



PERFORMANCE TRAJECTORY RELATED TO SPORTS CLASSIFICATION, SEX, AND AGE IN BRAZILIAN PARALYMPIC CANOE SPRINT COMPARED TO INTERNATIONAL KAYAK 200M COMPETITIONS

TRAJETÓRIA DE DESEMPENHO RELACIONADA À CLASSIFICAÇÃO ESPORTIVA, SEXO E IDADE NA CANOAGEM PARALÍMPICA DE VELOCIDADE BRASILEIRA EM COMPARAÇÃO COM COMPETIÇÕES INTERNACIONAIS DE CAIAQUE 200M

TRAYECTORIA DE RENDIMIENTO RELACIONADA CON LA CLASIFICACIÓN DEPORTIVA, EL SEXO Y LA EDAD EN EL PIRAGÜISMO PARALÍMPICO DE VELOCIDAD BRASILEÑO EN COMPARACIÓN CON COMPETICIONES INTERNACIONALES DE KAYAK 200M

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Abstract

This study analyzed the performance trajectory by gender, age, and sport class in Brazilian canoe sprint (PCS) kayak 200m competitions and compared results with international PCS competitions. Data were collected from 21 Brazilian national championships and 15 international championships. Running times of Brazilian PCS athletes decreased in all sport classes, except for women's kayak level 2. Brazilian PCS athletes had significantly slower race times than their international counterparts across all classes and genders. Among men, Brazilian PCS athletes exhibited greater variability in running times (coefficient of variation and amplitude) than the international group. Similar to international PCS, no temporal correlations were observed for the coefficient of variation and amplitude of Brazilian athletes. Brazilian female PCS athletes were older than their international counterparts, while no significant age difference was found among men. Despite general improvements across most sport classes, Brazilian athletes still lag behind internationally, displaying slower 200m times and greater variability.

Keywords: Athletic Performance; Physical Education and Training; Sports for Disabled People; Para Sports; Para-Athletes.

Resumo

Este estudo analisou a trajetória de desempenho segundo o sexo, a idade e a classe esportiva em competições brasileiras de canoagem de velocidade paralímpica (PCS) na prova de caiaque de 200 m, comparando os resultados com competições internacionais de PCS. Os dados foram coletados de 21 campeonatos nacionais brasileiros e 15 campeonatos internacionais. Os tempos de prova dos atletas brasileiros de PCS diminuíram em todas as classes esportivas, exceto no caiaque feminino nível 2. Os atletas brasileiros de PCS apresentaram tempos de corrida significativamente mais lentos do que seus equivalentes internacionais em todas as classes e gêneros. Entre os homens, os atletas brasileiros de PCS exibiram maior variabilidade nos tempos de corrida (coeficiente de variação e amplitude) em comparação com o grupo internacional. De forma semelhante ao observado em competições internacionais de PCS, não foram identificadas correlações temporais para o coeficiente de variação e a amplitude dos atletas brasileiros. As atletas brasileiras de PCS eram mais velhas do que suas contrapartes internacionais, enquanto nenhuma diferença significativa de idade foi observada entre os homens. Apesar das melhorias gerais na maioria das classes esportivas, os atletas brasileiros ainda permanecem atrás no cenário internacional, apresentando tempos mais lentos nos 200 m e maior variabilidade de desempenho.

Palavras-chave: Desempenho Atlético; Educação Física e Treinamento; Esportes Para Pessoas Com Deficiência; Paradesporto; Para Atletas.

Resumen

Este estudio analizó la trayectoria del rendimiento según el sexo, la edad y la clase deportiva en competiciones brasileñas de piragüismo paralímpico de velocidad (PCS) en la prueba de kayak de 200 m, y comparó los resultados con competiciones





internacionales de PCS. Los datos se recopilaban de 21 campeonatos nacionales brasileños y 15 campeonatos internacionales. Los tiempos de carrera de los atletas brasileños de PCS disminuyeron en todas las clases deportivas, excepto en el kayak femenino nivel 2. Los atletas brasileños de PCS presentaron tiempos de carrera significativamente más lentos que sus homólogos internacionales en todas las clases y géneros. Entre los hombres, los atletas brasileños de PCS mostraron una mayor variabilidad en los tiempos de carrera (coeficiente de variación y amplitud) en comparación con el grupo internacional. De manera similar a las competiciones internacionales de PCS, no se observaron correlaciones temporales para el coeficiente de variación y la amplitud de los atletas brasileños. Las atletas brasileñas de PCS eran de mayor edad que sus contrapartes internacionales, mientras que no se encontraron diferencias significativas de edad entre los hombres. A pesar de las mejoras generales en la mayoría de las clases deportivas, los atletas brasileños aún se encuentran rezagados a nivel internacional, mostrando tiempos más lentos en los 200 m y una mayor variabilidad en el rendimiento.

Palabras clave: Rendimiento Atlético; Educación Física y Entrenamiento; Deportes Para Personas con Discapacidad; Par Deporte; Para Atletas.

INTRODUCTION

Para canoe sprint (PCS) became a Paralympic sport at the Rio de Janeiro 2016 Paralympic Games. Athletes with reduced strength, limited range of motion, or disabilities affecting the lower limbs and trunk are eligible for PCS (International Canoe Federation, 2023). After a series of tests to assess trunk functionality, lower limb function, and water technique, PCS athletes are classified into one of three sport classes: 1) KL1 (kayak level 1): PCS athletes with greater motor impairment, typically with reduced or nonexistent strength in the trunk and lower limbs (e.g., spinal cord injury T12, AIS A); 2) KL2 (kayak level 2): PCS athletes with reduced motor impairment compared to KL1, usually with preserved or total trunk function and reduced or nonexistent lower limb strength (e.g., bilateral transfemoral amputations or spinal cord injuries below T12); and 3) KL3 (kayak level 3): PCS athletes with lesser motor impairment, typically with full or nearly full trunk function and partially preserved lower limb function (e.g., unilateral lower limb amputation) (Bjerkefors *et al.*, 2019; International Canoe Federation, 2023; Ribeiro Neto *et al.*, 2023).

