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Performance of Athletes With Visual Impairment in Track-and-Field Events at the Paralympic Games, From 1988 to 2016

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Abstract

Introduction: The Paralympic movement has grown considerably over the last decades, but few studies have analyzed the performance evolution of the best athletes with disabilities. This study examined the performance of athletes with visual impairments in track-and-field events over eight Paralympic Games (1988–2016). **Method:** Results in the Paralympic track-and-field events for athletes with visual impairments (and in the corresponding track-and-field Olympic events) were collected from official public websites. **Results:** Analysis showed that most performances at Paralympic track-and-field events increased linearly over the years, which finding contrasts with the general stagnation in Olympic events. The improvements from 1988 to 2016 in Paralympic sprinting, middle- and long-distance running, throwing, and long-jumping events were 4.0–16.3%, 3.2–16.2%, 23.0–54.2%, and 4.9–18.9%, respectively. Men had better performances than women in running, throwing, and jumping events. In general, sports classes with a less severe level of visual impairment achieved higher performance levels than those with a more severe level of visual impairment, especially men. The competition density of Paralympic track-and-field events showed modest improvements. **Conclusions:** This study provides evidence that the performance of track-and-field athletes with visual impairments have been improving persistently over the last eight Paralympic Games, confirming that Paralympic athletes are achieving high-level performances. **Implications for Practitioners:** This study will be helpful for coaches and athletes with visual impairments who are setting performance (and training) goals for the Paralympic Games and other international athletic events.

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The Paralympic Games are considered the worlds' largest sporting event for athletes with disabilities (Brittain, 2016). The first Paralympic Games were organized in 1960 (in Rome, Italy) and involved 400 athletes from 23 countries and eight sports (International Paralympic Committee, n.d.). At the 2016 Paralympic Games in Rio de Janeiro, 4328 athletes represented 159 countries and competed in 22 sports (International Paralympic Committee, n.d.). The first Paralympic Games were limited to participants with spinal cord injuries, but the event became open to athletes with physical, visual (since 1976), and intellectual impairments (Brittain, 2016). The range of impairments participating in the Paralympic Games contrasts with other important world disability sports events, such as the Special Olympics and the Deaflympics, which are directed to people with intellectual and hearing impairment, respectively.

Over the years, sport for people with disabilities has been moving from a rehabilitation model to an elite sports model (Brittain, 2012; Schantz & Gilbert, 2012). Concurrently, interest from the media and the general public in competitive disability sport has grown substantially (Blauwet & Willick, 2012; Mauerberg-deCastro, Campbell, & Tavares, 2016). Nonetheless, despite its constant growth in the effect on participants and society at large, sport for people with disabilities remains an under-researched area (Brittain, 2016; Patatas, De Bosscher, & Legg, 2018), and few studies examined whether they are being reflected in the level of athletic performance.

Track and field is the sport with the highest number of athletes in the Paralympics. There were 1,140 athletes (from 146 countries) competing in track-and-field events at the Rio 2016 Paralympic Games, which accounted for more than a quarter of all participants. Curiously, track and field is also the sport with the highest number of participants in the Olympic Games; in Rio 2016, about one-in-five athletes (2,283 of a total of 11,238) participated in this sport (World Athletics, 2016).

In disability sports, athletes are allocated into sport classes according to the potential effect of their impairment on sport performance (International Paralympic Committee, 2015). Athletes with visual impairments are distributed into three-sport classes according to visual acuity and visual field measurements, namely, B1, B2, and B3 (from the most to the least severe; International Paralympic Committee, 2015). In track and field, these classes correspond to the T/F11, T/F12, and T/F13 classes.

Track and field is an appealing sport for studying elite performance progression, since the results are objectively measured (in time or distance units), and data can be easily used to tracing performance changes over time. Moreover, most track-and-field events are present at both the Paralympic and Olympic Games, which facilitates the comparison of the performance evolution between athletes with and without disabilities (Grobler, Ferreira, & Terblanche, 2015).

Several studies examined the level of progression in track and field in athletes without disabilities, including the Olympic Games, revealing that the athletic performance in most events has stagnated or decreased in the recent decades, suggesting that athletes have reached their limits of performance (Berthelot et al., 2015; Heazlewood & Walsh, 2015). Regarding the performance of athletes with disabilities, such analysis has been very limited. One of the few studies on this subject (Grobler et al., 2015) showed a progression of sprint performances (100 and 200 m finals) of athletes with disabilities (visual impairments, amputations, and cerebral palsy) between 1992 and 2012, which largely surpassed the progression of Olympic athletes. More recently, a study focused on the performance of Paralympic athletes from the category T54 (wheelchair competitors or those with spinal cord injuries) concluded that there were no significant changes in their performance between 2009 and 2018 in sprint, middle- and long-distance events (de Macedo et al., 2020).

