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Age-related changes in endurance performance vary between modes of locomotion in men: an analysis of master world records

Brief report

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Abstract

Background: Age-related declines in sport performance are characteristic of all endurance and sprinting disciplines. However, it is not known if the mode of locomotion (i.e. swimming, cycling or running) influences the age-related decline in sport performance in sprinting and endurance events. **Methods:** To examine the age-related decline in three different modes of locomotion (i.e. swimming, cycling and running) for endurance and sprint events, the world best performances achieved for males in the age-groups 18-39 years, 40-44 years, 45-49 years, 50-54 years, 55-59 years, 60-64 years, 65-69 years, 70-74 years, 75-79 years and 80-84 years, were compared in swimming (1500-m and 50-m), cycling (1-h and 200-m) and running (10-km and 100-m). Each performance was considered as an average speed (throughout the distance) and the age-related decline in performance was expressed as a percentage of the world record (regardless of age group) for that discipline. **Results:** The results showed that the age-related decline in 1-h track cycling is less pronounced compared to 1500-m swimming and 10-km running after 60 years. In contrast, the age-related decline was similar among the three locomotion modes for the sprinting events. **Conclusion:** Our data show that the maintenance of high performance in cycling persists longer into old age than for running or swimming.

Keywords: Master athletes; running; swimming; cycling; aging

Introduction

Age-related changes in performance affect all sport disciplines from sprinting to endurance events ^{1,2}. For swimming and running, previous research has shown that performance decrements with age are greater for endurance events than for sprinting events ^{3–5}. However the reasons why exercise duration exerts an influence on performance-related physiological functional capacity with age are not clear. Some studies have indicated that the declines in muscular power with age are more delayed than that in events requiring cardiovascular endurance ^{3,6,7}. In contrast, previous findings suggested that the decline in aerobic and anaerobic power occur together with aging ⁴ while other works reported a greater impact of aging on anaerobic versus aerobic power ⁸.

Previous studies examining the age-related decline in triathlon performances (i.e. swimming, cycling and running) attempted to ascertain if the mode of locomotion influences the age-related changes in physical performance. Interestingly, these studies revealed that the decline in cycling was less pronounced compared to swimming or running ^{9–11}. Several hypotheses have been proposed to explain the smaller decline in cycling performance with age, such as differences in mechanical power, lactate threshold, greater muscular fatigue during running or a greater training stimulus in cycling compared to running ^{9–11}. However, all of these hypotheses remain speculative in view of the specificity of triathlon. Indeed, the findings of these studies are limited because the decline in the three modes of locomotion was explored in an event in which the disciplines were completed in succession. Therefore the state of fatigue experienced in each discipline following the swim may have been different than if cycling and running were studied in isolation. With this in mind, the possible effect of locomotion mode on the age-related decline in endurance performance remains to be determined when the three triathlon disciplines are performed separately. In addition, to verify whether the locomotion

mode effect is specific or not to endurance events, sprint events were also compared in the analysis.

Therefore, the aim of the present study was to examine the age-related decline in three modes of locomotion (i.e. swimming, cycling and running) for both endurance and sprint events in each discipline. For endurance events, the single disciplines, corresponding the more closely to those of Olympic distance triathlon (i.e. 1500-m swimming, 40-km cycling and 10-km running), were analysed. Because the 40-km time trial is not an official competitive distance in cycling, we chose to analyse 1-h track cycling performances. For sprint events, we compared disciplines having similar durations: 50-m swimming, 200-m track cycling and 100-m sprint running.

Methods

To investigate the age-related decline in swimming (1500-m and 50-m), cycling (1-h and 200-m) and running (10-km and 100-m), we compared the actual world best performances achieved in the following age-groups: 18-39 years, 40-44 years, 45-49 years, 50-54 years, 55-59 years, 60-64 years, 65-69 years, 70-74 years, 75-79 years and 80-84 years. The age-group 80-84 years corresponded to the oldest age-group for which data were available in all disciplines. Data were collected from the following websites of the international association or federations: <http://www.fina.org/content/masters-records> for swimming, <http://www.cyclingmasters.com/site> for cycling and <http://www.world-masters-athletics.org> for running. The data, initially presented as time performance, were recalculated as average speeds ($\text{km}\cdot\text{h}^{-1}$) for each event. Within each discipline, the age-related decline in performance was expressed as a percentage between each age-group performance and the performance of the age-group 18-39 years that corresponded to world record.

