in the matches becoming potentially more unbalanced.

Boccia athletes classified in the BC3 class are "unable to consistently propel a Boccia ball with purposeful direction and velocity into the field of play, and they use an assistive device (ramp) to propel the ball onto the field of play with the help of an assistant" (BisFed, 2021), a different profile compared to BC1, which hosts players with CP diagnosed with spastic quadriplegia or athetosis, or those with severe ataxia, or BC2 which hosts CP players diagnosed with spastic quadriplegia or with athetosis/ataxia (BisFed, 2021). We found differences (with a small association level) in BC3, based on 744 partials or 8.928 ball throws, in our perspective related to the dynamic of the game in this Boccia class, associated with the use of ramp, and participation of an assistant, placed in the box of the Boccia player. Thus, these two criteria that differentiate the game from other individual classes require deeper research aiming that the game is fair between players, ensuring that sports performance is only determined by an athlete's sporting excellence, and that the classification in Boccia effectively represents an instrument associated with sporting truth. This was also supported in our results when we combined separately BC1 and BC2, BC3 and BC4, and no differences were found, as well as when we analysed all the individual classes together (BC1 to BC4) and both pairs BC3 and BC4 combined.

An integral part of Paralympic sport is classification, the purpose of which is to minimize the impact of eligible impairment types on the outcome of competition (Tweedy & Vanlandewijck, 2011). More recently, Mann *et al.* (2021), indicated that research is encouraged and indeed necessary during the monitoring phase to evaluate the efficacy of a classification system, adding that even the best evidence-based system will have limited acceptance if the sport community does not understand the reason for implementing change, and how the new classification system was established. The authors also stated that research is needed to ensure it remains valid as the sport evolves and new equipment and medical treatments become available, concluding that effective implementation and monitoring of new sport-specific systems of classification will only be achieved through continued engagement between researchers and the Para sports community.

Each Paralympic sport requires its own classification system, which groups athletes according to the level that their impairment impacts on performance in that particular sport (Hutchinson *et al*., 2021). In a study of wheelchair rugby players, isometric trunk flexion strength was shown to significantly correlate with wheelchair propulsion acceleration performance (Altmann *et al.*, 2018) whilst isometric shoulder extension strength significantly correlated with freestyle swim speed in Para-swimmers (Hogarth *et al*., 2019) Arm extension, trunk flexion and combined arm-trunk strength also

correlated with top speed in wheelchair racing propulsion across a group with different sport classes (Connick *et al.*, 2018), however trunk flexion strength did not correlate with acceleration performance in athletes with the same classification (Vanlandewijck et al., 2011).

From our perspective, a limitation associated with Boccia is the lack of literature in this adapted sport, particularly in relation to the classifications system, which groups athletes into classes, and this classification regulates both the training process and the game at a competitive level. We should, at this point, again indicate the inexistence of partials results in other international-level Boccia events between 2012 and 2018 also as a limitation. Moreover, the results of this study should not be extrapolated to other contexts because it is related to elite athletes, representing their countries in international-level Boccia events such as EC, WC, and PG, and the large majority of Boccia players are involved in the adapted sport in institutions, clubs or at recreational level.

Regarding the future, it is our understanding that there is a big challenge in providing opportunity of participation to many athletes in these elite-level events. We can observe an increasing number of events taking place all over the world as a result of the development of Boccia and the visible increase in the number of practitioners but provide the opportunity for many athletes to attend the most prestigious events is a challenge for the future. This is particularly important for recognition, gender equality, and example to other individuals aiming the inclusion in society perspective, because most of these practitioners need more time for their sporting performance and daily activities, and events such as the PG are conditioned by time, particularly by the pressure of media (television broadcasts, among others). We also bear in mind that there is still little understanding of performance indicators in Boccia, and this study makes it possible to question the potential influence of tactics/strategies and the use of ramp and assistant support in BC3. Hence, more research into these specific areas, along with a deeper understanding of the FC with a perspective to correct integration into Boccia classes, are challenges for the future, along with understanding the rules (for example, observable in our study on Teams BC1 & BC2 - team constitution and regulatory dynamics of the game).

Conclusions

The results of this study underline the growing participation of Boccia players in international-level events and the need to further deepen research regarding the classification in this parasport. The observation that the majority of partials in individual, pairs, and teams were adjusted (1-2 balls difference), indicates a global correct classification of players, which leads to equilibrium in the games.

The differences observed in the Teams BC1 & BC2 class indicate the need to evaluate the team's constitution (currently three elements and at least one BC1, which could be more), intending to create equal and motivational conditions for players and teams. This is essential for individuals with disabilities and relatively low rates of PA, intending to promote and maintain the practice of Boccia. To this end, it may also be necessary to consider the rules that influence the game dynamics (currently, two balls per player and fixed boxes with the possibility for team members to choose who plays at what time).

With regard to BC3, the differences found show a potential influence of the use of a ramp and assistant support, which could jeopardize the truth of the sport, and the correct classification of players based on their FC, to ensure that sports performance is only determined by the athlete's sporting excellence, guarantee equal conditions for practice and competition to improve the quality of life, opportunities for inclusion in society, and setting an example for other citizens with and without disabilities to get involved in the practice of Boccia.

Practical applications

The results suggest that globally classification promotes close results in the individual and pairs partials during international-level games of Boccia, which is an overall indication that the classification in these international-level events directs the players to compete in classes according to their characteristics and fundamental, their functional capacity.

Notwithstanding, this study highlights the need for further detailed research into Boccia, particularly in relation to the individual class BC3 and Teams BC1 & BC2.

The class BC3 is for players with a very severe physical disability, assumption that itself can lead to marked differences in the ability of players, that use a device (ramp) to throw the balls in direction to the jack and are helped by a nominated person at the court, the assistant, who according to the rules must have his back to the game, but is in constant communication with the player, so his relationship with the player and training together could be factors that make the game unbalanced, distorting the classification system in Boccia, possibility that require deeper study.

With regard to Teams BC1 & BC2, the rule of number of BC1 players should also be studied in greater detail because it can favor or disfavor the constitution of the teams, as well as the dynamics of the game, namely the position in the boxes and the order of throwing, which seems to us to lead to tactical/strategic specificities during the games.

In 2015, BISFed published the profile of the new BC5 class for the sport of Boccia. The BC5 classification has been developed with players in mind whose disabilities are not severe enough to allow them to play in the BC2 or BC4 classification, This class in currently not considered in international Boccia official events, but its creation, along with changes in classification details over the years, reveals challenges in this area in Boccia. It is essential to have a classification system that promotes as much fairness as possible for the competition, further and more in-depth research is needed specifically in this area and particular characteristics of the game in BC3 and Teams BC1 & BC2.

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