ORIGINAL RESEARCH ARTICLE

Age-related decrements in cycling and running performance

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Abstract

Objective. This study examined age-related decrements in athletic performance during running and cycling activities.

Design. The age group winning times for males aged between 18 and 70 years competing in the 1999 Argus cycle tour (103 km) and 1999 Comrades running marathon (90 km), South Africa's premier endurance cycling and running events respectively, were examined.

Main outcome measures. The relationship between speed (cycling and running respectively) and age was calculated using a 4th order polynomial function. The derivative of each of these functions was determined and then the slope of the function corresponding to each age was calculated.

Results. The rate of decline in running speed occurred at an earlier age (~ 32 years) during the running race compared with the cycling tour (~ 55 years).

Conclusions. These findings establish a trend that there is 'accelerated' aging during running which can perhaps be attributed to the increased weight-bearing stress on the muscles during running compared with cycling.

Introduction

Aging is generally defined as a progressive loss of function, increasing susceptibility to age-related disease and an associated transition from independent to dependent lifestyle.[3,9] A decline in both cognitive and motor functions is associated with increasing age.[8,12] Skeletal muscle force output capacity remains stable until about the age of 45 years, and then decreases by ~ 10 -15% each decade from the age of about 50 years.[7,10,19]

Despite these negative consequences associated with aging, many people participate in sporting activities when they are 70 years and older. Exercise has been shown in some studies to reduce age-related declines in strength, aerobic capacity, flexibility and physical function.[14] However, while exercise can reduce the rate of decline in age-related exercise capacity, it cannot reduce the absolute effect of aging on the reduction in functional capacity.[21] An examination of the changes in athletic performances associated with aging, and particularly age-group records for athletic activity, provides an assessment of the effect of age on physical performance. This analysis of athletic performance and age was first performed by Bottiger[1,2] and has been repeated more recently by Noakes[21] and Spirduso.[23] Spirduso[23] found that running performance of elite and recreational runners deteriorated from the mid-thirties, and decreased by approximately 1% per year from this point. By the age of 80 years, running performance was approximately 50% of the best performances achieved in the late 20s and early 30s.

Recently, it has been suggested that both high-intensity and endurance running may damage the neuromuscular system.[6,16,18,24] Mechanical disruption of muscle fibres caused by prolonged eccentric muscle activity has been proposed as a cause of exercise-associated muscle damage.[5,13] Several studies have shown that muscle damage occurs after marathon and ultramarathon races. Hidika *et al.*[11] showed that severe muscle damage with signs of fibre necrosis and inflammation occurred in muscle biopsies performed on runners after running a marathon race. In a similar study up to 25% of the muscle fibres of runners after a marathon race showed areas of myofibrillar loss.[25] Sherman *et al.*[22] showed that isokinetic leg extensor strength decreased immediately after a marathon and was not fully recovered after 7 days. Chambers *et al.*[4] showed that the vertical jump height, a measure of leg extensor muscle power, was significantly decreased immediately after a 90 km race, and remained significantly lower than pre-race values for 18 days. Kuipers *et al.*[15] studied runners over a 7-month period while they trained for a marathon. They found a gradual increase in degenerative changes in both type I and type II fibres in the subjects' vastus lateralis muscles over this period. They suggested that these pathological changes were related to the total distance covered during

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running training rather than the intensity of training. It is tempting to speculate that these changes in muscle function and anatomy associated with acute or chronic training and racing bouts may cause permanent muscle damage which leads to an 'accelerated' aging process.

Indeed, Noakes[21] has suggested that top class marathon runners have about a 10-year period during which they can expect to perform well in their age-group. This observation can perhaps be explained by cumulative muscle pathology changes which occur after several years of training and racing marathons which results in the skeletal muscle 'ageing' at a faster rate than is expected.

