Performance Declines Are Accelerated in the Oldest-Old Track and Field Athletes 80 to 94 Years of Age

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Abstract

Physical performance declines with age, even in exercising, healthy individuals without major illnesses or orthopedic issues. The rate of performance decline is often reported to accelerate after the age of 70 years, but almost no data are available on performance in the fittest oldest-old. To assess their rate of decline in performance, the biggest data set of track and field athletes aged ≥ 80 years (1567 results) ever published was generated for different disciplines from German Athletics Federations including 1997–2019. Performance at age 80 years of athletes still participating at age 85 years was compared with those who discontinued. Only 1 of every 22 athletes competing at age 80 years still competed at age 90 years. The performance decline was more than three times as steep in athletes aged ≥ 80 years (on average 1.62%/year, men: 100 m, $R=0.31$, $p<0.001$; 200 m, $R=0.17$, $p=0.037$; long jump, $R=-0.37$, $p<0.001$; shot put, $R=-0.32$, $p<0.001$; discus, $R=-0.34$, $p<0.001$; javelin, $R=-0.43$, $p<0.001$; women: shot put, $R=-0.24$, $p=0.017$; discus, $R=-0.33$, $p=0.010$) compared with athletes aged 30–69 years (0.46%/year) and accelerated at an average of 67 years. This accelerated decline was most pronounced in the sprint disciplines and lowest in the throws. Performance at age 80 years was similar in athletes still participating at age 85 years to those who discontinued, and the variability in results was decreased after age 90 years. In conclusion, physical performance declines more than three times as fast after around the age of 67 years compared with before. This was particularly the case for sprinting but was not a result of dropout of poorer performing athletes.

Keywords: aging, athletics, activity, running, longevity, age

Introduction

OTHER THAN MANY of their sedentary peers or patients with orthopedic constraints, master athletes continue to exercise until high age.^{1–4} The age of peak performance usually occurs between 18 and 23 years, and performance starts to decline progressively after staying relatively constant in the third decade of life.¹ Maintaining high levels of physical exercise throughout the life seems to slow the multisystemic deterioration commonly observed in inactive individuals.⁵ Nevertheless, accelerated declines in performance after the age of 70 years have been reported in many athletic disciplines^{1,6–10} and are evident even in longitudinal data.^{11–13}

Factors that may contribute to this age-related decline are decreases in pulmonary function,¹⁴ muscle wasting and weakness,^{15,16} loss of motor units,¹⁷ and reductions in car-

diovascular function.¹⁸ World records give a rough understanding of the age-related decrement in performance,^{8,19} but they only reflect performance of the most exceptional individuals. While the better athletes might continue to perform well into high age, motivated by their successes, lower performers could show a faster drop in performance and stop competition altogether. If so, the accelerated decline in performance in the athlete population could in fact be even steeper than that reported for world records. Until now, however, this has not been systematically investigated.

Rates of performance declines seem to differ between disciplines and types of events^{1,20,21} with less of a decline in the throwing disciplines.¹ However, due to the low numbers of athletes aged 80 years and older, decline rates after 80 years are largely unknown, apart from some data showing an accelerated decline in the running disciplines.^{22,23} Insight in the

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rate of performance decline in the oldest-old athletes is important to inform specific training programs for older athletes.

We used a data set with a substantial number of longitudinal observations to (1) analyze patterns of performance declines in the oldest group of athletes and (2) assess whether older athletes who stop competing are indeed poorer performing individuals. The hypotheses were that (1) declines in performance are accelerated at high age and (2) better athletes continue longer, leading to an underestimation of the actual age-related rate of decline in performance in the master athlete population.

Methods

Ethical approval was given by RWTH Aachen University Hospital Institutional Review Board (reference number EK 300/17, date of approval: October 11, 2017). Informed consent was not needed, as only data from published result lists were used.

Generation of data set

Performance data of 80+-year-old athletes were extracted from the following official ranking lists of annual best results: North Rhine 2001–2019 (North Rhine Track and Field Association),²⁴ Westfalia 2001–2019 (Soccer- and Track and Field Association of Westfalia),²⁵ Rheinland 1997–2019 (Rheinland Track and Field Association),²⁶ and Bavaria 2012–2019 (Bavaria Track and Field Association).²⁷ All result lists are publicly available online. The named areas were selected, as their results are publicly available online and date back a decent number of years. The selected areas within Germany comprise a total population of more than 35 million, making this a valuable data set.

