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Original Articles

Geographical distribution of Brazilian para athletes in the sports of athletics and swimming

Distribuição geográfica de paratletas brasileiros das modalidades de atletismo e natação

Distribución geográfica de los para atletas brasileños en atletismo y natación

Carlos Makleyton Caetano Schuchter[a,b], Renato de Carvalho Guerreiro[c], Gilberto Tadeu Silva Cavalcante[d], Luiz Gustavo Teixeira Fabricio dos Santos[a], Gustavo Henrique Scarmigliat Cruz[a,d], Arthur Henrique Rodrigues Cordeiro[d], Marco Túlio de Mello[e,f], Ciro Winckler de Oliveira Filho[g], Andressa Silva[d*]

Keywords:
Geographic mapping; Sports for persons with disabilities; Swimming; Athletics.

ABSTRACT
The unequal distribution of athletes in Brazilian para sports, especially athletics and swimming, has concentrated participation in the Southeast. Since 2021, the Brazilian Paralympic Committee (CPB) has promoted decentralization strategies, including the 2024 Paralympic Meetings across all federal units. This study analyzed the 2024 geographic distribution of 3,380 athletes (2,255 in athletics; 1,125 in swimming) by sex and disability. Males (69.1%) and athletes with physical disabilities (66.7%) predominated. Participation rose in the North (2.9%→9.2%) and Northeast (11.0%→19.0%) but declined in the Southeast (65.7%→45.7%). Visual impairment (15.5%) and female (30.9%) participation also decreased. CPB actions expanded access but inequalities persist.

Palavras-chave:
Mapeamento geográfico; Esportes para pessoas com deficiência; Natação; Atletismo.

RESUMO
A distribuição desigual de atletas no paradesporto brasileiro, especialmente em atletismo e natação, concentrou-se historicamente no Sudeste. Desde 2017, o Comitê Paralímpico Brasileiro (CPB) adota estratégias de descentralização, como os Meetings Paralímpicos 2024 em todas as unidades federativas. Este estudo analisou a distribuição geográfica de 3.380 atletas (2.255 do atletismo; 1.125 da natação) por sexo e deficiência. Predominaram homens (69,1%) e atletas com deficiência física (66,7%). Houve aumento no Norte (2,9%→9,2%) e Nordeste (11,0%→19,0%), e redução no Sudeste (65,7%→45,7%). Já a participação de atletas com deficiência visual (15,5%) e mulheres (30,9%) diminuiu. As ações do CPB ampliaram o acesso, mas persistem desigualdades.

Palabras clave:
Mapeo geográfico; Deportes para personas con discapacidad; Natación; Atletismo.

RESUMEN
La distribución desigual de atletas en los paradeportes brasileños, especialmente en atletismo y natación, se ha concentrado históricamente en el Sudeste. Desde 2021, el Comité Paralímpico Brasileño (CPB) impulsa estrategias de descentralización, como los Meetings Paralímpicos 2024 en todas las unidades federativas. Este estudio analizó la distribución geográfica de 3380 atletas (2255 en atletismo; 1125 en natación) según sexo y discapacidad. Predominaron hombres (69,1%) y personas con discapacidad física (66,7%). Hubo aumento en Norte (2,9%→9,2%) y Nordeste (11%→19%) y reducción en Sudeste (65,7%→45,7%). La participación femenina (30,9%) y de personas con discapacidad visual (15,5%) disminuyó. Las acciones del CPB ampliaron el acceso, pero persisten desigualdades.

[a]Comitê Paralímpico Brasileiro – CPB. São Paulo, SP, Brasil.
[b]Universidade Federal de Juiz de Fora – UFJF. Juiz de Fora, MG, Brasil.
[c]Universidade Federal de Juiz de Fora – UFJF. Governador Valadares, MG, Brasil.
[d]Universidade Federal de Minas Gerais – UFMG. Belo Horizonte, MG, Brasil.
[e]Universidade Católica de Brasília – UCB. Brasília, DF, Brasil.
[f]Universidad Autónoma de Chile, Facultad de Ciencias de la Salud. Providencia, Chile.
[g]Universidade Federal de São Paulo – UNIFESP. São Paulo, SP, Brasil.