If the repeated weight-bearing eccentric activity of the locomotor muscles during running is indeed the cause of 'accelerated' aging, then the performance of a group of runners should show decrements in performance at an earlier age than that observed in other physically active subjects who engage in non-weight-bearing sporting activities. Cycling is an example of a physical activity characterised by repetitive contractions that are not weight bearing. Should this theory be correct it would be expected that muscle performance would decline with age at a faster rate in a group of runners than a group of cyclists.

Therefore, the aim of this study was to examine the age-related decrements in performance in a group of competitive runners and cyclists to determine whether running caused greater decrements in performance at an earlier age than cycling.

Methods

The race times of age-category winners for ages 18 - 70 years in the 1999 Comrades 90 km running race and Argus 103 km cycle race were obtained from the respective race organizers. These race times for each age were used for subsequent analysis.

The relationship which described the line of best fit between age and running or cycling speed was calculated using GraphPad Prism (version 3) software (GraphPad Software Inc., San Diego, CA, USA). In both running and cycling events, a 4th order polynomial equation was used to calculate the line of best fit.

The derivative of the 4th order polynomial function defining the relationship between age and running or cycling speed was subsequently calculated. Using the derivative (dy/dx), the slope of this relationship for each age year was calculated. A negative value indicated that running or cycling times were decreasing (or speed increasing) compared with the previous year, while a positive value indicated that the running or cycling time for the respective events had increased, or that speed had decreased compared with the previous year of age. The magnitude of the value (positive or negative) indicates the extent of the change in speed compared with the previous year.

Results

In 1999, 11 285 individuals completed the 1999 Comrades 90 km running marathon, and 28 440 individuals completed the Argus 103 km cycling race. The fastest time for the 90 km running marathon was 5 h 30 min 10 s by a 32-year-old competitor. The fastest time for the cycling race was 2 h 31 min 26 s by a 24-year-old competitor. Twelve other age categories were given similar finishing times for the cycling race, the oldest being a 36-year-old individual (ages 19 - 20, 22 - 27, 29 - 31, 34, 36).

The 4th order polynomial function equation describing the line of best fit for race time vs. age for the running marathon was: $Y = 1173 - 67.82X + 1.919X^2 - 0.02229X^3 + 0.0001226X^4$ ($R^2 = 0.85$, Fig. 1a), where Y = race time (min) and X = age (years).

The 4th order polynomial function equation describing the line of best fit for race time vs. age for the cycle race was: $Y = 317 - 19.01X + 0.7605X^2 - 0.01257X^3 + 0.00007571X^4$ ($R^2 = 0.90$, Fig. 1b), where Y = race time (min) and X = age (years).

Using the derivative of the 4th order polynomial function, the rate of change of race time was calculated for each year. The differential equations were solved for age and the resulting curves for the running marathon (Fig. 2a) and for the cycle tour (Fig. 2b) were plotted. The rate of decline occurred at an earlier age (~ 32 years) during the running race compared with the cycling race (~ 55 years). While the rate of improvement in running time was maintained until age ~ 32, and declined at an increasing rate after this age, there was

