Accelerated Decline in Running Performance in a Master Runner With a History of a Large Volume of Training and Racing


The aim of this study was to measure the change in running performance in a runner from age 27–64 years. During this time the runner had a history of high-volume training and racing. The change in his average running speed over 10-, 21.1-, 42.2-, and 90-km races was compared with the changes in the age-group records for each distance. He trained an average of 4,051 ± 1,762 km/year and ran 16,604 km during races. His training load reached a peak of 7,596 km/year at the age of 33. His rate of decline in running performance was higher than the expected age decline at 47 years for 10-km, 47 years for 21.1-km, 40 years for the 42.2-km, and 48 years for 90-km races. Decreases in performance with increasing age could be explained by reduced training volume. or, alternatively, high volumes of training and racing might accelerate the normal age-related decrements in running performance.

Key Words: aging, muscle damage, running speed

It is well documented that physical-performance capacity decreases with increasing age (Lambert & Keytel, 2000; Pollock et al., 1997; Trappe, Costill, Vukovich, Jones, & Melham, 1996). The decrease in physical performance can be related to various physiological functions. For example, VO_{2max} decreases by about 0.5 ml O_{2} · kg · min^{-1} every year from the age of approximately 25 years (Hagberg, 1987), and muscle cross-sectional area peaks at about 24 years and then steadily declines. By the age of 80 years, muscle mass has decreased by nearly 40% (Booth, Weedon, & Tseng, 1994).

Habitual physical activity can reduce the age-related decline in VO_{2max} (Wilson & Tanaka, 2000) and muscle mass (Booth et al., 1994). Therefore, by implication, habitual physical activity can reduce the age-related decline in physical performance. In accordance with this theory, the top junior athletes who maintain their consistent training as they age should still be the top age-group athletes after several decades. There are few examples, however, of high achievers in sports at a

The authors are with the MRC/UCT Research Unit for Exercise Science and Sports Medicine, Dept. of Human Biology, Sport Science Institute of South Africa, University of Cape Town, Newlands, 7725 South Africa.
young age who continue to be high achievers in their age groups after several decades of training. This is particularly evident in long-distance running, in which some runners start competing in their early 20s and continue training and racing for 4 decades (Lambert & Keytel, 2000; Sharwood, Lambert, St. Clair, & Noakes, 2000). In fact, it was found that most of the successful age-group runners over the age of 30 had been training and racing for less than 10 years (Lambert & Keytel). This suggests either that high volumes of training and racing sustained over several years might combine to have a negative effect on physical performance or that after about 10 years runners choose to stop competing at a high level because of "burnout." These observations are very difficult to examine in a controlled experiment. As a result, the effects of sustained, high-volume training over several decades on physical performance are poorly understood.

Accordingly, we conducted a case study in which the decrement in running speed of a veteran athlete was analyzed as he aged. These results were then compared with the age-expected decline in running speed determined from age-group records. The aim of the study was to determine whether the running speed of an athlete with a history of a large volume of training decreased at a rate similar to the age-expected decline in running performance.

Methods

The runner completed a questionnaire that asked for his best racing performances each year for 10-, 21-, 42-, 56-, and 90-km races. The data were extracted from logbooks he had meticulously kept on a daily basis since he started running. The average running speed (m/min) of the best performance for each race distance was calculated and plotted against the runner’s age. The relationship that described the line of best fit between age and running speed was calculated using GraphPad-Prism software, version 3 (GraphPad Software, Inc., San Diego, CA). A similar relationship was determined between age and the age-group records for the various distances. The U.S. age-group records were used for the 10-, 21-, and 42-km races, and the age-group race records were used for the Comrades ultramarathon (ranging from 86.9 to 91.7 km between Durban and Pietermaritzburg, South Africa).

The derivative of the function defining the relationship between age and running speed was determined. Using the derivative, the slope of this relationship for each year was calculated. A slope above zero indicated that running speed increased, whereas a slope below zero indicated that speed had decreased compared with the previous year.

Results

The runner was a 64-year-old man who, at the age of 27 years, started participating competitively in running events from 10 to 90 km. From there he participated in numerous races and has covered large distances during training. He kept detailed logbooks on all his training runs and races. Since he started training, he ran a total of about 153,944 km, with an average distance of 4,051 ± 1,762 km/year (M ± SD). The minimum and maximum distances he ran per year during this time were 833 and 7,596 km, respectively.
The runner has completed 34 Comrades races and 56 ultramarathons between 50 and 58 km. He has also participated in 10-km \((n = 48)\), 21.1-km \((n = 100)\), and 42.2-km \((n = 122)\) races. Of the 122 marathons he has run, he completed 88 of them in less than 3 hr. He covered a total of 16,604 km during races. A detailed description of all his races is presented in Table 1.