***Corresponding author:**
Andressa Silva
E-mail: andressa@demello.net.br

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INTRODUCTION

Since the first Summer Paralympic Games (SPG) in 1960, a remarkable evolution in the performance of para-athletes has been observed, reflected both in the improvement of medalists' results and in the significant increase in the number of competitors (Darcy et al., 2017). Over the years, the ratio of medals to registered athletes in the SPG has steadily decreased. An analysis of the past 20 years shows a ratio of 1.39 medals per athlete in the 1984 SPG, 0.42 in 2004, and 0.29 in 2024, indicating an increasing level of difficulty in winning a medal (WPA, 2025).

At the Paris 2024 SPG, Brazil ranked in the Top 5 of the medal table, continuing its upward trajectory in the rankings of recent Paralympic editions. One factor contributing to this progress was the implementation of public policies such as the Agnelo Piva Law, which established regular financial transfers to national committees (Santos et al., 2022). Brazil's success in the Summer Paralympic Games is also attributable to resource management and programs developed by the Brazilian Paralympic Committee (CPB) over the past two decades, as well as to the growing number of athletes in Brazilian delegations, which has increased the likelihood of reaching the podium across more disciplines and events. At the Sydney 2000 SPG, with 63 athletes, Brazil had only the 19th largest delegation (24th in the medal table). By 2004, with 94 athletes, the delegation ranked 12th in size (14th in the medal table), and in 2008, with 184 athletes, it was the 4th largest delegation while entering the top 10 in the medal table. In subsequent editions, Brazil ranked 5th (2012), 2nd (2016), 5th (2020+1), and 2nd (2024) in delegation size (IPC, 2024).

Despite these sporting achievements, Brazil has reached a plateau in the number of para-athletes since the Rio 2016 Games (Santos et al., 2022). In this context, a study published in 2019, based on 2015 data, mapped Brazilian para-athletes in athletics and swimming—the two sports with the highest participation rates, accounting for approximately 51% of athletes receiving financial scholarships in the country (Winckler et al., 2022). Furthermore, these sports include athletes with physical impairments (PI), visual impairments (VI), and intellectual impairments (II). The initial mapping revealed that 77% of these athletes were concentrated in the Southeast and South of Brazil, underscoring the need to expand Paralympic sport development in other regions of the country (Silva et al., 2019).

It is worth noting that until 2016, the CPB primarily focused on elite sport development, and its projects were not designed to decentralize, democratize, or broaden access to Paralympic sport (Furtado et al., 2022). With the implementation of a new strategic plan in 2017, the CPB adopted the following goals: (a) to be a global reference in the management and development of Paralympic sport, promoting the inclusion of people with disabilities in all its dimensions; (b) to foster Paralympic sport from grassroots to elite levels; and (c) to promote the inclusion of people with disabilities in society. This strategic plan was revised in 2022 (CPB, 2022).

From 2017 onward, several initiatives were launched to promote and expand Paralympic sport throughout Brazil, in alignment with the new strategic plan (CPB, 2022). The CPB's Sports Development Directorate established programs such as Reference Centers, the Paramilitary Project, and the Paralympic School. To meet the strategic plan's objectives, the CPB's High-Performance Directorate also introduced changes. For instance, between 2005 and 2019, athletics and swimming competitions were organized into four Regional Stages (Furtado et al., 2022) and from 2021 onward, however, the CPB introduced the "Meeting Paralímpico Loterias Caixa," aiming to provide competitions in strategically chosen locations across the country. Sixteen regional stages were held in both 2021 and 2022. In 2023, all stages took place in state capitals, including three in the Southeast (Rio de Janeiro, Belo Horizonte, São Paulo), two in the South (Porto Alegre, Curitiba), two in the Midwest (Campo Grande, Brasília), two in the Northeast (Recife, Fortaleza), and one in the North (Manaus). In 2024, the Meetings were held in all 27 federative units, thereby facilitating the participation of para-athletes from every Brazilian state.