Statistical analysis

All statistical tests were executed with IBM® SPSS® Statistics version 25. The six disciplines with the most participants in the targeted age group were selected for analysis: 100 and 200 m sprint, long jump, shot put, discus throw, and javelin throw. Regression analysis was performed, and regression lines and equations with their corresponding *p*-values are shown when significant (regression coefficient, significance level 0.05). The decline in athlete numbers with age was compared with the official population numbers in Germany (German Federal Sta-

tistical Office).²⁸ A two-sided *t*-test was used to compare performance of athletes who had a result at both 80 and 85 years with athletes who had a result at age 80 years but not at age 85 years. The percent annual decline was calculated for the 80+-year-old athletes by normalizing their performance to the average performance values at age 80 years.

For presentation purposes and to calculate the age of onset of accelerated decline, the performance for all athletes was normalized to the average performance at age 30 years, making use of our previously published data set.¹ Normalization of data is further explained in the Results section. The age of onset of accelerated decline was calculated from regression equations of the younger (30–69 years) and older (≥ 80 years) athletes, based on the percent annual decline normalized to age 30 years, using the following formula (regression equation: $Y = aX + b$):

$$\text{Age of onset of decline} = (b_{30-69} - b_{\geq 80}) / (a_{\geq 80} - a_{30-69})$$

Implement weights in the throwing disciplines stay constant for athletes older than 79 years, which means that the results are not biased by changes in weights of javelins, discuses, and shots. The following implements are used by athletes aged 80 years and older: shot put: men 3 kg, women 2 kg; discus throw: men 1 kg, women 750 g; javelin throw: men and women 400 g.²⁹ In data of younger athletes, changing implement weights will cause some bias in the regression statistics.

Results

Characterization of data set

A total of 1567 results of 80- to 94-year-old athletes (1422 and 145 results from men and women, respectively) from six athletic disciplines were included in the analysis (Table 1). In 80+-year-old athletes, throwing disciplines were the most popular track and field events. In men, shot put was the most popular discipline, followed by discus throw and javelin throw. For the women, discus throw was the most popular discipline, followed by shot put and javelin throw.

Participation and performance

Figure 1 shows the decline in the number of ≥ 80 -year-old male (Fig. 1A) and female (Fig. 1B) participants with age and compares these numbers with official population numbers for

TABLE 1. NUMBERS OF RESULTS INCLUDED IN THE DATA SET AND COMPARISON OF SLOPES OF PERFORMANCE DECLINES IN PERCENT PER YEAR IN MALE ATHLETES AGED 30–69 YEARS COMPARED WITH MALE ATHLETES AGED 80 YEARS AND OLDER

Discipline	Men (n)	Women (n)	Total	Slope men aged 30–69 years (%/year)	Slope men aged ≥ 80 years (%/year)	Age of onset of accelerated decline in men (years)
100 m	162	4	134	0.58	2.92	71.3
200 m	78	5	66	0.68	3.45	69.3
Long jump	92	5	74	0.75	1.46	71.2
Shot put	428	47	387	0.36	1.28	71.6
Discus throw	367	59	345	0.02	1.24	55.2
Javelin throw	295	25	262	0.95	1.45	70.1
Total/average	1422	145	1567	0.46	1.62	66.9

All data were normalized to the average performance at age 30 years to allow direct comparison of percent values. The data of the athletes aged 30–69 years was taken from the data set published by Ganse et al.¹

FIG. 1. Declines in number of ≥ 80 -year-old participants with increasing age displayed for male (A) and female (B) athletes. (C) Official population numbers for Germany in the year 2019 in thousands compared with the absolute numbers of results from our data set. (D) Ratio of results in our data set for men and women as a proportion of the German population at a given age. Color images are available online.

Germany in the year 2019 (Fig. 1C). While the overall pattern of population and participation decline with age appears similar, the proportion of the population participating in master athletics decreases with increasing age (Fig. 1D).

Overall, there were 415 results of 80-year-old (women and men) and only 19 of 90-year-old athletes. This means that only 1 of 22 athletes who competed at age 80 years still participated at age 90 years. Figure 2 shows individual longitudinal changes of performance in shot put (the most popular discipline) in absolute (Fig. 2A) values and as percentage of performance at age 80 years (Fig. 2B). It can be seen that the performance declined in the large majority of athletes.