In the Paralympic Games, World Championships, and World Cups, all PCS races cover a distance of 200m and are individual events (International Canoe Federation, 2023). In recent years, all sport classes have achieved race times under one minute, emphasizing the speed characteristic, which depends on interrelated variables such as strength and anaerobic power. Strength increases linearly from early childhood and is more pronounced in males during puberty (Baker, 2001; Croix, 2007). Additionally, performance is influenced by other variables, such as sports class, sex, time since injury (Ribeiro Neto; Winckler; Gomes Costa, 2024), and socio-economic opportunities, which are often considered specific to both Olympic and Paralympic sports (Allen; Hopkins, 2015; Longo *et al.*, 2016; Severin *et al.*, 2023). Technological advancements, specifically in vessels and paddle designs, promote greater efficiency and



speed (Michael; Smith; Rooney, 2009). As a result, there has been an improvement in training technique and efficiency, which, together with increased access to financial resources, may have played a crucial role in sport's progress over the years. The growing number of PCS athletes could be a relevant factor for more pronounced performance enhancement, as increased competitiveness promotes performance improvements and a consequent reduction in time differences among sport classes (Ribeiro Neto *et al.*, 2023).

Ribeiro Neto *et al.* (2023) contextualized the performance trajectory in relation to age, sex, and sports class in international PCS kayak elite athletes; however, there is a lack of information on performance trajectories related to these variables in Brazilian PCS competitions. Brazil is a powerhouse in Paralympic sports, achieving 7th place at the Tokyo 2020 Paralympic Games and its best-ever ranking, 5th place, at the Paris 2024 Paralympic Games (IPC; International Paralympic Committee, 2024). The country also ranks as the second-highest producer of articles related to the Summer Paralympics (Pilon; Prince, 2024). In PCS, Brazil has secured eight medals in PCS kayak: two gold, four silver, and two bronze, and fielded the second-largest PCS team at the Paris 2024 Paralympic Games (CPB, 2024). Therefore, precise references of results specific to a country could guide coaches in monitoring and planning the development of national PCS athletes, in setting realistic performance goals, and even in the appropriate selection for a Paralympic sport (Morgan, 2014; Severin *et al.*, 2023). Furthermore, by comparing national and international trajectories, it is possible to observe patterns that influence sports performance, understanding how the modality has evolved over time in different contexts related to a specific country. This comparison could help in the proper allocation of resources for the sport and in motivating the scientific community and coaches to seek innovations and improvements, driving the field of national sports research and development.

Thus, the current study aimed to analyze the performance trajectory related to sex, age, and sports class in Brazilian PCS kayak 200m championships and compare it with international PCS competitions. The initial hypotheses were: (1) Brazilian PCS race times would decrease over the years across all sport classes, for both male and female athletes, but would remain longer than those in international competitions; (2) Brazilian PCS would exhibit greater variability in 200m race times compared to international competitions, although this variability would decrease over the years; and (3) Impairments would show varying prevalences according to sports class in Brazilian PCS, with these patterns expected to be similar to those observed in international PCS competitions.



METHODS

Experimental Approach to the Problem

This longitudinal retrospective observational study examined the performance trajectory concerning sports class, sex, and age in Brazilian PCS competitions compared to international competitions. Data were analyzed from publicly available online databases, including final race results from 21 Brazilian national championships and 15 international championships, obtained from a prior study focused on international performance trajectories (Ribeiro Neto *et al.*, 2023). To address the study's aims, three main analysis categories were created: athletes' characteristics (sex, sport class, age, and impairment) and included competitions, race time comparisons, and race time variability.

Data Collection

Data on Brazilian final kayak race results of national championships between 2015 and 2024 were retrieved from publicly available databases online on the Brazilian Canoe Confederation website (<http://www.canoagem.org.br/>), which contains information about athletes (name, sex, sport class, impairment, race times, dates, and birth date). International PCS kayak race results were sourced from a previously published study by Ribeiro Neto *et al.* (Ribeiro Neto *et al.*, 2023), encompassing a total of 15 competitions held between 2015 and 2022, including 2 Paralympic Games, 7 World Championships, and 6 World Cups. The international race times of each final race above the 50th percentile were discarded to prevent extreme and discrepant values from influencing the comparisons. In contrast, all finalists were included in the Brazilian dataset. This methodological difference is justified by three main factors. First, the smaller number of participants in Brazilian national championships, particularly during the early years of PCS development, would have resulted in very limited samples if only the top 50% of finalists had been considered. In some events, this approach would have reduced the available data to only one or two athletes per year, compromising the ability to characterize performance trajectories over time, which was the primary objective of the study. Second, including all finalists ensured a statistically viable sample size for longitudinal analyses. Third, this approach more accurately reflects the ecological reality of the developing Brazilian PCS system, where athletes with different performance levels, ranging from novices to elite competitors, frequently compete in the same races. The Human Research Ethics Committee





approved the study (protocol n. 6.754.358) and stated that written informed consent was not required because all data were obtained from publicly available online sources. The inclusion criteria were: 1) men and women eligible for PCS and; 2) participants with a valid time in the final of at least one Brazilian PCS championship. Athletes whose date of birth is not recorded in the database were excluded.

Procedures

Athletes were analyzed within their respective sport classes (KL1, KL2, and KL3), by sex (M: male; F: female), and by competitive level (Brazilian and international). The origin of the impairment was stratified into acquired impairment (i.e., post-birth impairment) and congenital impairment (i.e., birth impairment) (Dehghansai *et al.*, 2020; Lopes-Silva; Franchini; Kons, 2022; Ribeiro Neto *et al.*, 2023). The age in years of each athlete was calculated as a decimal age by subtracting the birth date from the official date of each championship (Morgan, 2014):

$$\text{Age (years)} = \frac{\text{Competition date} - \text{Birth date}}{365.25}$$

Main Outcomes

Variability (coefficient of variation, CV), race times (sec), amplitude of race times (sec), and age (years) were the main outcomes used to compare the race times between Brazilian and international PCS competitions throughout the nine-year study period. The prevalence of impairments was assessed in each sport class for men and women.