Given the relevance of developing Paralympic sport across the national territory and the importance of monitoring and mapping Brazilian para-athletes, the present study aimed to analyze the geographic distribution, sex, and impairment classification of Brazilian para-athletes competing in athletics and swimming in 2024. The working hypothesis suggests that, following the implementation of the Meetings and, subsequently, the organization of competitions in all Brazilian federative units, greater equity in para-athlete participation will be observed compared to the data presented by Silva et al. (2019). This analysis seeks to contribute to the understanding of participation dynamics and the inclusion of people with disabilities in Paralympic sport, while also providing a solid basis for future public policy strategies and assessing the extent to which CPB programs aimed at democratizing and decentralizing opportunities for people with disabilities (PwD) in Brazil have been effective.

METHOD

The data for the para-athletes in this study were obtained from the national rankings, which compile all sporting results of athletes in athletics and swimming. These rankings are available on the Brazilian Paralympic Committee's (CPB) club registration website for all affiliated clubs. This database records performances in regional competitions (such as the Meetings), as well as national and international competitions recognized by the CPB. For this study, data were collected for the period from January 1, 2024, to December 31, 2024.

PROCEDURES

For the present study, data were compiled into a master spreadsheet in Microsoft Excel®, containing information from athletes in athletics and swimming. The following variables were collected for each athlete: name, sport class, impairment type, federative unit of the club, and geographic region. The ranking lists the athlete's best result in each event, considering all CPB-recognized competitions. As an exclusion criterion, duplicate entries were removed, as well as athletes from classes and/or events not included in at least one official senior-level CPB competition (Brazilian Championships, Loterias Caixa Circuit, and Meeting Paralímpico).

After assembling the database, filters were applied to exclude athletes from classes or events not offered in official senior competitions in athletics (n = 88) and swimming (n = 48). Duplicate entries were also removed from athletics (n = 3,136) and swimming (n = 3,384). After structuring the spreadsheet, data analysis was carried out.

Initially, the database contained 5,479 athletics athletes and 4,557 swimming athletes, totaling 10,036 athletes. After applying the filters, 3,380 athletes remained, consisting of 1,125 swimmers and 2,255 athletes in athletics.

DATA ANALYSIS

The dataset was organized in Microsoft Excel® 365, and statistical analyses were performed using IBM SPSS Statistics® version 20, applying descriptive statistics. Data are presented as absolute numbers and percentages (%), considering absolute frequency (overall analysis) and relative frequency (sex, federative unit, region, and sport). In addition, a choropleth map was created in Excel to visualize the distribution of athletes by federative unit in Brazil.

In addition, the percentage change and the variation in percentage points were calculated. The change in percentage points was obtained by the difference between the representativeness in the current study and that of the study by Silva et al. (2019). For example, in the North region, representativeness increased from 2.9% (Silva et al., 2019) to 9.2% in the current study, resulting in a variation of 6.3 percentage points (9.2% – 2.9% = 6.3).

Percentage change was calculated proportionally using a rule of three, based on the variation relative to Silva's study. For example: if 2.9% corresponds to 100%, then 6.3% represents X%. Thus, X = (6.3 × 100) / 2.9 ≈ 217.2%, indicating an increase of approximately 217.2% compared to Silva et al. (2019).

RESULTS

The distribution of para-athletes in athletics and swimming by sex and type of impairment is presented in Table 1. A higher prevalence of male athletes and of those with physical impairments can be observed in both sports.

Figure 1 presents the choropleth map showing the current (2024) distribution of para-athletes in athletics and swimming across the 26 federative units and the Federal District. São Paulo (1,010), Minas Gerais (319), Santa Catarina (263), Federal District (194), Pernambuco (190), and Ceará (162) are the federative units with the highest number of athletes, as indicated in the map. In contrast, Maranhão (7), Bahia (13), Alagoas (22), Acre (24), Rondônia (29), and Tocantins (29) were the states with the lowest number of para-athletes.

Figure 2 presents a choropleth map showing the distribution of para-athletes by region. In addition, the figure includes a comparative table with data from Silva et al. (2019) and data obtained in the present study. The table highlights an increase in the total number of para-athletes from 1,708 to 3,380, as well as regional changes in athlete numbers, expressed both in percentage points and percentage change.