In this study, we analyze the performance of athletes with visual impairments in the track-and-field events at the Paralympic Games. Our main goal is to examine the athletic performance trends in running, throwing, and jumping events during eight Paralympic Games (Seoul 1988 to Rio 2016). For a better understanding of the performance changes over the years at the Paralympics, we also analyze the performance changes in the correspondent events at the Olympics. We also intend to examine the effects of gender, competition type (Paralympics or Olympics), and visual impairment sports classes on athletic performance. Considering the considerable growth of the Paralympic Games over the last few decades and the expansion of sports opportunities and competitions for athletes with disabilities, we expect to find evidence of performance increments along the approximately 30 years of Paralympic Games covered in this study.

Method

We collected data for track-and-field events for athletes with visual impairments during eight Paralympic Games (Seoul 1988 to Rio 2016), as well as for the corresponding Olympic events during the same period. Data were collected from two websites: Paralympic.org and Olympic.org. For examining athletic performance trends, we selected the track-and-field events that took place in the Rio 2016 Paralympic Games and for which there was available data in at least four previous Paralympic Games. In total, 32 Paralympic athletic events (18 and 14 for male and female athletes, respectively) were considered for performance trend analysis, including sprint, middle- and long-distance running, throwing, and long-jumping competitions. The performance of finalists for each visual impairment sports class was included in the analysis; for events where there was only one final round, the best eight performances were used instead. The three sports classes for athletes with visual impairments are:

- T/F11, no light perception in either eye up to light perception, but inability to recognize the shape of a hand at any distance or in any direction;
- T/F12, from ability to recognize the shape of a hand up to a visual acuity of 2/60 in the best eye with best correction and/or visual field of less than 5°; and
- T/F13, from visual acuity above 2/60 up to visual acuity of 6/60 in the best eye with best correction and/or visual field of more than 5° and less than 20°. (US Paralympics, 2017, p. 98).

Statistical Analysis

We use a two-way analysis of variance (ANOVA) to study the effects of gender, visual impairment class, and competition event (Olympics vs Paralympics) on time (for each running event) or distance (for each throwing event and the long jump). The magnitude of the effects was assessed using partial eta-squared (ηp^2), with cut-off scores of .01, .06, and .14 for small, medium, and large effects, respectively (Cohen, 1988).

To analyze whether the performance progression has been constant over the years, simple linear regression analysis was computed for Paralympic and Olympic track-and-field events, in which performance (finalists or the eight best performances) and calendar year were added as dependent and independent variables, respectively. The percentage change in performance from 1988 to 2016 was calculated for each event using the formula: 100 × (Paralympic (or Olympic) 2016 event result−Paralympic (or Olympic) 1988 event result)/Paralympic (or Olympic) 1988 event result). Percentage change from previous events is a common measure to analyze performance trends in the sports literature (e.g., Dyer, 2015; Grobler et al., 2015).

For visualizing performance trends over the years, we plotted the mean of the top three performances at each Paralympics and Olympic

Games, as well as the differences (in percentage) between such performances, calculated using the formula 100 × (Paralympics event results−Olympics event results)/Olympics event results. Whenever there were two or three competition events in the same athletic discipline at the Paralympics (e.g., T11, T12, and T13), the mean difference to the Olympic reference event was computed.

The level of competitiveness of each athletic event at the 1988 and 2016 Games was calculated using the formula (Grobler et al., 2015): Competition density = *nfinish*/(*plast*−*pfirst*), where *n finish* is the number of athletes in the final round of the event, *plast* is the performance of the last competitor of the final round and *pfirst* is the performance of the winner. We also examined the differences in performance between Paralympic and Olympic athletes at the 2016 games using effect sizes (Cohens' *d*), calculated as the difference of the means of the two groups of athletes divided by the weighted pooled standard deviations of the groups (Cohen, 1988). We considered effect sizes as small ($d = 0.2$), medium ($d = 0.5$), or large ($d = 0.8$). We checked for outliers, excluding the performances exceeding the mean by 2.5 or more. Statistical analyses were performed with the Statistical Package for Social Sciences (SPSS) software (version 22); the level of significance was $p < 0.05$.

Results

In total, 2,522 performance results (1,396 and 1,126 for Paralympic and Olympic athletes, respectively) were used for data analysis. For Paralympic male athletes, the track-and-field events analyzed were: 100 m (T11-13), 200 m (T11, T12), 400 m (T11-13), 1,500 m (T11, T13), 5,000 m (T11, T13), marathon (T12), discus (F11), shot put (F12), javelin (F13), and long jump (F11, F12). For Paralympic female athletes, the events analyzed were: 100 m (T11-13), 200 m (T11, T12), 400 m (T11-13), 1,500 m (T12), discus (F11), shot put (F12), javelin (F13), and long jump (F11, F12). Longitudinal data were gathered for 50 track-and-field events (32 Paralympic events and 18 Olympic events).