Supplementary Figure S1 shows results of regression analyses for 100m (Supplementary Fig. S1A), 200m (Supplementary Fig. S1B), long jump (Supplementary Fig. S1C), shot put (Supplementary Fig. S1D), discus throw (Supplementary Fig. S1E), and javelin throw (Supplementary Fig. S1F) in the 80+-year-old athletes. The three exceptionally slow 200m results were excluded from the anal-

ysis, as they were not representative for the master athlete population. In men, there was a linear decline in performance in all six disciplines. Exponential, logarithmic, and polynomial regression models led to lower R^2 values in all disciplines compared with linear regression. In women, due to lower participation, only the discus throw showed a significant age-related decline in performance that was similar to the rate of decline seen in men. Regression lines are only shown when significant.

The onset and rate of accelerated decline

Table 1 and Figure 3 show the data of the present study combined with those in Ganse et al.¹ Regression lines are shown for the 30- to 69-year-old athletes and the 80+-year-old athletes. In each discipline, the slope of performance decline is steeper in the older athletes (≥ 80 years) compared with those aged 30–69 years. The regression equations were used to calculate the age of onset of an accelerated decline, defined

FIG. 2. Longitudinal individual changes in shot put performance with age in absolute values (**A**) and normalized to performance at age 80 years (**B**). Color images are available online.

as the age at which the two regression lines cross (Table 1). The average age at which the accelerated decline started was 67 years (Table 1). Shot put (Fig. 3B) was the discipline with the latest onset, and discus throw (Fig. 3D) was the earliest onset of accelerated decline (see also Table 1). In Figure 3G, we pooled the data of all disciplines and normalized the performance to the average performance at 30 years in each discipline. In Figure 4A, it can be seen that the average performance decline after the age of 80 years as a percentage of the performance at the age of 80 years was 2.5%.

The end of participation is independent of performance

To answer the question whether the dropout of poorer performers affected the rate of decline, performance at age 80 years of athletes who still participated at age 85 years was compared with those who discontinued (Fig. 4B). We found no difference in performance between these groups in any of the disciplines (100 m: $p=0.9$ men; 200 m: $p=0.1$ men; long jump: $p=0.1$ men; shot put: $p=0.5$ men and $p=0.6$ women; discus: $p=0.9$ men and $p=0.9$ women; javelin: $p=0.9$ men; due to limited numbers of athletes, women are only reported for shot put and discus throw). Figure 4C shows a decreased variability in performance after the age of 90 years, which may reflect that at this very advanced age cessation of poorer performers may play a role.

Discussion

In the present study, we analyzed 1567 competition results of 80- to 94-year-old master athletes. The main findings of the study were as follows: (1) the performance decline was on average more than three times as steep in athletes aged

≥ 80 years compared with athletes aged 30–69 years; (2) the onset of this accelerated decline occurred at an average age of 66.9 years; (3) only 1 of 22 athletes competing at age 80 years still competed at age 90 years; (4) performance at age 80 years was similar in athletes still participating at age 85 years to those who discontinued; (5) there was a decreased variability in results after age 90 years.

Performance in athletes aged 80 years and older

We found a faster rate of decline in performance in athletes older than 80 years than we previously reported in 30- to 69-year-old athletes,¹ which is in line with previous smaller studies showing an accelerated decline after the age of 70 years.^{2,6–9} One potential criticism of such studies is that they may underestimate the rate of performance decline in the older master athletes as particularly the weaker athletes may stop competing. In line with this criticism is our observation that the proportion of the older population participating in master athletics decreases with age, suggesting that indeed frail or ill individuals usually do not compete anymore. To clarify this point in more detail, we compared the performance at age 80 years of athletes who still participated at age 85 years with those who discontinued master athletics competitions and found no difference in their performance at 80 years. This thus indicates that performance selection does not introduce bias in the accelerated decline we observed in our 80+-year-old athletes. Further evidence supporting the decline is real and is reflected by the similar coefficient of interindividual variation in performance up to the age of 90 years and the similar rate of decline in the longitudinal data on shot putters. Although the decline may

FIG. 3. Data set shown together with data set from our previous article¹ to illustrate the accelerated decline. Arrows indicate crossing points of regression lines for the male athletes, indicative for the age of onset of accelerated decline in performance (age of accelerated decline is given in Table 1). (A–F) The individual disciplines are shown with regression equations (regression lines shown for male athletes). (G) Normalized to age 30 years. Color images are available online.

be masked somewhat by the improved performance of master athletes over the last decades,^{20,22} a “fading integrative physiological capacity” and stochastic processes, such as accumulation of DNA damage,³⁰ have been suggested to cause an accelerated decline in old age.³¹