Tables 2 and 3 show the geographic distribution of para-athletes by sport, type of impairment, and sex across the regions of Brazil. It can be observed that the majority of para-athletes are from the Southeast region, in both athletics and swimming. Additionally, in athletics, the Midwest region (19.0%) showed a higher percentage contribution of athletes with II compared to those with PI (10.9%), whereas the South region presented a higher contribution of athletes with VI (17.7%) and II (15.9%) than with PI (13.7%) (Table 2).

In swimming, a higher concentration of athletes with PI was also observed. However, the Northeast region showed the highest percentage contribution of athletes with II (22.3%), and the Midwest region also presented higher contributions of athletes with II (10.9%) and VI (12.1%) compared to the proportion in the Federal District (Table 3). Additionally, a low number of athletes with VI in swimming was observed in the North region of Brazil.

Table 1. Distribution of athletes in Athletics and Swimming according to sex and disabilities.

	Sex		Disability			Total
	Male	Female	Physical	Intellectual	Visual	
Athletics	1,589 (70,5%)	666 (29,5%)	1,501 (66,6%)	353 (15,7%)	401 (17,8%)	2,255 (66,7%)
Swimming	745 (66,2%)	380 (33,8%)	754 (67,0%)	247 (22,0%)	124 (11,0%)	1,125 (33,3%)
Total	2,334 (69,1%)	1,046 (30,9%)	2,255 (66,7%)	600 (17,8%)	525 (15,5%)	3,380 (100%)

Data presented in absolute numbers and percentages in relation to the total by disability and by sex.