Statistical Analysis

The Shapiro-Wilk test was used to verify the assumptions of normality of the variables. Descriptive data are presented as median and interquartile range (25th and 75th percentiles) for the outcomes. The origin of the athlete's impairment and the type of impairment are expressed in frequencies.

The Mann-Whitney U test with two groups (Brazilian and international) was used to compare race times between the previous and following years. The variability of the athletes' times in the 200m finals was measured using the CV. The CV is a measure of data consistency (i.e., the higher the CV, the lower the consistency of the data) and represents the variability of results based on the ratio of the standard deviation to the mean. The variation in the range of race times (amplitude, Δ) was measured by





the difference between the last and the first race times, in seconds. Spearman (rho) correlations were used to verify the associations of the year with race times, CV, and amplitude of the race times, and were classified based on the following standards (Cohen, 1988): below 0.40 – the level of clinical significance is poor; 0.40 to 0.59 – fair; 0.60 to 0.74 – good; and 0.75 to 1.00 – excellent.

The Jamovi statistical package (version 2.3, The Jamovi Project, Sydney, Australia) was used for all analyses, and the statistical significance was set at 5% ($P \leq 0.05$, two-tailed).

RESULTS

Athletes' Characteristics and Included Competitions

A total of 21 Brazilian national championships were analyzed, encompassing 126 finals and a dataset comprising 626 race results. In 2020, all competitions were halted due to the outbreak of the coronavirus disease 2019 (COVID-19).

There were no significant differences in the mean ages over the years for male and female Brazilian PCS athletes, while the median age ranged from 28.0 years to 45.2 (KL1-F), 19.7 to 42.3 years (KL2-F), 35.9 to 42.6 years (KL3-F), 30.6 to 38.2 years (KL1-M), 29.1 to 35.3 years (KL2-M), and 23.4 to 43.1 years (KL3-M) (Tables 1 and Table 2). The median age of Brazilian PCS female athletes (38.0 years, P25-P75: 29.8-42.2 years) was significantly higher than that of international athletes (32.8 years, P25-P75: 28.3-37.7 years). There was no significant difference in age between Brazilian and international PCS male athletes.

Similarly to international PCS athletes, acquired impairments were more prevalent than congenital impairments in Brazilian PCS athletes across all sport classes and years, except for the KL2-F class in 2016. In the male and female KL1 and KL2 classes, spinal cord injury was the most common impairment. Amputation was the most prevalent impairment in the female and male KL3 classes (Tables 1 and 2). The main difference in impairment frequency compared to international PCS athletes was observed in the KL2-M class, where amputation was the most prevalent impairment.



Table 1 – Age, origin of impairment, impairment, and number of Brazilian female Para canoe sprint athletes from 2015 to 2024. Age is presented as median (percentiles 25th and 75th), and the origin of the impairment and the impairment are expressed as frequencies

KL1-F										
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
(n)	3	6	4	10	11	-	5	10	11	3
Age (years)	45.0 (38.3-45.2)	33.1 (32.6-37.4)	34.8 (27.9-40.9)	33.2 (22.3-39.8)	28.0 (24.6-40.8)	-	30.0 (28.3-33.4)	43.3 (24.8-51.4)	44.3 (28.6-48.6)	45.2 (38.8-49.3)
Origin of impairment										
Acquired	100.0%	60.0%	75.0%	80.0%	75.0%	-	50.0%	60.0%	75.0%	66.6%
Congenital	0.0%	20.0%	25.0%	20.0%	25.0%	-	25.0%	20.0%	25.0%	33.3%
Not obtained	0.0%	20.0%	0.0%	0.0%	0.0%	-	25.0%	20.0%	0.0%	0.0%
Impairment										
Poliomyelitis	0.0%	20.0%	25.0%	20.0%	25.0%	-	25.0%	20.0%	25.0%	33.3%
Spinal Cord Injury	100.0%	60.0%	75.0%	80.0%	75.0%	-	50.0%	60.0%	75.0%	66.6%
Not obtained	0.0%	20.0%	0.0%	0.0%	0.0%	-	25.0%	20.0%	0.0%	0.1%
KL2-F										
(n)	3	2	8	9	14	-	4	5	11	5
Age (years)	19.7 (19.4-30.9)	20.4 (20.3-20.6)	25.7 (20.3-40.8)	30.3 (22.5-40.3)	34.8 (23.5-38.3)	-	33.1 (25.8-43.0)	34.1 (30.1-37.8)	42.3 (36.7-50.2)	37.4 (32.6-42.3)
Origin of impairment										
Acquired	50.0%	0.0%	83.3%	80.0%	60.0%	-	66.7%	50.0%	100.0%	80.0%
Congenital	50.0%	100.0%	16.7%	20.0%	40.0%	-	33.3%	25.0%	0.0%	20.0%
Not obtained	0.0%	0.0%	0.0%	0.0%	0.0%	-	0.0%	25.0%	0.0%	0.0%
Impairment										
Arthrogryposis	50.0%	100.0%	16.6%	20.0%	20.0%	-	0.0%	0.0%	0.0%	0.0%
Amputation	0.0%	0.0%	16.6%	20.0%	20.0%	-	0.0%	0.0%	20.0%	20.0%
Agenesis	0.0%	0.0%	0.0%	0.0%	0.0%	-	33.3%	25.0%	0.0%	0.0%
Muscle Ischemia	0.0%	0.0%	0.0%	0.0%	20.0%	-	0.0%	0.0%	0.0%	20.0%
Poliomyelitis	50.0%	0.0%	16.6%	20.0%	0.0%	-	0.0%	0.0%	40.0%	20.0%
Spinal Cord Injury	0.0%	0.0%	50.0%	40.0%	40.0%	-	66.7%	50.0%	40.0%	40.0%
Not obtained	0.0%	0.0%	0.2%	0.0%	0.0%	-	0.0%	25.0%	0.0%	0.0%
KL3-F										
(n)	8	4	10	14	14	-	6	16	16	5
Age (years)	36.7 (35.0-40.3)	37.6 (37.3-38.7)	38.3 (37.2-39.6)	36.8 (33.8-39.3)	38.0 (36.2-39.4)	-	42.6 (40.9-43.8)	38.5 (40.4-44.1)	39.5 (31.0-44.3)	35.9 (30.9-41.3)
Origin of impairment										
Acquired	66.7%	66.7%	37.5%	57.1%	66.6%	-	100.0%	50.0%	50.0%	40.0%
Congenital	33.3%	0.0%	25.0%	28.6%	16.7%	-	0.0%	25.0%	25.0%	40.0%
Not obtained	0.0%	33.3%	37.5%	14.3%	16.7%	-	0.0%	25.0%	25.0%	20.0%
Impairment										
Amputation	66.6%	66.6%	37.5%	57.1%	50.0%	-	66.6%	25.0%	25.0%	20.0%
Agenesis	0.0%	0.0%	0.0%	14.2%	16.6%	-	0.0%	25.0%	25.0%	40.0%
Muscle Ischemia	33.3%	0.0%	12.5%	14.2%	0.0%	-	0.0%	0.0%	0.0%	0.0%
Orthopedic Injury	0.0%	0.0%	0.0%	0.0%	16.6%	-	16.7%	0.0%	0.0%	0.0%
Poliomyelitis	0.0%	0.0%	12.5%	0.0%	0.0%	-	0.0%	12.5%	12.5%	0.0%
Spinal Cord Injury	0.0%	0.0%	0.0%	0.0%	0.0%	-	16.7%	12.5%	12.5%	20.0%
Not obtained	0.0%	33.4%	37.5%	14.5%	16.8%	-	0.0%	25.0%	25.0%	20.0%

