Physiological profile of a 59-year-old male - World record holder - marathoner

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Short title: Physiological profile of a 59-year-old ex-Olympian athlete

Conflicts of interest

All authors declare no conflicts of interest. Results of the present study do not constitute endorsement by ACSM and are presented honestly without fabrication or falsification data.

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ABSTRACT

Purpose: This study assessed the cardiorespiratory capacity and running economy of a 59-year-old ex-Olympian athlete who ran a marathon in 2:30:15 in 2019. The athlete retired from running at 32 years old (best marathon performance: 2:13:59) for a 16-year period after his participation at the Olympics.

Methods: Heart rate (HR), oxygen uptake (VO_2), ventilation (VE), blood lactate concentration (La), step frequency (SF) and running economy (RE) were measured during a treadmill-running test.

Results: His HR_{max}, VE_{max}, La_{max}, VO_{2max} were 165 beats.min^{-1}, 115 l.min^{-1}, 5.7 mmol.l^{-1} and 65.4 ml.kg^{-1}.min^{-1}, respectively. At his marathon pace, his RE was 210 ml.kg^{-1}.km^{-1} with a SF of 199±0.55 s.min^{-1} and his oxygen uptake corresponded to 91% of his VO_{2max}.

Conclusion: This study shows that despite a 16-year break in training, this 59-year old former Olympian marathoner has managed to limit the age-related decline in performance to ~5% per decade. More generally, these data suggest that high level endurance masters athletes can limit the age-related decline in endurance performance at least until the age of 60 years and can preserve their ability to sustain high intensity effort (> 90% of VO_{2max}) for long duration (2-3h) exercises.

Key Words: AGING, RUNNING, MASTER ATHLETE, OXYGEN CONSUMPTION, AEROBIC EXERCISE, ENDURANCE

INTRODUCTION

While physical exercise during youth and adulthood might help reach old ages with a remarkable aerobic fitness compared to sedentary individuals, keeping physical activity levels high in later years seems to be a prerequisite to attenuate the age-related decline in cardiorespiratory capacity (1). Masters athletes are unique in that they have chronically undertaken high levels of physical activity until an advanced age. These athletes strive to maintain performances they achieved at younger ages, even though athletic performance inevitably declines with aging (2). Peak endurance performance is generally maintained until ~35 years of age, followed by modest decreases until 50–60 years, with progressively steeper declines thereafter (3). The master athlete's model represents a valuable source of insight into human's ability to maintain peak physical performance and physiological function with aging.

In the present study, we evaluated the cardiorespiratory capacity and running economy of a 59-year-old former Olympian athlete who ran a marathon in 2:30:15 in 2019, establishing a new single age marathon World record (www.arrs.run/SA_Mara.htm). This study is unique in the sense that this athlete had a 16-year break in training following his participation at the Olympics at the age of 32 (best marathon performance: 2:13:59) before resuming at the age of 48. Moreover, despite his long running break, his decline in performance over a 27-year period (from 32 to 59 years) corresponds to only 11%, a decrease that is exceptionally low since after 35 years the decline in performance is generally of 7-10% per decade.

METHODS

Subject

At the date of the evaluation (July 2019), the athlete was a 59 years old Irish Caucasian, living in Northern Ireland. He was 169 cm high and weighted 61.2 kg (his weight was around 64 kg during his thirties). His total body fat measured via Dual-energy X-ray absorptiometry (Hologic QDR Series, USA) was 10.9 %. The athlete was an elite full-time runner from the age of 21 to 32. He retired from running and any other type of structured exercise training following his participation at the 1992 Olympics marathon. After a 16-year break, he resumed training at the age of 48 and competed in running events from 5-km to marathon. On April 7th 2019, the athlete ran the Rotterdam marathon in 2:30:15 (average speed 16.85 $km.h^{-1}$). Although the athlete did not have a precise training diary, he recognized that he could run up to 160 km per week during specific training periods for the marathon. The athlete's training routine usually consisted in running twice a day with a long run (25-30 km) on the weekend and no rest day. He did not perform any structured high intensity training sessions as he reported preferring to race at local competitions in preparation for his main goals.

The athlete volunteered for the study and was informed about its nature and aims, as well as the associated risks and discomfort prior to giving his oral and written consent to participate in the investigation. The protocol was in conformity with the Declaration of Helsinki (last modified in 2013). The experimental protocol was approved by the Research Ethics Committee of Liverpool John Moores University.

Performance testing

Performance testing was performed on a motorized treadmill (HP Cosmos, Germany) and consisted of a submaximal running economy (RE) test followed by an incremental running test until volitional exhaustion (maximal oxygen consumption - VO_{2max} - test). Oxygen uptake was measured using indirect calorimetry via an automated open circuit system (Oxycon Pro, Carefusion, Germany). Heart rate (HR) was monitored via a Polar V800 heart rate monitor (Polar, Finland). We used the same testing protocol as Robinson et al. (4) but with higher running velocities. In brief, after completion of a 6-min warm-up at running velocities varying from 12 to 15 $km.h^{-1}$, the athlete ran at four pre-selected velocities (15, 16, 17, 18 $km.h^{-1}$) for 5 min with 5 min of passive recovery in between. Following the last RE stage, the athlete performed the VO_{2max} test during which a velocity of 16 $km.h^{-1}$ was held constant while the treadmill gradient was increased by 1 % every minute until volitional exhaustion. A 30-s interval containing the two highest 15-s O_2 consumption values was used to determine VO_{2max}. Blood lactate (La) was measured in finger-prick blood samples (50µl) using a portable lactate analyzer (Lactate Pro2, Arkray, Japan). Measurement was performed before and one minute after each RE stage and after the VO_{2max} test. A foot pod monitor (Stryd Powermeter, Boulder, CO, USA) was attached to the left shoe during the RE submaximal test in order to evaluate stride parameters. The *Stryd* foot pod is valid and reliable for the monitoring of step length and step frequency at running speeds ranging from 8 to 20 $km.h^{-1}$ (5).