Because the present study is only based on the actual world best performances achieved in the different age-groups, it was not possible to perform a rigorous statistical analysis. Therefore, the results and their interpretations correspond only to a descriptive analysis.

Results

Figure 1A shows that the age-related decline in 1-h track cycling is less pronounced compared to 1500-m swimming and 10-km running after 60 years. The greatest difference appears for the age-group 70-74 years where in comparison to the world record, the performance was reduced by ~25% for cycling, while it dropped by ~30% for running and swimming. In contrast, Figure 1B shows a very similar age-related decline for the three sprinting events. Compared to the world records, the performances are reduced by ~35% at the age of 80 years regardless of the mode of locomotion.

The duration of the events affected the age-related changes in performance for running (75-79 years: -34% vs. -29% for endurance and sprint, respectively; 80-84 years: -38% vs. -33%), but not for swimming (75-79 years: -32% vs. -32% for endurance and sprint, respectively; 80-84 years: -35% vs. -35%) and cycling (75-79 years: -30% vs. -27% for endurance and sprint, respectively; 80-84 years: -35% vs. -36%).

Discussion

The present results suggest that the age-related decline in cycling is less pronounced compared to swimming and running events for endurance disciplines after 60 years of age. In contrast, the age-related decline appeared to be similar for sprint events when all disciplines were taken together. These data confirm previous findings reported for triathlon suggesting that the age-related decline in endurance performance depends upon the mode of locomotion.

The specificity of endurance performance on cycling compared to other modes of locomotion cannot be neglected. The results from sprinting events, for which similar age-

related declines in performance among the three disciplines was found, suggest a homogenous decrease in skeletal muscle power during aging. Therefore, we suggest that such an age-related change in muscular power appears not to influence the smaller decline in endurance cycling events after 60 years of age. However, locomotion efficiency is an important factor of endurance performance. Interestingly, a recent study including young (28 years) and master (60 years) triathletes showed that, compared with the young athletes, master triathletes presented a lower cycling efficiency (-11%) and a greater energy cost of running ($+11\%$)¹². In addition, when the data were scaled to lean body mass rather than total body mass, these changes in energy cost of running were even more pronounced during running ($+22\%$). These findings suggest that, at least within trained triathletes, cycling efficiency may be more preserved than the energy cost of running.

The biomechanical constraints and thus the risk of injury are also greater in running compared to cycling¹³. These factors may limit the amount of training undertaken in running compared to cycling in older athletes. Swimming, on the other hand, is a much less injury-prone activity¹⁴ but requires upper limb flexibility and technical skills that may limit performance with advanced age compared to cycling and running.

In the present study, the difference between cycling and swimming tended to be reduced for the older age-groups considered i.e. 80-84 years. It would be interesting to examine if this trend is maintained for master athletes older than 80 years. Unfortunately, to date, data across each of the three modes of locomotion are missing for these age groups. One limitation of the present study is the use of only one performance per male age-group even if the performance corresponded to the world best performance. The present findings need also to be verified for female master athletes even if the data pertaining to cycling performances in female master cyclists are limited.

Anecdotally, one 1-h track cycling performance is available for a centenarian athlete, the Frenchman Robert Marchand who cycled 26.92 km in one hour in 2014 at the age of 102 years. This performance corresponds to a speed reduction of ~50% in regard to the actual 1-h World record set at 54.52 km by Bradley Wiggins in 2015. This amazing performance achieved by a centenarian athlete can unfortunately not be compared with a corresponding centenarian 10-km running or 1500-m swimming performances¹⁵. It is nevertheless possible to extend the comparison of this performance with the world records established by a female centenarian (Mieko Nagaoka) in 1500 m swimming and by a male centenarian (Fauja Singh) in marathon and 5 km running. In regard to the respective actual records, the performances of Mieko Nagaoka and Fauja Singh correspond to a speed reduction of 79% and 75%, respectively. This confirms the data presented in this study, showing that for endurance events, a lower age-related decline occurs in cycling performances compared to running and swimming performances.

Conclusion

The present study showed that endurance cycling performances are better preserved compared to swimming and running performances after 60 years of age. Lower reductions in locomotion efficiency, less mechanical constraints and less technical abilities for cycling compared to running and swimming with advancing age may explain, in part, this finding. These data suggest that cycling is the locomotion mode and physical activity for which it is easier to maintain the highest level of performance with advancing age.