Source: original formulation.



Table 2 – Age, origin of impairment, impairment, and number of Brazilian male Para canoe sprint athletes from 2015 to 2024. Age is presented as median (percentiles 25th and 75th), and the origin of the impairment and impairment are expressed as frequencies

KL1-M										
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
(n)	17	13	14	20	19	-	10	14	15	6
Age (years)	30.6 (28.7-32.7)	31.3 (30-33.8)	31.8 (30.4-34.2)	32.8 (30-35.4)	34.1 (32.5-37.1)	-	32.3 (32-37.3)	35.6 (25.8-38.8)	38.2 (36.6-40.6)	34.7 (26.5-38.4)
Origin of impairment										
Acquired	77.8%	54.5%	70.0%	81.9%	66.7%	-	62.5%	87.5%	83.3%	100.0%
Congenital	0.0%	0.0%	0.0%	0.0%	0.0%	-	0.0%	0.0%	0.0%	0.0%
Not obtained	22.2%	45.5%	30.0%	18.1%	33.3%	-	37.5%	12.5%	16.7%	0.0%
Impairment										
Spinal Cord Injury	77.8%	54.5%	70.0%	81.9%	66.7%	-	62.5%	87.5%	83.3%	100.0%
Not obtained	22.2%	45.5%	30.0%	18.1%	33.3%	-	37.5%	12.5%	16.7%	0.0%
KL2-M										
(n)	14	15	15	18	15	-	9	19	20	6
Age (years)	29.1 (25.8-35.2)	30.9 (26.7-37.1)	31.6 (30.5-33.5)	31.3 (28.4-32.8)	29.6 (28.9-31)	-	31.6 (29.1-33)	32.7 (29.9-36.2)	35.3 (30.9-37.2)	33.9 (31.9-36.2)
Origin of impairment										
Acquired	54.5%	58.3%	58.3%	58.3%	75.0%	-	62.5%	66.7%	61.6%	83.3%
Congenital	0.0%	0.0%	0.0%	0.0%	0.0%	-	0.0%	0.0%	0.0%	0.0%
Not obtained	45.5%	41.7%	41.7%	41.7%	25.0%	-	37.5%	33.3%	38.4%	16.7%
Impairment										
Amputation	18.1%	16.6%	16.6%	8.3%	0.0%	-	0.0%	22.2%	15.3%	16.6%
Spinal Cord Injury	36.3%	41.6%	41.6%	50.0%	75.0%	-	62.5%	44.4%	46.1%	66.6%
Not obtained	45.6%	41.8%	41.8%	41.7%	25.0%	-	37.5%	33.4%	38.6%	16.8%
KL3-M										
(n)	17	16	18	20	20	-	8	22	23	6
Age (years)	29.0 (28.7-42.1)	43.1 (29.6-47.5)	26.4 (19.9-31)	36.0 (23.1-38.2)	27.5 (22.7-32.8)	-	23.4 (23.4-23.4)	35.6 (27.1-39.9)	25.2 (24.9-27.6)	28.5 (28.5-28.5)
Origin of impairment										
Acquired	55.5%	63.7%	50.0%	66.7%	58.3%	-	37.5%	46.7%	23.0%	33.3%
Congenital	0.0%	0.0%	0.0%	0.0%	0.0%	-	0.0%	0.0%	0.0%	0.0%
Not obtained	44.5%	36.3%	50.0%	33.3%	41.7%	-	62.5%	53.3%	77.0%	66.7%
Impairment										
Amputation	55.5%	54.5%	50.0%	41.6%	41.6%	-	37.5%	40.0%	23.0%	33.3%
Orthopedic	0.0%	0.0%	0.0%	8.3%	8.3%	-	0.0%	6.6%	0.0%	0.0%
Spinal Cord Injury	0.0%	9.0%	0.0%	16.6%	8.3%	-	0.0%	0.0%	0.0%	0.0%
Not obtained	44.5%	36.5%	50.0%	33.5%	41.8%	-	62.5%	53.4%	77.0%	66.7%

Source: original formulation.