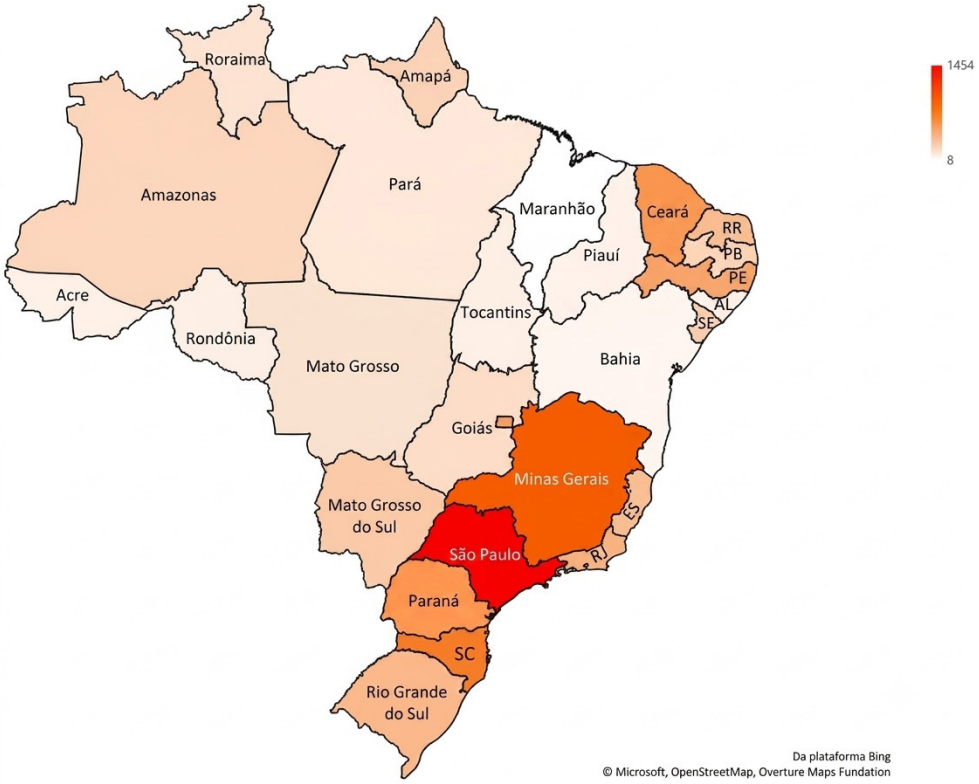
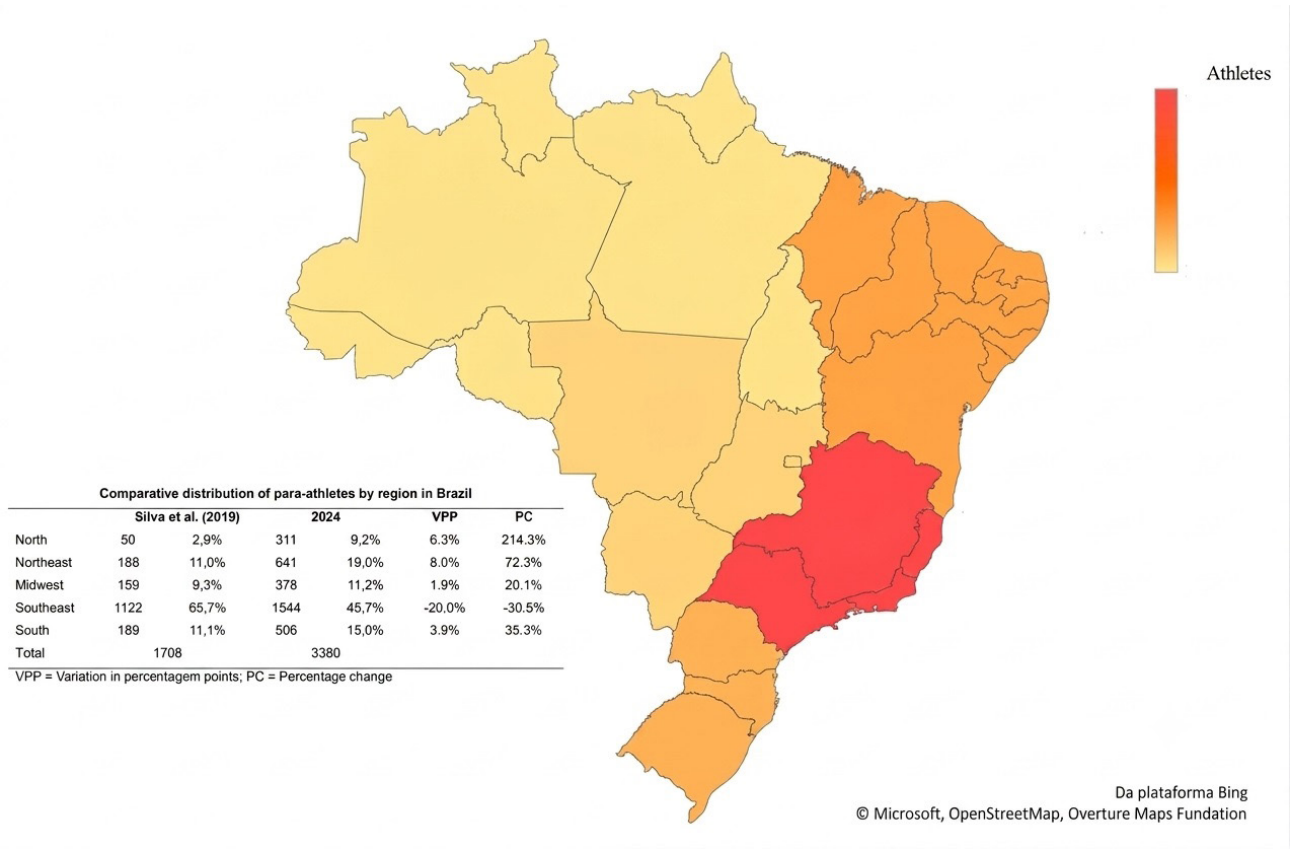


Figure 1. Choropleth map of distribution of para-athletes in athletics and swimming by federative unit. Legend: AL = Alagoas; ES = Espírito Santo; PE = Pernambuco; PB = Paraíba; RJ = Rio de Janeiro; RR = Roraima; SC = Santa Catarina; SE = Sergipe.
Source: Research data.