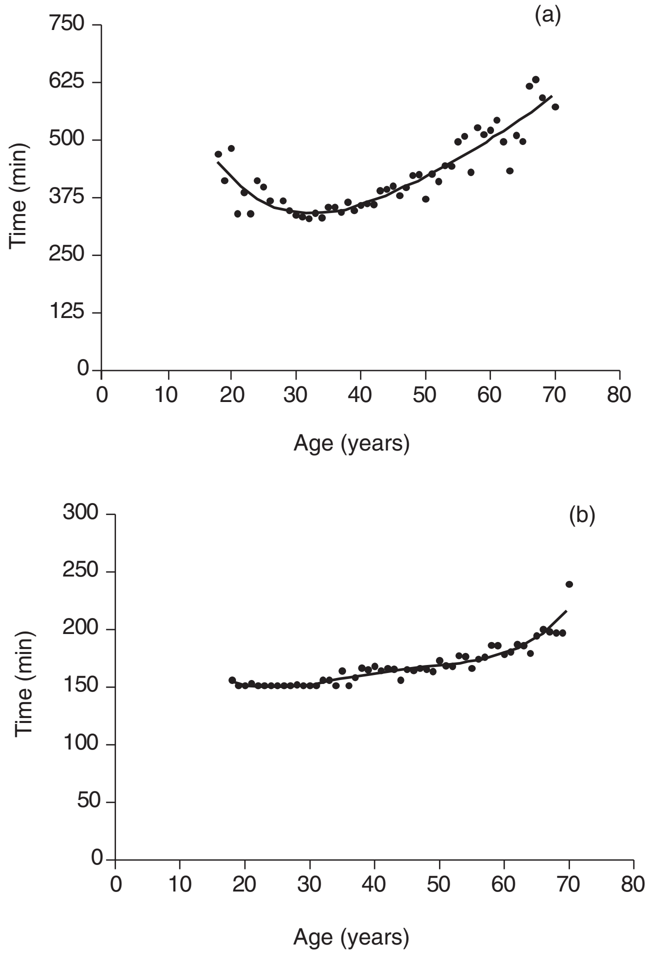

Fig. 1. Age-related changes in race time (min) for the Comrades 90 km running marathon (a) and for the Argus 103 km cycle tour (b).

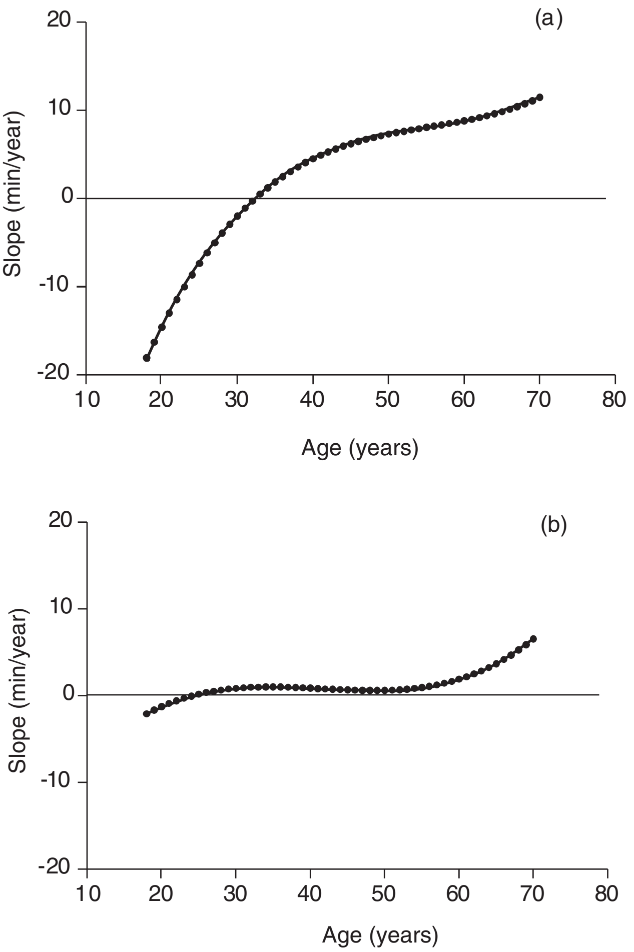

Fig. 2. The rate of change of speed for each age for the Comrades 90 km running marathon (a) and the Argus 103 km cycle tour (b). A positive slope represents a slower time compared with the previous year.

minimal change in cycling time until age ~ 55, after which time rate of change in cycling time increased.

Discussion

The important finding from this study was that the age-related decrements in performance began at an earlier age in runners compared with cyclists. In the runners, there was an improvement in performance until age 32 years, and thereafter there was a marked decrement in performance. The rate of decrease in performance accelerated with increasing age. In contrast, the cyclists generally maintained performance until age 55 years. Thereafter, performance declined, with the rate of decline increasing with increasing age, similar to that found in the runners at an earlier age.