Effects of Variables on Athletic Performance

A two-way ANOVA showed that men perform better than women at all track-and-field events ($p < 0.01$; $\eta_p^2 = 0.217$–0.756). For male athletes, visual impairment class was related to performance ($p < 0.01$) in all sprint distances: 100 m ($\eta_p^2 = 0.075$), 200 m ($\eta_p^2 = 0.337$), and 400 m ($\eta_p^2 = 0.121$). Available data made it possible to examine the performance of male athletes from the three-sport classes of visual impairment in the 100 m and 400 m, and the post-hoc analysis showed that, in both distances, T13 and T12 athletes had better performances than T11 athletes ($p < 0.05$). No significant effect of the visual impairment sports classes was found for women on sprint events. In men's 1,500 m and 5,000 m, we analyze the effect on the performance of two classes of visual impairment, and, in both cases, T13 was better than T11 performance ($p < 0.01$, $\eta_p^2 = 0.365$ and 0.362 in 1,500 m and 5,000 m, respectively). In the long jump, F12 athletes had better performance than F11 athletes ($p < 0.01$; $\eta_p^2 = 0.344$ and 0.272 for men and women, respectively).

There was a large effect of competition event (Olympic or Paralympics) across the eight games covered on all track-and-field events, where Olympic athletes had better results than Paralympic athletes ($\eta_p^2 > 0.680$ in all events).

Performance Progression From 1988 to 2016

Linear regression results are presented in Table 1. For Paralympic male athletes, all linear regression models were statistically significant ($p < 0.05$), showing that performances have been consistently improving over the years. The coefficient of determination (r^2) varied between 0.071 (F11 long jump) and 0.801 (T11 100 m). For Paralympic female athletes, 13 of the 15 models were statistically significant, showing improvements over the Paralympic Games with r^2 ranging from 0.110 (T12 1,500m) to 0.840 (T12 100 m); F11 long jump and discus throw

Table 1. Simple Linear Regression Analysis for Track-and-Field Events Using Performance and Calendar Year as Dependent and Independent Variables, Respectively.

	Men				Women			
Events	r^2	*p*	Model (yr)	*N*	r^2	*P*	Model (yr)	*N*
100 m (s)								
Olympics	0.253	< 0.001	23.70 – 0.007	8	0.047	0.089	18.91 – 0.004	8
T11	0.801	< 0.001	72.13 – 0.03	8	0.623	< 0.001	113.8 – 0.05	8
T12	0.570	< 0.001	74.29 – 0.031	8	0.840	< 0.001	147.29 – 0.067	8
T13	0.625	< 0.001	80.16 – 0.034	8	0.544	< 0.001	128.80 – 0.058	6
200 m (s)								
Olympics	0.045	0.099	35.40 – 0.008	7	0.006	0.575	27.94 – 0.003	7
T11	0.595	< 0.001	180.34 – 0.078	7	0.360	0.001	169.67 – 0.082	7
T12	0.550	< 0.001	126.79 – 0.052	7	0.806	< 0.001	327.54 – 0.151	7
400 m (s)								
Olympics	0.001	0.830	47.79 – 0.002	8	0.012	0.403	32.85 + 0.009	8
T11	0.742	< 0.001	345.59 – 0.146	8	0.388	0.002	678.73 – 0.309	6
T12	0.489	< 0.001	316.15 – 0.133	8	0.685	< 0.001	764.9 – 0.352	7
T13	0.391	< 0.001	323.29 – 0.136	8	0.204	0.004	412.026 – 0.175	6
1,500 m (s)								
Olympics	0.099	0.012	−136.26 + 0.177	8	0.148	0.002	−691.90 + 0.469	8
T11	0.387	< 0.001	1396.1 – 0.570	8	—	—	—	
T12	—	—	—	—	0.110	0.017	2113.42 – 0.905	8
T13	0.429	< 0.001	1467.83 – 0.612	8	—	—	—	—
5,000 m (s)								
Olympics	0.040	0.111	87.84 + 0.358	8	—	—	—	—
T11	0.257	< 0.001	7218.6 – 3.111	8	—	—	—	—
T13	0.499	< 0.001	6454.78 – 2.66	8	—	—	—	—
Marathon (s)								
Olympics	0.280	< 0.001	20838 – 6.456	8	—	—	—	—
T12	0.125	0.004	58667 – 24.388	8	—	—	—	—
Discus (m)								
Olympics	0.035	0.188	−24.11 + 0.045	8	0.176	0.001	316.25 – 0.125	8
F11	0.256	< 0.001	−452 + 0.243	7	0.152	0.059	−402.93 – 0.215	5
Shot put (m)								
Olympics	0.008	0.470	9.21 + 0.006	8	0.125	0.004	81.77 – 0.031	8
F12	0.391	< 0.001	−209.81 + 0.11	8	0.339	< 0.001	−210.65 + 0.111	8
Javelin (m)								
Olympics	0.018	0.291	−6.38 – 0.045		0.013	0.373	146.37 – 0.041	8
F13	0.422	< 0.001	−693.57 + 0.373	8	0.531	< 0.001	−973.87 + 0.502	5
Long jump (m)								
Olympics	0.002	0.734	10.04 – 0.001	8	0.013	0.374	12.080 – 0.003	8
F11	0.071	0.033	−17.79 + 0.012	8	0.057	0.127	−12.795 + 0.009	5
F12	0.502	< 0.001	−66.95 + 0.037	7	0.414	< 0.001	−72.063 + 0.039	8