Comparative distribution of para-athletes by region in Brazil

	Silva et al. (2019)		2024		VPP	PC
North	50	2,9%	311	9,2%	6.3%	214.3%
Northeast	188	11,0%	641	19,0%	8.0%	72.3%
Midwest	159	9,3%	378	11,2%	1.9%	20.1%
Southeast	1122	65,7%	1544	45,7%	-20.0%	-30.5%
South	189	11,1%	506	15,0%	3.9%	35.3%
Total	1708		3380			

VPP = Variation in percentagem points; PC = Percentage change

Figure 2. Choropleth map of distribution of para-athletes in athletics and swimming by region.
Source: Research data.

Table 2. Distribution of athletics athletes according to sex and disabilities by region.

Region	Disability			Sex	
	Intellectual	Visual	Physical	Male	Female
North	28 (7,9%)	51 (12,7%)	166 (10,5%)	167 (10,5%)	78 (11,7%)
Northeast	67 (19,0%)	47 (11,7%)	334 (22,3%)	332 (20,9%)	116 (17,4%)
Midwest	67 (19,0%)	31 (7,7%)	163 (10,9%)	184 (11,6%)	77 (11,6%)
Southeast	135 (38,2%)	201 (50,1%)	633 (42,2%)	682 (42,9%)	287 (43,1%)
South	56 (15,9%)	71 (17,7%)	205 (13,7%)	224 (14,1%)	108 (16,2%)
Subtotal	353 (15,7%)	401 (17,8%)	1,501 (66,6%)	1,589 (70,5%)	666 (29,5%)

Data presented in absolute numbers and percentages in relation to the total by disability and by sex.

Table 3. Distribution of **swimming** athletes according to sex and disabilities by region.

Region	Disability			Sex	
	Intellectual	Visual	Physical	Male	Female
North	12 (4,9%)	3 (2,4%)	51 (6,8%)	46 (6,2%)	20 (5,3%)
Northeast	55 (22,3%)	14 (11,3%)	124 (16,4%)	142 (19,1%)	51 (13,4%)
Midwest	27 (10,9%)	15 (12,1%)	75 (9,9%)	83 (11,1%)	34 (8,9%)
Southeast	116 (47,0%)	69 (55,6%)	390 (51,7%)	375 (50,3%)	200 (52,6%)
South	37 (15,0%)	23 (18,5%)	114 (15,1%)	99 (13,3%)	75 (19,7%)
Subtotal	247 (22,0%)	124 (11,0%)	754 (67,0%)	745 (66,2%)	380 (33,8%)

Data presented in absolute numbers and percentages in relation to the total by disability and by sex.

DISCUSSION

The primary aim of this study was to map the geographic distribution of Brazilian para-athletes in athletics and swimming in 2024, as well as to evaluate changes in their distribution following the implementation of the Paralympic Meetings. In 2024, the CPB held competitions in all federative units of Brazil, providing para-athletes the opportunity to compete in their home states, which facilitated access to official athletics and swimming competitions. To meet the objectives of the study, athlete names were recorded in the CPB 2024 ranking and organized as described in the Methods section. Data from 2015, published by Silva et al. (2019), were used for comparative purposes. The results reveal significant advances both in the number and distribution of para-athletes nationwide. Although the Southeast region continues to show the highest concentration of para-athletes, all other regions have shown growth in their representation within the Paralympic landscape, particularly in the North and Northeast regions.

Compared to Silva et al. (2019), the Southeast region, while still hosting the largest number of para-athletes, saw its relative representation decrease from 65.7% to 45.7%. The South and Midwest regions observed modest increases, from 11.1% to 15.0% and from 9.3% to 11.2%, respectively. The most substantial growth was observed in the North and Northeast regions, which increased from 2.9% to 9.2% and from 11.0% to 19.0%, respectively. The increase in the North corresponds to a rise of 6.3 percentage points, or 214.3%, compared to 2015, while the Northeast increased by 8 percentage points, or 72.3%, over the same period. This evolution underscores the effectiveness of strategies aimed at promoting inclusion and strengthening Paralympic sport across all Brazilian regions. These results align with the report on scholarships distributed between 2010 and 2022, which shows São Paulo, Minas Gerais, Rio de Janeiro, Paraná, Pernambuco, and Santa Catarina as the states with the highest scholarship prevalence (Winckler et al., 2022).