One may therefore postulate that running causes more profound changes in anatomical structures and physiological mechanisms necessary to maintain pacing strategies during racing, and may lead to 'accelerated' aging. Another interpretation is that the stresses associated with training and racing induce changes which prevent the athlete from sustaining a high training volume, and it is this reduced training volume which causes the reduction in performance. Cycling is a non-weight-bearing activity, with little or no eccentric activity in contrast to that found during running, where marked eccentric activity is necessary to maintain an upright posture against gravitational forces, and where eccentric activity is part of the stretch-shortening cycle which makes up part of the normal energy transfer during weight-bearing activity.[20] A large body of work has shown that eccentric activity causes muscle damage, and that this muscle damage is found after marathon and ultramarathon running.[4,11,15,22,25] In contrast, no studies have shown similar pathology in cyclists after endurance cycling events. Therefore, it is reasonable to speculate that the decrements in age-related running times may have been caused by chronic muscle or musculoskeletal damage and perhaps 'premature aging' of the lower limb muscles of older runners, due to the cumulative effects of years of biomechanical stress and eccentric activity related to running training and racing. Interestingly, Spirduso[23] showed that age-related decrements in rowing performance occur at age ~ 45 years. As rowing is also a non-weight-bearing activity using predominantly upper body muscles, and as the age-related decrements in performance also occurred at a later age than in the runners in our study, the findings of Spirduso[23] support the hypothesis that running as a sport in particular may cause 'accelerated' aging of muscle function in the legs.

A further reason for the decrement in performance may have been that the veteran runners trained less than the younger runners, and that this difference in training volume may be the cause of the decrements in their performance. Lambert and Keytel[17] similarly showed that the age-related decrements in performance during a 56 km marathon began at age 28 in men and age 32 in women. They suggested that these decrements in performance were related to training volume, with the older runners running less distances per week than the younger runners. Further work is needed to examine this suggestion.

Another reason for the differences in age-related decrements in performance between running and cycling activities may be due to the nature of cycling racing itself. Bunch riding and drafting (slipstreaming) is common in cycling and thus the older cyclists may have been able to produce the maintained level of performance by drafting behind younger cyclists, or by staying in a competitive bunch which would require less absolute work to be performed by the veteran cyclists.[23] This may have explained why several age categories had similar times for the cycle race.

It must be noted that the duration of the cycling and running tests were different, with the winning times of the cycle race being 2h 31 min and running marathon 5 h 30 min. Therefore, the greater decrements in performance in the runners may have been related to the longer duration of the running race. The older runners may have adopted different pacing strategies during the longer duration running race than the cyclists did in their race. The pacing strategies may have been alike if the duration of the two events had been more similar. However, Lambert and Keytel[17] showed that the performance decrements occurred in runners at age 40 or younger in race distances ranging from 10 km to 56 km, which would be of the same time period or shorter than that of the cycle race in this study. Therefore, it is unlikely that the differences in the decrement in performance with age between runners and cyclists were due solely to the differences in duration of the running and cycling races.

It must also be noted that the age point at which performance declined in both groups has been described in an approximate manner. With further statistical analysis using differential equations a more exact age deflection point may have been determined. However, we did not wish to over-interpret our data, given that this was essentially a descriptive study of finishing times for the two races which were given to us by the race organizers, and therefore we have been deliberately conservative in the analysis of our data.

Finally, a further finding was that the rate of improvement in performance was greater in younger age categories in runners compared with cyclists. It is not clear whether these differences were also caused by the ability of younger cyclists to benefit from the different pacing strategies involved in cycling, or whether differences were due to more time being necessary for a younger individual to adapt to the biomechanical and physiological stresses associated with running.

Conclusion

In conclusion, this study established a trend that age-related decrements in performance occur at an earlier age in running compared with cycling in the specific races used in this study. It is tempting to speculate therefore that running causes more muscle damage which leads to premature aging of the muscles at a younger age than that which occurs in cycling. Further work is necessary to examine these different causes of age-related decrements in performance found in this and other studies. The trend identified in this study has clinical relevance and physicians should consider the possibility of a premature muscle aging process induced by running in runners in their fourth and fifth decades presenting with symptoms of reduced exercise tolerance.

Acknowledgements

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