Note. *N* refers to the number of Paralympic or Olympic editions used for analysis (some of the Paralympic events were absent in some of the editions). In the case of the 200 m, as the event was introduced in the 1992 Paralympics, both Paralympic and Olympic performance analyses include data from 1992 to 2016.

were the only two track-and-field events in which the performance did not change significantly.

For most (12 out of 18) of the Olympic events, the linear regression models did not fit the data, since they were not statistically significant ($p > 0.05$). For four competition events (men's 1,500 m; women's 1,500 m, discus and shot put), the linear models were statistically significant ($p < 0.01$), showing a declining trend over the years in performance, although with relatively small r^2 (0.099–0.176). In men's 100 m and marathon, the linear regression model showed performance improvements over the years (p's < 0.01; $r^2 = 0.253$ and 0.280 for 100 m and marathon, respectively).

The performance progression (mean of the top three results) of athletes with visual impairments in the track-and-field events at the Paralympics (1988–2016) and athletes without disability in the correspondent Olympic events is plotted in Figure 1. In line with the linear regression results, the visual observation of the graphics points to the stagnation of performance in most Olympic events over time and a reduction of their difference (in %)

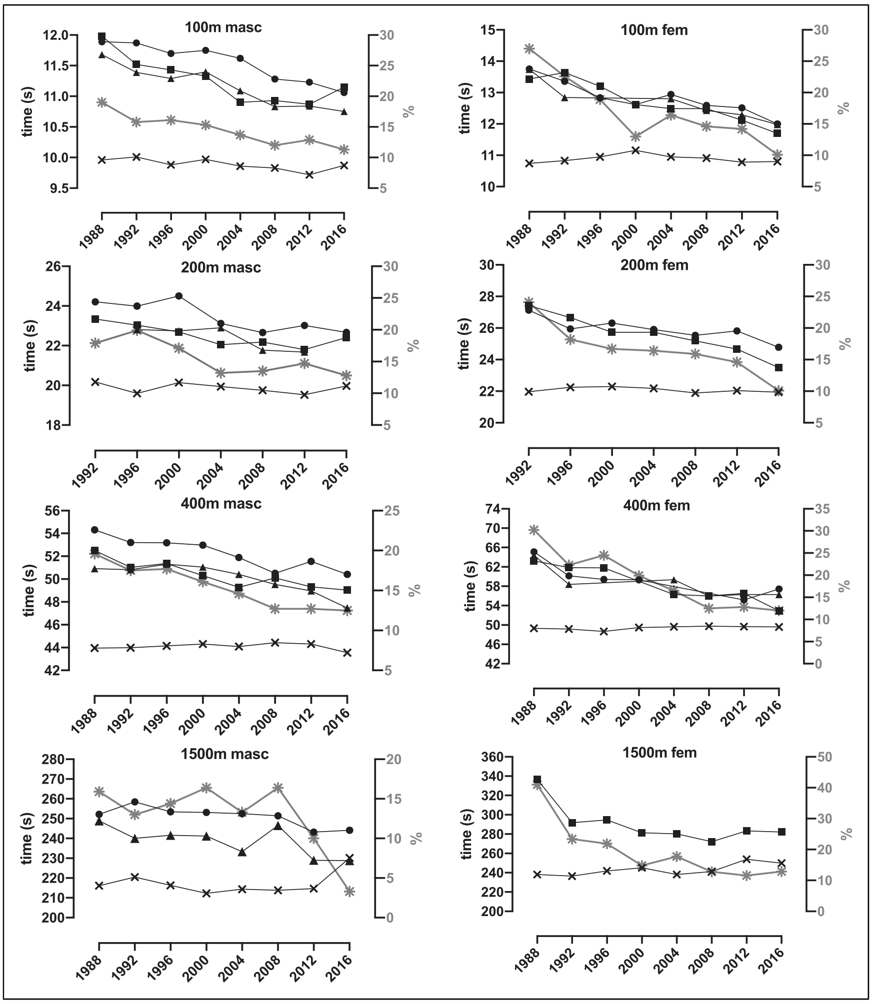

Figure 1. Performance of athletes with visual impairment in Paralympic Track-and-Field events between 1988 and 2016, and performance in match events of the Olympic Games (left y-axes). The mean difference between the performance of Paralympics and Olympics athletes is also plotted (right y-axes).

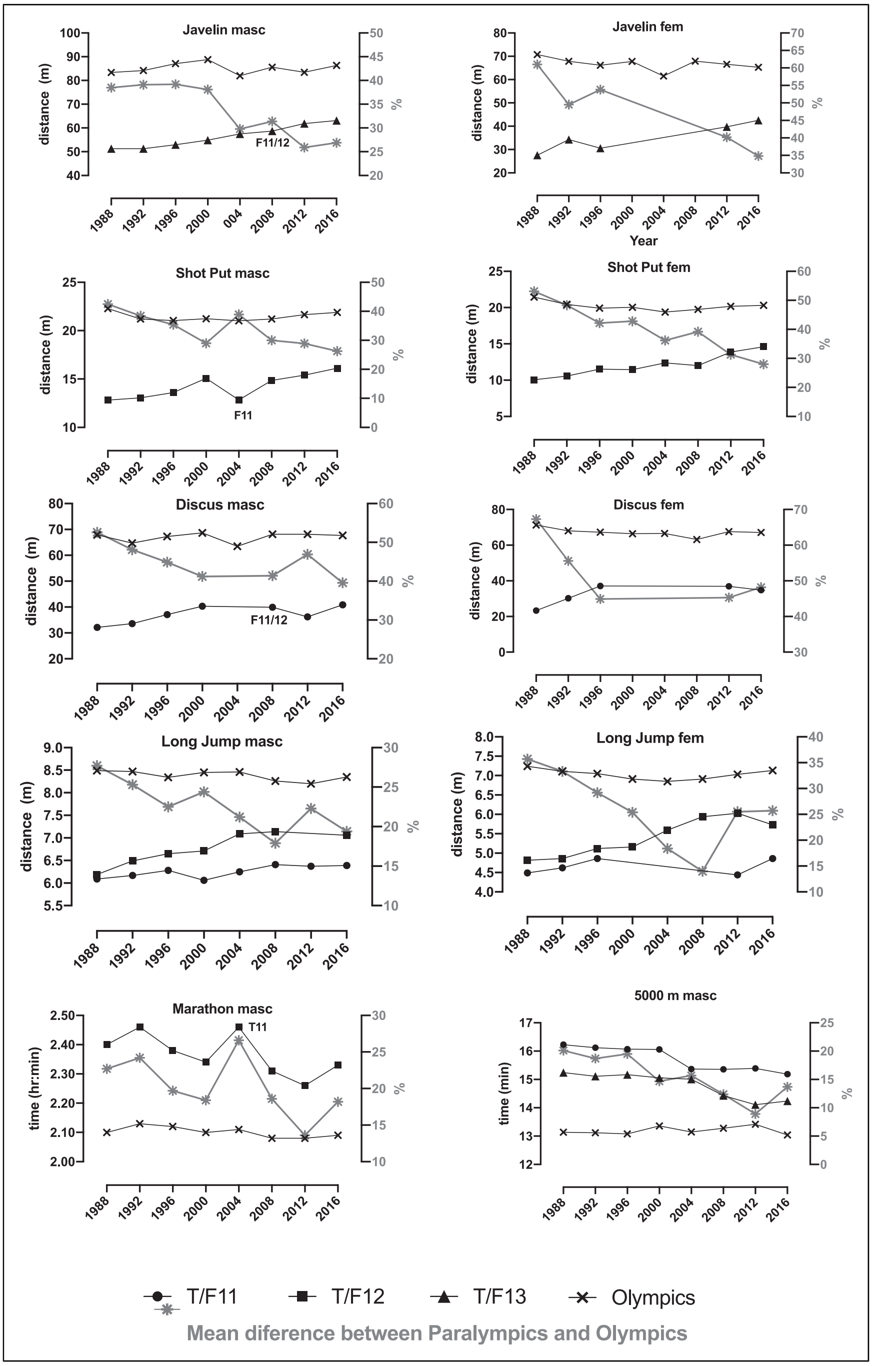

Figure 1. Continued.

to athletes with visual impairments (Paralympic Games).