Comparatively, in 2019, the last year of regional competitions, the CPB organized four events: 1) Rio/South Regional (Curitiba - PR); 2) North/Northeast Regional (João Pessoa - PB); 3) Midwest/East Regional (Uberlândia - MG); 4) São Paulo Regional (São Paulo - SP) (CPB, 2019). In this distribution, it is possible to observe that two of the four stages were held in the Southeast, one in the South, and one in the Northeast, while there were no stages in the Midwest or North of Brazil, which made it difficult for beginner athletes from these regions to access official competitions.

The Southeast region's dominance in the concentration of Paralympic athletes can be explained by several factors: 1) it was a pioneer in the implementation of Paralympic sports in Brazil; 2) the CPB is headquartered in São Paulo, with major competitions held there (such as Brazilian Championships and Loterias Caixa circuits); 3) the region's greater socioeconomic development allows for greater investment in Paralympic sports; and 4) its higher population density.

The most prevalent type of disability in the 2024 Paralympic scenario, considering athletics and swimming, was PI, with 66.7%. This predominance may be linked to the greater number of classes for athletes with PI in athletics (28) and swimming (10), compared to classes for VI (3 per sport) and II (1 per sport) (WPA, 2022; Swimming, 2018). Furthermore, PI is generally more easily identified, while individuals with II or low vision may go unnoticed and not be recognized as PwD. Despite its high prevalence, invisible impairments are often poorly understood and less acknowledged (Granjon et al., 2025).

In the present study, VI was identified as the least prevalent impairment, representing 15.5% of para-athletes. Although this condition is the most common among the Brazilian population, affecting 8.9% of individuals aged two years or older (IBGE, 2025), the discrepancy may be attributed to the VI definition used by IBGE, which differs from the eligibility criteria in Paralympic competitions (Malta et al., 2016). According to the visual classification agreed upon by the CPB, World Para Athletics, and World Para Swimming, an athlete is eligible if they have reduced or absent vision caused by damage to the ocular structure, optic nerves or pathways, or visual cortex in both eyes, excluding individuals with monocular vision who have one functional eye (WPA, 2024; WPS, 2024). Furthermore, it is important to note that VI often develops at an advanced age, which can hinder the inclusion of these individuals in Paralympic sports. While this low number can be justified, the results observed in this study reinforce the need for greater attention to the development of sports inclusion policies aimed at people with VI.

In the study by Silva et al. (2019), it was observed that 65.3% of para-athletes had PI, 9.4% II, and 25.1% VI. Data collected in 2024 show changes in the percentage distribution by impairment. The population of PI para-athletes showed little variation, from 65.3% in 2015 to 66.7% in 2024. In contrast, II and VI data revealed notable changes. In 2015, athletes with VI represented 25.1% of the total, whereas in 2024 this fell to 15.5%, a reduction of 9.6 percentage points. The decline in VI participation may reflect environmental and personal barriers (Matoso and Portela, 2019), as well as a lack of professionals trained to work with this population (Linsenbigler et al., 2018). Nevertheless, initiatives exist aiming to maximize sports participation for individuals with VI (Holton, 2022).

These challenges may include accessibility factors (holes, tactile floors, obstacles), safety (risk of falls or collisions), and transportation (infrastructure, guidance, and communication), as well as a lack of adapted physical activity programs (Rimmer et al., 2004). Moreover, individuals with VI may require personal support, such as guides or tappers, to train and compete, increasing participation costs. Environmental limitations can be mitigated through assistive technologies and increased investment in accessibility. Both national and international companies are increasingly providing technological resources that facilitate the integration of individuals with VI into sports, especially through the use of smartphones (Lima, 2019). However, this same accessibility to new technological means can, paradoxically, contribute to the exclusion of children, young people, and adults from sports. Increased smartphone use has been associated with increased sedentary behavior, which can negatively impact physical and mental health. Studies show that young adults and adolescents who spend more time on their smartphones tend to have lower levels of physical activity and more time spent inactive (Grimaldi-Puyana et al., 2020).