Race Time Comparisons

Brazilian PCS athletes did not show significant differences in race times between consecutive years. However, the race times decreased across all sport classes except for KL2-F, which showed no significant correlation over the years ($\rho=0.250$; $p\geq 0.05$). The correlation coefficients for the other sport classes ranged from "poor" to "excellent" ($\rho = -0.917$ to -0.233). Additionally, the race times of Brazilian PCS athletes were significantly higher than those of international PCS athletes across all sport classes and sexes over the years ($p\leq 0.05$) (Tables 3, 4, and 5 and Figure 1).

Race Time Variability

In male athletes, Brazilian PCS exhibited greater variability in race times (in both CV and amplitude) compared to international PCS across all sport classes over the years. Similar to international PCS, the coefficient of variation and amplitude for Brazilian PCS athletes showed no statistically significant correlation with the years (Table 5 and Figure 2).



Table 3 – Comparisons of 200m race times for sport classes of female Para canoe sprint athletes. Race times are presented as median (percentiles 25th and 75th), the coefficient of variation is shown as a percentage (%), and amplitude is presented in seconds (Δ).

Years	KL1		KL2		KL3	
	INT	BRZ	INT	BRZ	INT	BRZ
RACE TIMES (sec)						
2015	61.9 (59.4-62.3)	75.4 (73.9-76.3)*	56.5 (55.6-59.1)	63.3 (60.4-72.3)*	53.8 (51.0-54.3)	65.2 (58.2-69.3)*
2016	62.1 (59.9-63.8)	82.3 (77.2-107.0)*	58.7 (56.5-59.8)	60.3 (59.5-61.1)*	52.4 (51.9-53.1)	60.0 (57.5-66.6)*
2017	59.9 (58.7-62.7)	75.3 (68.3-86.5)*	55.2 (52.5-57.8)	68.9 (64.3-80.6)*	52.6 (52.0-53.0)	70.0 (64.7-74.5)*
2018	57.3 (56.9-58.8)	74.2 (70.3-79.6)*	57.5 (53.4-59.6)	62.8 (61.8-69.8)*	57.2 (54.8-57.8)	64.3 (58.4-66.4)*
2019	58.9 (58.0-59.3)	72.0 (59.1-69.3)*	53.5 (51.1-53.8)	62.5 (61.1-78.1)*	49.9 (49.0-50.5)	66.9 (64.2-69.4)*
2020	-	-	-	-	-	-
2021	56.9 (54.8-58.2)	67.5 (66.9-68.8)*	54.2 (51.9-56.7)	68.7 (66.9-70.7)*	51.5 (49.8-52.3)	62.8 (60.9-64.7)*
2022	54.0 (52.9-58.0)	67.3 (63.1-70.0)*	52.7 (50.0-56.7)	68.3 (66.3-71.4)*	48.3 (46.9-49.8)	64.7 (56.2-65.8)*
2023	55.6 (53.8-56.9)	62.9 (62.7-66.0)*	54.6 (50.8-55.7)	66.4 (64.3-78.0)*	48.7 (47.2-49.0)	60.4 (54.2-63.7)*
2024	54.8 (53.6-57.5)	61.9 (61.6-64.3)*	55.9 (52.2-57.7)	69.2 (62.1-69.3)*	47.9 (47.1-49.5)	62.7 (55.6-62.9)*
COEFFICIENT OF VARIATION (%)						
2015	6.0%	3.2%	4.3%	18.3%	3.7%	12.2%
2016	5.6%	25.4%	4.5%	3.8%	2.2%	20.2%
2017	7.8%	27.3%	5.8%	19.8%	3.0%	11.6%
2018	2.9%	42.0%	5.9%	18.8%	3.7%	16.2%
2019	11.0%	11.2%	5.1%	14.5%	3.2%	8.8%
2020	-	-	-	-	-	-
2021	22.0%	20.5%	8.6%	4.5%	3.4%	11.1%
2022	6.5%	23.1%	10.7%	8.4%	3.5%	11.8%
2023	5.3%	4.9%	6.3%	16.9%	3.2%	12.5%
2024	4.4%	4.6%	9.3%	12.3%	3.6%	12.3%
AMPLITUDE (Δ, sec)						
2015	12.445	4.790	7.518	23.747	4.933	23.440
2016	10.433	56.774	7.843	3.268	3.372	29.492
2017	15.239	51.320	9.417	38.757	4.978	25.247
2018	5.010	117.720	10.850	41.310	6.240	36.120
2019	22.935	28.690	7.840	26.540	4.495	20.470
2020	-	-	-	-	-	-
2021	57.253	37.280	19.834	7.200	6.318	21.620
2022	10.763	55.030	18.206	15.520	4.615	25.790
2023	9.610	10.320	9.419	34.710	4.997	30.260
2024	6.790	5.320	16.010	21.910	5.390	18.830

*Significant difference from INT in the same year ($p \leq 0.05$).

BRZ: Brazilian; KL1: Kayak Level 1; KL2: Kayak Level 2; KL3: Kayak Level 3; INT: international.

Source: original formulation.



Table 4 – Comparisons of 200m race times for sport classes of male Para canoe sprint athletes. Race times are presented as median (percentiles 25th and 75th), the coefficient of variation is shown as a percentage (%), and amplitude is presented in seconds (Δ).