The analysis of the performance changes in the track-and-field events (top three athletes) from 1988 to 2016 (see Table 2) showed that the mean competition time in the 2016 Paralympic individual sprint events improved between 4.0 and 16.3% relative to the 1988

Table 2. Percentage Change From 1988 to 2016 in Track–and–Field Events at the Paralympic (Athletes With Visual Impairments) and Olympic Games.

	Men				Women			
Event	T/F11	T/F12	T/F13	Olympics	T/F11	T/F12	T/F13	Olympics
100 m	–7.0	–6.9	–8.0	–0.9	–12.7	–12.9	–12.8	+0.6
200 m	–6.4	–4.0	—	–1.0	–8.7	–14.3	—	–1.0
400 m	–7.2	–6.6	–6.8	–0.9	–11.8	–16.3	–12.6	+0.6
1,500 m	–3.2	—	–8.1	+6.5	–16.2	—	—	+4.9
5,000 m	–6.4	—	–6.6	–0.8	—	—	—	—
Marathon	—	–4.5	—	–0.9	—	—	—	—
Discus	+27.0	—	—	–0.3	+49.1	—	—	–5.9
Shot put	—	+25.7	—	–1.8	—	+45.2	—	–5.4
Javelin	—	—	+23.0	+3.5	—	—	+54.2	–7.7
Long jump	+4.9	+14.1	—	–1.6	+8.2	+18.9	—	–1.5

Note. In the running events, a negative change means performance improvement; in the throwing and long jump events, a positive change means performance improvement. Results are for the top three athletes.

events; for the Olympic sprint events, changes from 1988 to 2016 were narrow (−1.0–0.6%). In middle- and long-distance running events, Paralympic athletes showed better performances (lower final time) in 2016 than in 1988 (−3.2 to −16.2%), which contrasts with the Olympic athlete's evolution (−0.8–6.5%). In the throwing events, the performance progression of Paralympic athletes from 1988 to 2016 varied 23.0–54.2%, contrasting with the decline (−0.3 to −7.7%) on five (out of six) throwing events at the Olympic Games. In the long jump, the performance progression from 1988 to 2016 of Paralympic athletes was between 4.9% and 18.9%, which diverges from the (slight) decline in the performance of their Olympic counterparts (−1.5 and 1.6%, for women and men, respectively).

The competition density (see Table 3) improved from 1988 to 2016 in 56.3% and 83.3% of the finals at the Paralympics and Olympics, respectively. The Olympics finals' competition density was higher than in the Paralympic correspondent finals, excepting in four 1988 events (men's F11 and F12 long jump; women's F11 discus and F13 javelin), where the competition density was higher in the Paralympics, and the long jump at the 2016 games, where the competition density was identical between the F12 Paralympic and Olympic finals. Finally, the effect sizes showed that the difference between Olympic and Paralympic performances at the 2016 games was very large ($d \geq 0.8$, favoring the Olympic athletes) in all track-and-field events, except for men's 1,500 m T13, where Cohen's d was 0.69.

Discussion

Overall, the results showed a clear progression in the performance of athletes with visual impairments along the approximately 30 years covered in this study, which contrasts with a general stagnation of Olympic track-and-field performance. There was a significant linear improvement in performance throughout the eight Paralympic Games (1988–2016) in 30 out of the 32 track-and-field events analyzed. Such increases occurred in running (sprint, middle- and long-distance running), throwing, and jumping events. The athletic performance enhancement occurred almost every 4 years in most Paralympic track-and-field events. Considering the evident linear tendency, we will probably continue to see further enhancements in the athletic performance in a substantial number of Paralympic track-and-field events. This expectation is aligned with the conclusions of a recent study focused on age-related changes in the performances of athletes with

Table 3. Competition Density in Track-and-Field Events at the Paralympic (Athletes With Visual Impairments) and Olympic Games of 1988 and 2016.