The runner’s average training distance per year versus age is shown in Figure 1. His training load reached a peak at 33 years of age and decreased steadily from the age of 46. His average speeds for 10-, 21-, 42-, and 90-km races for each year, together with the average speed for the age groups, are shown in Figure 2.

### Table 1: Number of Races of Varying Distances the Runner Ran Between the Ages of 27 and 64 Years

<table>
<thead>
<tr>
<th>Race distance</th>
<th>Number of races</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 km</td>
<td>48</td>
</tr>
<tr>
<td>15 km</td>
<td>25</td>
</tr>
<tr>
<td>16 km</td>
<td>20</td>
</tr>
<tr>
<td>21.1 km</td>
<td>100</td>
</tr>
<tr>
<td>25 km</td>
<td>15</td>
</tr>
<tr>
<td>32 km</td>
<td>50</td>
</tr>
<tr>
<td>42.2 km</td>
<td>122</td>
</tr>
<tr>
<td>50–58 km</td>
<td>56</td>
</tr>
<tr>
<td>Comrades marathon (±90 km)</td>
<td>34</td>
</tr>
</tbody>
</table>

![Figure 1](image)

**Figure 1.** Training distance (km/year) for the runner from the age of 27 to 64 years. The relationship between training distance and age is described by the following equation: \(y = -38,940 + 2,541x - 45.13x^2 + 0.2373x^3\) (where \(y = \text{km/year}\) and \(x = \text{age}\)).
Figure 2. The average running speed (m/min) for the runner for 10-, 21.1-, and 42.2- km races and the Comrades marathon (±90 km) from the age of 27 to 64 years. These are compared with the U.S. national age-group records for the 10-, 21.1-, and 42.2-km events and the Comrades marathon age-group records.

The equations describing the lines of best fit for running speed versus age for the runner and the age-group running speed versus age are shown in Table 2. Using the derivative, the rate of change in running speed (slope) was calculated for each year. The differentiated equations were solved for age, and the resulting curves were plotted (see Figure 3). The rate of decline was higher in the runner than the expected age decline at 47 years for 10 km, 47 years for 21.1 km, 40 for 42.2 km, and 48 years for the Comrades marathon.

At the age of 60 years the runner had a clinical examination for joint disease. This examination included X rays of both knees. The examination did not reveal any signs of knee-joint degeneration. At the age of 61 years the runner had an embolism and was sedentary for a few months before resuming training.

Discussion

The aim of this case study was to examine changes in running performance in a long-distance runner as he aged from 27 to 64 years. During this time the runner ran a total of 153,944 km during training and 16,604 km during races and a total of 212 marathon and ultramarathon races. Two unusual features of this athlete were his
Table 2  Equations Describing the Line of Best Fit for Average Running Speed (m/min) vs. Age (years) for 10-, 21-, 42-, and 90-km Races

<table>
<thead>
<tr>
<th>Race distance</th>
<th>Subjects</th>
<th>Age-group record</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 km</td>
<td>$y = 154.7 + 2.79x + 0.08145x^2 - 0.001925x^3; R = .91$</td>
<td>$y = -126.0 + 48.53x - 1.725x^2 + 0.02570x^3 - 0.0001420x^4; R = .99$</td>
</tr>
<tr>
<td>21.1 km</td>
<td>$y = 729.3 - 33.35x + 0.8188x^2 - 0.006849x^3; R = .96$</td>
<td>$y = -258.9 + 61.49x - 2.232x^2 + 0.03404x^3 - 0.0001906x^4; R = .97$</td>
</tr>
<tr>
<td>42.2 km</td>
<td>$y = -3770 + 353.4x - 11.45x^2 + 0.1633x^3 - 0.0008733x^4; R = .93$</td>
<td>$y = 28.61 + 28.41x - 0.9396x^2 + 0.01251x^3 - 0.0000619x^4; R = .97$</td>
</tr>
<tr>
<td>Comrades</td>
<td>$y = -934.2 + 86.98x - 2.375x^2 + 0.02825x^3 - 0.0001307x^4; R = .67$</td>
<td>$y = 552.5 - 33.44x + 1.446x^2 + 0.02659x^3 + 0.0001693x^4; R = .91$</td>
</tr>
</tbody>
</table>

Note. $y =$ running speed (m/min); $x =$ age (years).