Years	KL1		KL2		KL3	
	INT	BRZ	INT	BRZ	INT	BRZ
RACE TIMES (sec)						
2015	53.8 (53.0-54.3)	59.4 (56.7-73.5)*	46.2 (43.4-47.3)	52.3 (49.2-63.9)*	40.1 (39.8-41.5)	45.9 (43.5-47.9)*
2016	51.9 (51.2-53.1)	68.8 (55.8-75.4)*	45.5 (44.6-47.5)	61.5 (53.1-66.7)*	41.8 (40.1-43.0)	48.6 (45.4-51.8)*
2017	49.8 (48.0-50.1)	68.8 (53.3-78.1)*	44.9 (43.1-45.9)	55.5 (51.4-58.3)*	40.8 (40.1-41.0)	45.9 (44.3-51.0)*
2018	52.9 (51.4-55.0)	57.7 (52.8-77.8)*	43.8 (43.2-44.2)	54.8 (48.1-57.2)*	41.3 (40.9-41.6)	49.8 (44.7-56.8)*
2019	47.5 (46.5-48.4)	54.0 (51.8-70.2)*	43.8 (43.544.3)	56.3 (52.3-58.8)*	42.3 (40.7-42.5)	47.8 (44.7-51.0)*
2020	-	-	-	-	-	-
2021	52.5 (48.0-52.8)	59.1 (51.2-81.8)*	43.1 (42.6-43.7)	53.4 (52.3-55.1)*	41.5 (41.0-42.5)	45.9 (43.2-49.2)*
2022	53.9 (51.0-65.8)	58.5 (52.8-67.6)*	44.6 (44.2-47.5)	51.4 (48.9-58.9)*	42.7 (41.8-43.4)	46.9 (44.5-53.4)*
2023	47.6 (46.0-50.5)	56.6 (49.3-82.2)*	42.1 (41.7-42.3)	48.1 (46.8-53.0)*	40.6 (40.5-41.4)	43.2 (41.7-47.1)*
2024	49.5 (48.4-51.0)	58.5 (53.5-63.7)*	43.9 (43.6-44.4)	50.8 (46.2-54.5)*	41.0 (40.4-41.1)	44.8 (42.9-46.7)*
COEFFICIENT OF VARIATION (%)						
2015	2.5%	25.1%	4.3%	21.4%	2.9%	9.3%
2016	2.8%	20.2%	4.8%	15.0%	4.1%	12.6%
2017	4.9%	21.4%	4.3%	19.4%	2.1%	10.0%
2018	6.5%	48.5%	4.6%	15.8%	2.9%	23.9%
2019	4.4%	27.5%	2.5%	12.9%	2.9%	10.9%
2020	-	-	-	-	-	-
2021	5.9%	40.3%	2.6%	9.1%	2.8%	11.1%
2022	14.0%	21.4%	5.9%	12.6%	1.9%	14.6%
2023	4.7%	26.5%	2.2%	16.5%	1.7%	8.8%
2024	5.3%	13.6%	2.2%	10.9%	1.2%	10.8%
AMPLITUDE (Δ, sec)						
2015	4.437	64.641	5.016	45.156	3.129	16.824
2016	4.353	45.134	6.432	26.540	4.111	26.126
2017	8.278	39.584	4.995	37.950	2.700	16.348
2018	11.620	140.850	6.785	30.050	3.621	48.680
2019	7.335	51.100	3.640	26.240	3.630	21.840
2020	-	-	-	-	-	-
2021	8.798	81.500	4.011	15.740	4.666	14.440
2022	21.021	50.570	8.147	25.110	2.093	28.050
2023	6.657	45.660	3.635	37.560	2.074	14.570
2024	8.120	21.740	3.370	13.210	1.410	13.900

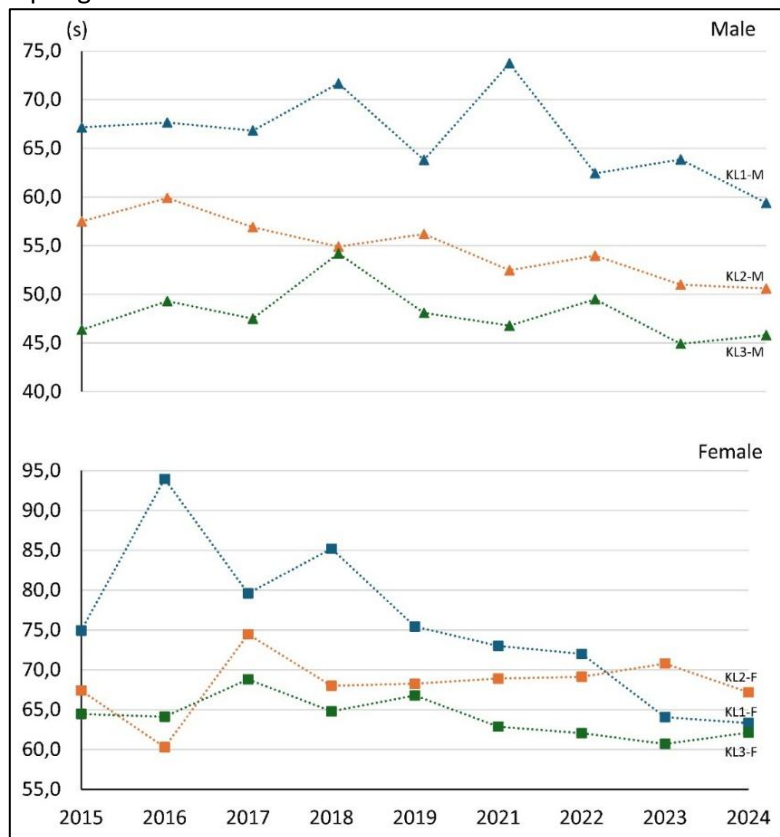
*Significant difference from INT in the same year ($p \leq 0.05$).

BRZ: Brazilian; KL1: Kayak Level 1; KL2: Kayak Level 2; KL3: Kayak Level 3; INT: international.

Source: original formulation.



Figure 1 – Annual progression of mean race times of KL1, KL2, and KL3 for male (triangle) and female (square) Para canoe spring athletes



KL1: kayak level 1; KL2: kayak level 2; KL3: kayak level 3; M: male; F: female.

Source: original formulation.