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Conflicts of interest

None of the authors have potential conflicts of interest to be disclosed.

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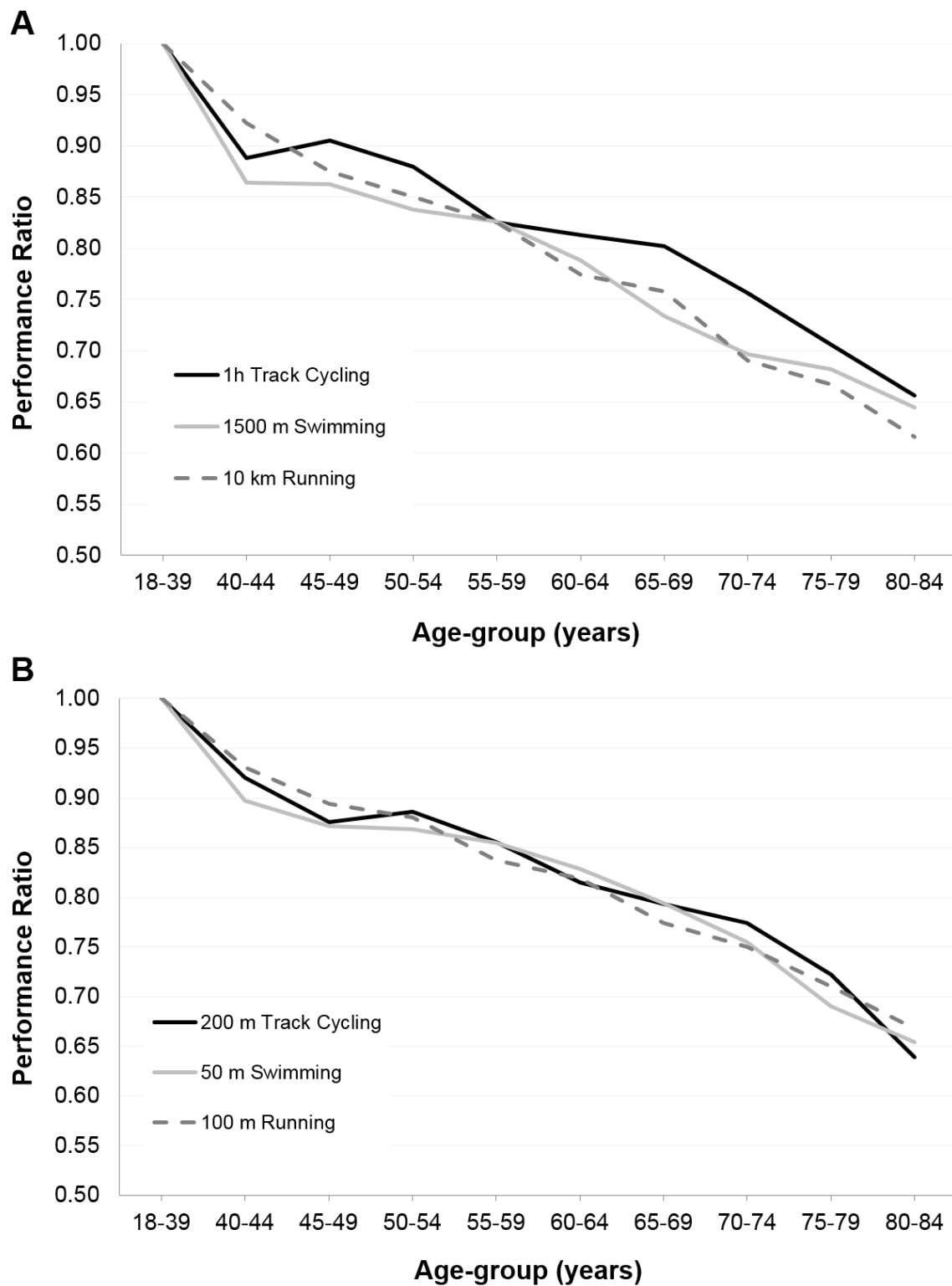


Figure 1: Age-related changes in performance for endurance (Panel A) and sprint events (Panel B) based on world best performances for each age group.