	Men			Women		
Event	1988*	2016		1988*	2016	
100 m Olympics	31.57	32.00	↑	8.42	30.43	↑
T11 100 m	17.39	12.12	↓	7.69	27.27	↑
T12 100 m	9.52	7.41	↓	5.06	4.65	↓
T13 100 m	11.94	9.81	↓	3.11	7.41	↑
200 m Olympics	10.13	12.30	↑	9.76	8.79	↓
T11 200 m	6.25	5.00	↓	1.31	5.25	↑
T12 200 m	15.38	8.69	↓	3.63	5.48	↑
400 m Olympics	6.89	9.41	↑	2.31	4.42	↑
T11 400 m	1.89	5.63	↑	0.60	2.38	↑
T12 400 m	0.73	0.68	↓	0.56	2.65	↑
T13 400 m	2.14	2.49	↑	2.23	0.98	↓
1,500 m Olympics	3.29	7.34	↑	0.04	1.90	↑
T11 1,500 m	0.18	0.49	↑			
T12 1,500 m				0.062	0.20	↑
T13 1500m	0.53	0.94	↑			
5,000 m Olympics	0.54	1.36	↑			
T11 5000 m	0.05	0.07	↑			
T13 5,000 m	0.10	0.94	↑			
Marathon Olympics	0.052	0.044	↓			
T12 marathon	0.0053	0.0044	↓			
Discus Olympics	1.44	1.72	↑	1.26	1.30	↑
F11 discus	0.64	0.65	↑	1.32	0.28	↓
Shot put Olympics	3.79	4.26	↑	3.31	3.33	↑
F12 shot put	1.96	2.97	↑	1.25	1.69	↑
Javelin Olympics	1.34	1.02	↓	0.57	2.45	↑
F13 javelin	1.00	0.85	↓	0.68	0.85	↑
Long Jump Olympics	9.64	24.24	↑	10.00	16.7	↑
F11 long jump	14.80	9.32	↓	6.38	5.26	↓
F12 long jump	11.76	24.24	↑	8.42	4.88	↓

Note. Results are presented in competitors/s and competitors/m for running events and throwing and long jump events, respectively. *Since the 200 m event was absent in the Paralympic Games of 1988, the competition density presented is for the 1992 Paralympic or Olympic Games.

disabilities (Schipman et al., 2019), including athletes with visual impairments.

Our results showed that the enhancement of athletic performance in the Paralympics contrasted with its general stabilization in the track-and-field performance at the Olympics. This finding is in line with other studies that reported that athletic performance appears to have reached a state of stagnation in the last two or three decades (Berthelot et al., 2015; Marck et al., 2017). It has been argued that the optimization of several factors has contributed to the high contemporary expression of human athletic potential in regular sports, including training methodology, sport sciences, medicine, technology, population morphology parameters, phenotypic selection, socio-cultural events (e.g., Olympic Games and world championships), and economic resources (Berthelot et al., 2015). Most probably, the development of these (and other) sport performance-related factors had begun later in disability sports and could still be relatively far from being optimized.

Despite the progression trend in performance at Paralympic athletic events, our study shows that there is still a significant gap in performance at Olympic events, as evidenced by the effect size results in the last Olympic and Paralympic Games in 2016. Thus, only in men's 1,500 m T13, Cohen's *d* was bellow 0.8 (large). Nevertheless, one should note that, in this case, the 2016 Olympic performance (mean of 230.1 s for the top three athletes) fell well below (at least 10 s) of the previous Olympic performances. Such an unexpected result was probably due to athletes' tactical decisions during the final race, rather than a reflection of the athletes' potential.

Men had better performances than women, confirming results from other studies in both sports with and without disabilities (de Macedo et al., 2020; Thibault et al., 2010). Our results also show that the track-and-field performance level was related to the level of visual impairment in male athletes. In 100 m and 400 m events, it was possible to compare the performance athletes of the three-sport classes of visual impairment, and the results showed that both T13 and T12 athletes had better performances than T11 athletes. In other athletic events (200 m, middle-distance running, and long-jumping events) where data analysis included more than one class of visual impairment, male athletes with less impairment had better performances. There were few data available for female athletes, and the analyses were restricted to the sprint events and the long jump. In these cases, we find a significant effect of the class of visual impairment in the women's long jump performance (F12 > F11), but not in the sprint events (100 m, 200 m, and 400 m).

Few previous studies analyzed sports performance according to visual impairment classes. A recent study reported that B1 judokas are in a disadvantage in some performance parameters in comparison with B2 and B3 judokas (Gutiérrez-Santiago, Gutiérrez, & Prieto-Lage, 2020). Another study found mixed results in goalball, since B1 players had higher game performance in defense, while B2 and B3 players demonstrated higher efficiency in offensive actions (Bartosz et al., 2015). In general, our results support that sport classes are associated with track-and-field performance especially in male athletes, and that T/F11 athletes seem to experience a higher effect of visual impairment in performance than the other two sport classes (T/F12-13). Nevertheless, caution should be used in interpreting these results, since there are factors that differ across sports classes that can confound the analysis of the association between visual impairment and performance, including the use of eyeshades, guide-runners, and acoustic assistance (World Para Athletics, 2018). Furthermore, a debate is currently taking place about whether the evaluation of visual acuity and visual field that is currently used for classification of athletes by sports classes is sufficient to account for the influence of severity of visual impairment on sports performance (Mann & Ravensbergen, 2018).