Table 5 – Minimum and maximum results, and correlation (rho) of race times (sec), coefficient of variation (%), and amplitude (sec) over the years

Minimum - Maximum			Correlation (rho)	
	INT	BRZ	INT	BRZ
RACE TIMES (sec)				
Female				
KL1	55.522 - 62.352	58.240 - 186.010	-0.833*	-0.633
KL2	52.338 - 58.006	54.890 - 100.090	-0.667	0.250
KL3	48.307 - 56.613	50.120 - 88.200	-0.810*	-0.750*
Male				
KL1	47.842 - 53.543	45.360 - 188.460	-0.262	-0.567
KL2	42.034 - 45.716	41.710 - 82.200	-0.476	-0.917*
KL3	40.596 - 42.642	39.976 - 89.070	0.357	-0.233
COEFFICIENT OF VARIATION (%)				
Female				
KL1	2.9% - 22.0%	3.2% - 41.9%	0.095	-0.267
KL2	4.3% - 10.7%	3.8% - 19.8%	0.857*	-0.250
KL3	2.2% - 3.7%	8.8% - 20.2%	-0.048	-0.100
Male				
KL1	2.5% - 14.0%	13.6% - 48.5%	0.595	-0.117
KL2	2.2% - 5.9%	9.1% - 21.9%	-0.357	-0.583
KL3	1.7% - 4.1%	8.8% - 21.9%	-0.714*	-0.083
AMPLITUDE (Δ, sec)				
Female				
KL1	5.010 - 57.253	4.790 - 117.720	-0.048	-0.217
KL2	7.518 - 19.834	3.268 - 41.310	0.667	-0.050
KL3	3.372 - 6.318	18.830 - 36.120	0.333	-0.217
Male				
KL1	4.353 - 21.021	21.610 - 140.850	0.500	-0.217
KL2	3.635 - 8.147	13.210 - 45.156	-0.310	-0.667
KL3	2.074 - 4.666	13.900 - 48.680	-0.357	-0.517

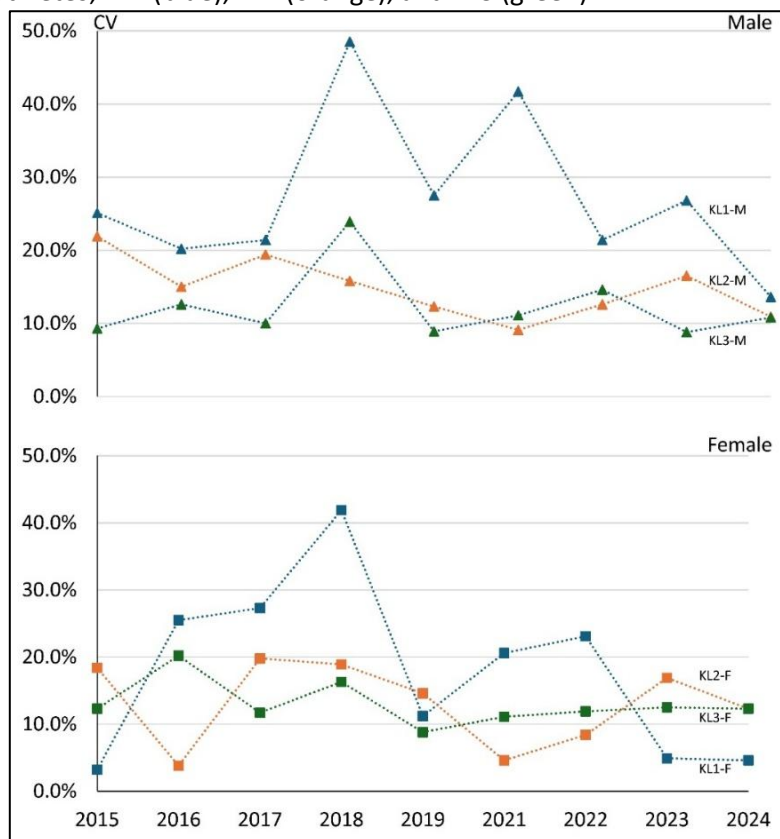
*Statistically significant.

BRZ: Brazilian; KL1: Kayak Level 1; KL2: Kayak Level 2; KL3: Kayak Level 3; INT: international.

Source: original formulation.



Figure 2 – Annual progression of the coefficient of variation (CV) of male (triangle) and female (square) Para canoe spring athletes; KL1 (blue), KL2 (orange), and KL3 (green).



KL1: kayak level 1; KL2: kayak level 2; KL3: kayak level 3; M: male; F: female.

Source: original formulation.

DISCUSSION

The primary findings indicate that while Brazilian PCS race times have decreased over the years across all sport classes, they remain longer and exhibit greater variability than international competitions. Furthermore, the prevalence of impairment types, such as amputation in the KL2-M class, differs from international patterns. These distinct trajectories suggest that performance improvements in Brazil are influenced by the unique characteristics of its developing sports system, the number of competing athletes, and the overall technical level of the championships.

The median race times in Brazilian PCS competitions have decreased over the years, reflecting the evolution of PCS in Brazil. While significant differences and correlations over time were not found across all sport classes or sexes, the number of final race results and the heterogeneity at the national level may have influenced the statistical analysis. First, it is important to note that the number of athletes



has increased over the years, highlighting the growth of PCS in Brazil. This rising interest in PCS may be attributed to the strong performance of Brazilian athletes in World Championships and Paralympic Games (IPC; International Paralympic Committee, 2024). Despite this growth, it is crucial to recognize that in specialized populations, such as kayak Para canoe athletes, null-hypothesis significance testing might face challenges related to sample size when aiming to achieve a significant p -value for performance outcomes (Batterham; Hopkins, 2006; Bernardes *et al.*, 2017). The p -value derived from such tests can be misleading, depending on the magnitude of the statistic, measurement error, and sample size (Batterham; Hopkins, 2006), as seen in the non-significant differences found in the comparisons of race times between consecutive years. Second, the variability in race results (including the coefficient of variation and gap between first and last places) offers insights into the sport's developmental trajectory (Ribeiro Neto *et al.*, 2024). However, the wide range of race times in Brazilian PCS national competitions warrants important considerations. While Ribeiro Neto *et al.* focused on race times above the 50th percentile (i.e., 1st to 4th places) (Ribeiro Neto *et al.*, 2023), the current study opted to analyze all finalists in order to capture the full spectrum of the Brazilian PCS reality and maintain a sufficient sample size for statistical analysis. As a result, the discrepancies in race times were expected due to factors such as the learning curve associated with adaptations to equipment and the sport itself, athletes withdrawing but still having their race times recorded upon course completion, and varying skill levels among competitors. Moreover, in many cities, the Brazilian national championships are the only competition available for athletes to participate in, limiting opportunities for developmental stages for beginners. These national competitions serve as an entry point for new athletes, who may still be in a rehabilitation context (Gomes Costa; Ribeiro Neto; Winckler, 2024), into the Paralympic movement. Further research, adopting similar methodological approaches to those of Ribeiro Neto *et al.* (Ribeiro Neto *et al.*, 2023), is needed to fully understand the complex interplay of these variables and their impact on the sport's development and the performance of Brazilian PCS.