*This event varied between 86.9 and 91.7 km and alternated directions each year.

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Figure 3. Using the derivative, the rate of change in running speed (slope) was calculated for each year for 10-, 21.1-, 42.2-km races and the Comrades marathon (+90 km) for the runner and the age-group records. The differentiated equations were solved for age, and the resulting curves were plotted.
meticulous record keeping of every training run and race he ran during that time and the consistency of his training methods.

During those years his running performance increased and then steadily decreased over time in distances ranging from 10 to 90 km (Figure 2). Using the age-group records as a source of reference it can be seen that between the ages of 40 and 48 years the speed of the runner began to decrease at a rate that exceeded the rate of decrease of the age-group record holders. The decrease in running performance was not related to degeneration in his joints—his knee joints were examined when he was 60 years old and there were no signs of any degeneration or pathology.

Although it could be argued that the runner's decrease in performance was simply the result of a reduction in training volume, this is unlikely to be the only explanation. When the runner was interviewed he stated that his perception of effort related to the training load remained similar despite the reduced training load. Given this, he experienced changes that affected his ability to sustain a high training volume in addition to his ability to resist fatigue during a race.

A number of explanations have been given over the years for the decrease in running performance with age. The traditional explanation is that a decline in running performance is linked to a decline in maximal oxygen consumption with age, although studies have not established a causal relationship. For example, investigators have shown that the reduction in aerobic power with increasing age is less than (Heath, Hagberg, Ehsani, & Holloszy. 1981; Pollock et al., 1997; Rogers, Hagberg, Martin, Ehsani, & Holloszy, 1990). or not different from, the reduction in physical performance of sedentary subjects (Atomi & Miyashita, 1974; Dehn & Bruce, 1972; Wilson & Tanaka, 2000). Furthermore, in a longitudinal study of elite long-distance runners, participants who continued to train between the ages of 46 and 68 years had a greater than predicted decline in maximal aerobic capacity (Trappe et al., 1996). Whether these changes are the consequences of some underlying physiological mechanism remains to be determined. It has been suggested that chronic exercise training might result in irreversible muscle damage and a subsequent decrease in exercise performance (Lambert, St. Clair, Derman, & Noakes, 1999). Also, a study has shown that excessive exercise was possibly the cause of mitochondrial myopathy in a former elite athlete (St. Clair Gibson et al., 1998). The myopathy in that runner induced a condition that was described as "premature aging."

Our runner had an embolism at the age of 61 years. There was no sudden decrease in performance preceding this event. It is unlikely that the stroke can be used as an explanation for the precipitous decline in running performance that occurred 15–20 years earlier. It should also be emphasized that no knee-joint abnormalities were found that could explain the sudden decrease in performance.

The running and swimming records of master athletes provide useful data for examining age trends. Different forms of analysis have yielded conflicting conclusions, however, about the changes occurring with age (Stones & Kozma, 1986). For example, although decrements of swimming performance occurred in a cross-sectional group of swimmers from the age of 34 to 84 years, when cohorts of these swimmers were monitored over time, the changes in performance were found to be substantially less (Hartley & Hartley, 1984). Should these findings apply to running, we have underinterpreted the decline in performance of our runner rather than overinterpreted it.
The design of this study limits the interpretation of the data. Nonetheless, single-case studies do serve a purpose in highlighting questions for further study (Reboussin & Morgan, 1996). Furthermore, "record" age-group performances should be used as a control with caution (Spirduso, 1995). First, these are cross-sectional data compared with the longitudinal data of our runner. Also, the age-group records represent the performance of talented well-trained athletes, combined with environmental conditions conducive for fast performances. Although our runner reported that he attempted to run to the best of his ability, he might have been prevented from doing so on some occasions by the weather. The data were analyzed as trends, however; therefore a relatively poor performance one year would not have had a major impact on the rate of decline of running speed. The control data represent the potential best performances for each age group, and our runner's data represent his best performances in the presence of changing training volumes and perhaps motivation to push himself to the limits as the age-group record holders might have done. It should be in this context that the results are interpreted.

With this in mind it is tempting to speculate that the runner experienced changes in his muscles that occurred as a result of the years of heavy training (Figure 1) and racing (Table 1), and after several years these changes had a negative effect that resulted in a decrease in speed at a higher rate than was expected for his age. This speculation cannot be proved by the data in this study but warrants further investigation in a controlled experiment.

Acknowledgments

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References