Although there is a general perception that the profile of elite athletes with disabilities has changed to become closer to that of nondisabled athletes (Dieffenbach & Statler, 2012; Legg & Steadward, 2013), few studies analyzed the progression of both group of athletes. In line with the results of the present study, it was reported that the Paralympic performance improvements between 1992 and 2012 were much more significant than those in the Olympics (Grobler et al., 2015). Regarding visually impaired athletes, Grobler et al. (2015) reported progressions of 7.1 and 5.8% (100 m), and 6.8 and 7.4% (200 m), for the T12 and T13 classes, respectively. The same study reported that the performance improvement of the Olympic athletes from 1988 to 2016 was 2.8 and 2.2% in the 100 m and 200 m, respectively. The current study adds to the findings of Grobler et al. (2015), since it provides evidence of a performance progression in a much higher number of track-and-field events of the Paralympics and throughout a larger time period.

Our results show that the competition density was higher in 2016 than in 1988 in most Paralympic events; still, 43.7% of the events had lower competition densities. Considering the growth of the Paralympic movement in many aspects (e.g., number of participants and training conditions), it is expected that the level of competitiveness between the best performers will be higher in the future. For the Olympic Games' track-and-field events, despite the fact that best performances have not improved significantly over the years, in 83.3% of the events, the level of competitiveness was higher in 2016 than in 1988. The fact that the best Olympic athletes are becoming closer in their performances seems to indicate that more athletes are acceding to the best training and competition conditions and getting near their physical limits. Moreover, the improvement in doping control systems could have influenced the general stagnation (or even decline, in some events) of track-and-field performance since 1988 (Berthelot et al., 2010), but also the shortening of the differences in performances between athletes. Historical aspects, such as the number of sport participants, training protocols, policies, technical and financial support, and professionalism, are probably responsible for the higher competition density found in most track-and-field events of the Olympic Games in comparison to the Paralympic Games.

Several factors could account for the positive performance trend found in Paralympic track and field. The media attention directed to the Paralympic Games has increased substantially, especially since 1988, when both Olympics and Paralympics were held in the same city for the first time (Schantz & Gilbert, 2012). Several changes occurred in sports for people with disabilities, including an increase in financial support in the area and its progressive integration (including track and field) in the general sports organizations (e.g., national sports federations; Bouttet, 2016; Howe, 2007; Marit & Nina, 2006). Thus, national sports policies have been progressively emphasizing sporting associations and governing bodies to take responsibility for the development of athletes with disabilities, instead of encouraging disability-specific sports organizations (Jeanes et al., 2018).

Another aspect that might have also contributed to the development of sports participation (and performance) of people with visual impairments is the implementation of education inclusion policies in many countries, especially since the United Nations' Declaration of Salamanca in 1994 (Heck & Block, 2019). Although we have not found studies that directly relate the performance in sports for people with disabilities with the movement for education inclusion, it makes sense to hypothesize that the benefits of such pedagogical action (e.g., social participation, sport-related skills, and self-empowerment; Bailey, 2005; Qi & Ha, 2012) could translate into higher motivated sports participation of young people with disabilities.

This study adds valuable information to the current (scarce) sport-science literature on the performance progression of track-and-field athletes with visual impairments. The data gathered here could be very useful for coaches and athletes to set performance (and training) goals for the Paralympic Games (and other international athletic events) and to incite sports scientists to give more attention to the field of disability sports, both to the performance achievements and factors underlying such achievements.

Limitations

This study has some limitations that should be highlighted. First, the track-and-field events at each Paralympic Games underwent a number of changes over the years, limiting the data available for statistical analyses, especially for women (e.g., the 800 and 5,000 m were part of the competitive calendar at only a few Paralympic Games). Second, although the Paralympic Games are the most important athletic competition for people with disabilities, other sources of information (e.g., world championships and world records) can also provide meaningful information for studying trends in sport for people with disabilities.

Conclusions

In summary, the current investigation fills a void in the literature related to Paralympic studies. It provides evidence of a consistent progression of the performance of athletes with visual impairments in Paralympic track-and-field events. It also shows that such a positive trend in track-and-field athletics contrasts with the stagnation in the performance of most Olympic track-and-field events. As advances occur in athletic performance-related aspects, like talent identification, prevention of injuries, training methodology, and sport policies (Houlihan & Chapman, 2017; Patatas et al., 2018; Slocum, Blauwet, & Anne Allen, 2015), future performance gains in Paralympic athletes are a strong possibility.

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