The onset of an accelerated decline

Our data set combined with our previous data set¹ allowed us to calculate the age at which the accelerated decline occurred. Data suggest that shot put (71.6 years) was

FIG. 4. (A) Performance of male athletes aged 80 years and older normalized to performance at 80 years and separated by disciplines. (B) Box plots for comparison of the average performance at age 80 years (normalized to the performance of all athletes at age 80 years) of those athletes who still competed at age 85 years (85) and those who discontinued (80). (C) The variation of results (standard deviation/average, all disciplines) displayed for each age group. Color images are available online.

the discipline with the latest, and discus throw (55.2 years) was the earliest onset of accelerated decline. The early onset in discus throw is certainly affected by an apparently steady performance in earlier years, caused by the extensive declines in the weight of the discus with age. All disciplines require muscle power, and the decrease in power with age seems to be a key factor in the decline in performance in master athletes.¹⁵ To a limited extent changes in technique also contribute, as we have shown in javelin throwers.² Another factor might be that some disciplines are more injury-prone than others.³²

Decreased variability from age 90 years

The similar variation in muscle mass between young adults and older people³³ suggests that the rate of muscle aging does not differ much between individuals at population level. Similarly, we found that the variation in performance of master athletes was relatively constant up to the age of 90 years but decreased to almost half the original variation in participants older than 90 years. The cause of this decline in variation could, in contrast to the absence of selection between 80 and 85 years, be a selection of athletes with the healthiest physiology who can continue in sports

until that high age. In fact, only 1 of 22 athletes competing at the age of 80 years was still competing at the age of 90 years. These survivors deserve further study as they may reveal some factors contributing to their longevity and excellent performance into old age.

Differences between disciplines

In the present study, we found the steepest percent performance decline per year in the sprint disciplines. This is a remarkable difference to the younger master athletes,¹ where in women javelin throw and 400 m, and in men pole vault and 800 m showed the steepest declines. The cause of this steeper decline in sprint performance in the oldest athletes is unknown, but the observation that resistance exercise can improve explosive power in master sprinters³⁴ suggests that this is at least partly related to an accelerated muscle weakening, particularly in the lower body.

Sex aspects

Ten times more men participated in track and field competitions than women, even though life expectancy of

women exceeds that of men. Reasons for the lower participation of women may be related to traditional role models in the generation born in the 1930s and 1940s.³⁵ This influence of role model is also reflected by the relatively late introduction of organized female athletic competitions. For instance, the first women were allowed at the Olympic Summer Games in 1928 and other disciplines were opened for women much later: long jump, 200 m, and shot put in 1948, 400 m in 1964, 5000 m in 1996, and pole vault as late as 2000.

Practical applications

The present data give an indication of which performance declines to expect in the healthiest oldest-old. This is relevant in many fields, be it for the older people and athletes themselves, in rehabilitation, for decision makers, for the design of infrastructure, or for insurance companies. Most people are not aware of rates of performance decline with age, and this knowledge could help them plan their lives better and clarify expectations.

Strengths and weaknesses

The major strength of the study is the exceptionally large amount of data of athletes older than 80 years. It is the first study to analyze such a large number of the oldest-old athletes. A weakness is that the majority of the data are cross-sectional, but longitudinal data from a substantial number of older athletes followed the same pattern as the cross-sectional observations. In addition, we do not have data on medical history or training volumes. Due to the anonymized analysis, we are not able to name the total number of athletes included in the study, just the number of results. Although we cannot provide information on the reasons for termination of master athletics, the absence of a difference in performance between those continuing and stopping participation shows that the drop in number of master athletes does not cause bias in the age-related decline in performance. It would also be good to see longitudinal data of individual athletes spanning 30 years and combine this with information on injuries and other life events to evaluate the actual effects of aging effects in individual participants.

Conclusions

Our study is the biggest data set of athletes aged 80 years and older ever published, and it gives new insights into the rate of decline in performance and abilities of the oldest-old athletes. Performance declines accelerated around the age of 70 years, and this accelerated decline is not underestimated by dropout of the poorest performers after the age of 80 years. The performance decline was more than three times as steep in athletes aged ≥ 80 years compared with athletes aged 30–69 years. However, the lower interindividual variability in performance after the age of 90 years might be related to the selection of the toughest in the very oldest-old.

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Author Disclosure Statement

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Supplementary Material

Supplementary Figure S1

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