Another notable change in the distribution of para-athletes was the increase in II from 9.4% to 17.8%. In athletics, the representation of para-athletes with II rose from 8.4% to 15.7% nationally, while in swimming, it more than doubled, increasing from 10.3% to 22.0%. This increase may be related to improved identification and facilitation of recognition of intellectual impairments (Malta et al., 2016). In addition to better identification, Brazil has seen in recent years an expansion of institutions and organizations, such as Associations of Parents and Friends of the Exceptional and Specialized Rehabilitation Centers, which work to improve quality of life and social inclusion for individuals with disabilities. In this context, sport serves as an effective tool for inclusion, promoting social cohesion, the integration of people with disabilities, and the development of positive social identities, although its effectiveness can still be limited by structural barriers (Klotz, 2021).

Another notable point observed in this mapping is the significant disparity in participation between male and female para-athletes. In 2015, 63% of para-athletes were men, while 37% were women. By 2024, this difference had widened, with female participation decreasing to 30.9%. This decline is particularly notable in swimming, where female representation fell from 41% in 2015 to 33.8% in 2024. These data contrast with trends observed in the Paralympic Games. Female participation in the Paralympic Games has shown a gradual upward trend. During the 2016 Rio Games, 40% of para-athletes were women, although among Brazilian participants, this proportion was lower (35%) (Kirakosyan, 2021). At the Tokyo 2021 Games, female representation increased to 42%, reaching 45% in Paris 2024 (Padovani, 2024). In absolute numbers, Paris 2024 included 1,983 women, more than double the 988 participants in Sydney 2000, a milestone for gender representation in Paralympic sport (Padovani, 2024).

The International Paralympic Committee aims to equalize athlete participation by sex in future competitions, targeting balance by 2028. As part of this strategy, the 2025 calendar includes competitions exclusively for women, expanding opportunities and supporting the growth of female sport. This initiative is an important step toward consolidating inclusion and representation of female para-athletes worldwide. In Brazil, greater investment, awareness, and research are needed to understand and implement strategies to increase women's participation in Paralympic sport.

These results demonstrate the positive impact of inclusive public policies. Along with the strong international performance of Brazilian athletes, it is essential to highlight the role of sports inclusion for people with disabilities, ensuring access and opportunities for participation. However, significant challenges remain, as approximately 78% of Brazilian municipalities still do not offer programs aimed at the inclusion of people with disabilities through sports, indicating that much remains to be done to expand access and participation (Lima-Trigo et al., 2023).

CONCLUSION

The present study focused on the geographic mapping of Brazilian para-athletes in athletics and swimming. By comparing the data obtained in 2024 with those presented by Silva et al. (2019), it was possible to observe a greater distribution of para-athletes across the national territory. This evolution suggests that the implementation of regionalized events and the new strategic plan introduced in 2017 are beginning to impact this distribution, with emphasis on the North and Northeast regions, which showed significant growth in their representation. However, the study also identified a concerning reduction in the number of para-athletes with VI and in female participation. Therefore, it is essential that future policies focus on promoting and encouraging these groups within the Paralympic movement.

In terms of future perspectives, it is important to monitor whether the policies implemented are also reflecting in high-performance development. To do so, it is recommended to compare the distribution of para-athletes selected for national teams with those receiving financial support through the "Bolsa Atleta" program across the country.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are openly available in Comitê Paralímpico Brasileiro at https://cpb.org.br/competicoes/circuito-loterias-caixa/edicoes/.

AUTHORS' CONTRIBUTION

Schuchter, C. M. C.: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Software, Supervision, Visualization, Writing – original draft, Writing – review & editing. Guerreiro, R. C.: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. Cavalcante, G. T. S.: Data curation, Writing – review & editing. Santos, L. G. T. F.: Data curation, Writing – review & editing. Cruz, G. H. S.: Data curation, Writing – review & editing. Cordeiro, A. H. R.: Data curation, Writing – review & editing. Mello, M. T.: Visualization, Writing – original draft, Writing – review & editing. Oliveira Filho, C. W.: Visualization, Writing – original draft, Writing – review & editing. Silva, A.: Methodology, Supervision, Visualization, Writing – original draft, Writing – review & editing. All authors have read and agreed to the published version of the manuscript.

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