The persistently high variability observed in Brazilian PCS may be interpreted as a marker of a developing competitive system. In mature sport systems, athlete pathways, talent identification processes, and access to training opportunities tend to produce a larger pool of athletes with comparable performance levels, reducing race-time dispersion. Conversely, high variability may reflect differences in competitive experience, training background, and access to sport-specific resources, which are common



characteristics of emerging Para sport systems. Therefore, reducing performance variability may represent an important indicator of competitive maturation within Brazilian PCS over the coming years.

The development of Brazilian PCS aligns with the progression observed in international PCS since 2015, marked by reduced race times and decreased variability over the years. As anticipated, race times in Brazilian PCS championships were higher compared to international PCS, which can be attributed to the differing inclusion criteria and the varying levels of athlete experience in competitions. Notably, the KL3-M class showed reduced race times and variability, indicating an advanced stage of PCS development, similar to international results reported in previous studies (Ribeiro Neto *et al.*, 2024, 2023). In contrast, the KL1-F class had fewer athletes and higher race times, with greater variability, suggesting an earlier stage in the developmental trajectory of this sport class. This increased variability in KL1-F, likely due to the greater severity of impairments typical of this sport class profile, was also observed in other studies (Ribeiro Neto *et al.*, 2024, 2023). The limited number of athletes in KL1-F may contribute to reduced competitive depth, resulting in larger performance gaps between finalists. Furthermore, recruitment and retention challenges, particularly among women with more severe impairments, may restrict the development of a broader competitive base. Similar mechanisms may help explain the variability observed in KL2-F, highlighting the importance of targeted development strategies for these sport classes. Given the unique characteristics of the Brazilian national championships, PCS plays a crucial role by providing valuable insights for coaches, national teams, and the sport selection process, especially in the contexts of rehabilitation and Para sport initiation.

Another significant aspect of national championships is the influence of country-specific contexts and policy factors, such as variations in etiology, impairment types, and rehabilitation services, all of which can affect the introduction to Para sports, athletic success, and athlete characteristics (De Bosscher *et al.*, 2006). In Brazilian PCS, female athletes were older than their international counterparts, while no significant age difference was observed among male athletes (Ribeiro Neto *et al.*, 2023). Regarding the origin of impairments, the higher prevalence of acquired impairments (spinal cord injury in the KL1 class and amputation in the KL3 class) over congenital impairments aligns with previous studies (le Toquin *et al.*, 2022; Lopes-Silva; Franchini; Kons, 2022; Patatas *et al.*, 2021; Ribeiro Neto *et al.*, 2024, 2023). In the international PCS, amputation was most prevalent in the KL2-M class, highlighting a notable difference from Brazilian PCS. This distinction may reflect differences in recruitment pathways, rehabilitation services, and access to Para sport programs, which can influence the representation of





specific impairment groups within national sport systems. Finally, there have been fewer female athletes in Brazilian PCS, consistent with international female participation. The greater variability in race times among female athletes indicates that there are still significant variations in performance, suggesting that women's canoeing has considerable potential for further improvement. Therefore, initiatives aimed at increasing female participation, strengthening recruitment pathways, and facilitating the transition from rehabilitation programs to competitive sport may be particularly valuable for accelerating the development of women's PCS in Brazil. Such efforts could contribute not only to increasing participation but also to enhancing competitive depth and reducing performance variability over time.

Study Limitations

First, it is important to note that while the manuscript on international PCS data focused on race times below the 50th percentile to avoid outliers, some Brazilian athletes were included in the international PCS dataset, which may have introduced confounding effects. Despite this limitation, the study was still able to detect significant differences between Brazilian and international PCS athletes, which enhances the external validity of the findings. Second, unlike the methodological approach used for international PCS, which included the best race times to reduce variability, in the current study, we chose to analyze all finalists (Ribeiro Neto *et al.*, 2023). This approach was intended to improve external validity and ensure sufficient sample size for robust statistical analysis. Future studies could consider conducting separate analyses for Brazilian athletes or applying similar percentile thresholds to ensure more accurate cross-dataset comparisons. Finally, this study did not account for climatic factors, such as wind speed and direction, which could have influenced race results.

PRACTICAL APPLICATIONS

This study highlights the evolving performance trajectory of Brazilian PCS kayak athletes, revealing both progress and ongoing challenges. While race times have generally improved across most sport classes, Brazilian athletes still lag behind their international counterparts, with greater race times in 200m and variability observed in national competitions. The study also underscores the influence of country-specific factors, such as the prevalence of acquired impairments and the sex and age distribution among athletes, particularly noting the older age of female athletes in Brazil. These findings suggest that targeted interventions, including enhanced programs, talent identification initiatives, expanded regional





competition opportunities, and strategies to increase female participation, could help bridge the performance gap between Brazilian and international PCS athletes. Ultimately, addressing the specific structural and technical barriers in high-variability classes, such as KL1-F and KL2-F, is not just about improving individual performance, but a necessary step to mature the entire Brazilian Para canoe system and close the gap with international standards.

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Author 1: contributed to conceptualization, formal analysis, investigation, project administration, and writing;

Author 2: contributed to writing and review

Author 3: contributed to writing and review





Author 4: contributed to writing and review

Author 5: contributed to conceptualization, project administration, supervision, and writing;

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