RESULTS

The results of performance testing are presented in Figure 1. During the final increment of the VO_{2max} test, maximal HR was 165 $beats.min^{-1}$, maximal ventilation was 115 $l.min^{-1}$, maximal respiratory exchange ratio was 1.04, maximal lactate concentration was 5.7 $mmol.l^{-1}$ and VO_{2max} was 65.4 $ml.kg^{-1}.min^{-1}$. When comparing the athlete's VO_{2max} with the American College of Sports Medicine average percentile values (6), the athlete ranked above the 99^{th} percentile for his age group.

RE values calculated during the RE submaximal test were 203 $ml.kg^{-1}.km^{-1}$, 211 $ml.kg^{-1}.km^{-1}$, 210 $ml.kg^{-1}.km^{-1}$ and 206 $ml.kg^{-1}.km^{-1}$, at 15 $km.h^{-1}$, 16 $km.h^{-1}$, 17 $km.h^{-1}$ and 18 $km.h^{-}$

$^{-1}$, respectively. At his record marathon pace, his oxygen uptake was approximately 59 $ml.kg^{-1}.min^{-1}$ and corresponded to 91 % of his VO_{2max}, while HR corresponded to 93 % of his HR_{max}.

DISCUSSION

This study reports the physiological profile of an ex-Olympian marathon runner who ran a marathon in 2:30:15 at the age of 59 despite a 16-year break in training between the age of 32 and 48 years.

This master athlete has conserved a very high cardiorespiratory capacity as shown through a VO_{2max} of 65.4 $ml.kg^{-1}.min^{-1}$. In comparison, Heath et al. (7) found a mean VO_{2max} of 58.7 $ml.kg^{-1}.min^{-1}$ in a group of highly trained runners aged 59±6 years. VO_{2max} values of ~30 $ml.kg^{-1}$ and ~45 $ml.kg^{-1}.min^{-1}$ are classically reported in sedentary peers (8) and age-matched well-trained runners, (9) respectively.

This very high VO_{2max} for the age likely contributed to the exceptional marathon performance, associated with a very good specific endurance capacity at marathon pace (10). Indeed, the results showed that at his record marathon pace the athlete's oxygen uptake corresponded to 91% of his VO_{2max}, as it is reported in top class marathon runners (11). These data are in accordance with the study of Robinson et al. (4) who reported the physiological profile of a 70-year-old master athlete who ran a marathon in 2:54:23 (World record time for men over 70 years) and was able to sustain a running velocity eliciting 93% of VO_{2max} during the marathon. These observations suggest that compared to young runners, master's runners might be able to run closer to their VO_{2max} for the duration of the marathon (12).

Running economy is clearly important to running performance (13). Despite his age, this master athlete has maintained a good running economy close to 210 $ml.kg^{-1}.km^{-1}$ at his marathon pace. This running economy value corresponds to those measured by Billat et al. (11)

in top class male European marathon runners (marathon performance time < 2:12:00) but remains higher to those measured in elite East African runners such as Eritrean runners who reach 180-190 $ml.kg^{-1}.km^{-1}$ (14). Running economy has been found to decrease with aging in Olympic-caliber running athletes when they stop competitions (1). In our case study, the maintenance of a high training volume associated with a high step frequency (199±0.55 $s.min^{-1}$ at 17 $km.h^{-1}$) could explain the good running economy of this master athlete (15).

Could we predict the marathon running performance of the present athlete at the age of 70? Supposing that this athlete will be able to maintain a high level of training in the future with a decline in VO_{2max} of 7% in the next decade (16), his VO_{2max} would be 60 $ml.kg^{-1}.min^{-1}$ at 70 years old. This extrapolated VO_{2max} value at the age of 70 would be much higher than that of the current over 70 years marathon World record holder which was 47 $ml.kg^{-1}.min^{-1}$ (4) and to our knowledge, close to the highest VO_{2max} value ever reported in the literature for this age (17). The age-related change in running economy has been scarcely described in the literature. Everman et al. (1) found an increase in running economy of about 5% per decade in former elite distance runners, but these runners had stopped competitions. We can expect that with training maintenance, the running economy of the present athlete would increase by less than 3%, corresponding to a running economy of 216 $ml.kg^{-1}.km^{-1}$ at the age of 70. Finally, if we assume that his ability to sustain an intensity close to 90% of VO_{2max} during the marathon would not decline with age, the equation of di Prampero et al. (18) predicts a running speed of 4.16 $m.s^{-1}$ at the age of 70, the equivalent of completing a marathon in 2 h 49 min - a time that is 5 min faster than the current marathon World record time for men over 70 years.

A limitation of this study is the absence of comparative physiological data for this athlete when he was young at the top of his career. Such data would provide information on whether the subject's physiological capacities declined linearly or in a disparate manner. Furthermore, some differences in physiological parameters such as running economy could occur between treadmill running and overground running though they are probably minor for well-trained runners (19).

In conclusion, this study shows that despite a 16-year break in training, this 59-year old former Olympian marathoner has managed to limit the age-related decline in performance by maintaining a high VO_{2max} and remarkable ability to sustain a high percentage of VO_{2max} during the marathon. More generally, these data suggest that it might be possible to limit the age-related decline in endurance performance to ~5% per decade at least until the age of 60 years by maintaining a high training volume. Our data also suggest that endurance masters athletes could preserve their ability to sustain high intensity efforts (at least 90% of VO_{2max}) for long duration (2-3h) exercises. Further research is needed to better understand the conditions required to maintain such remarkable endurance capacity with aging.

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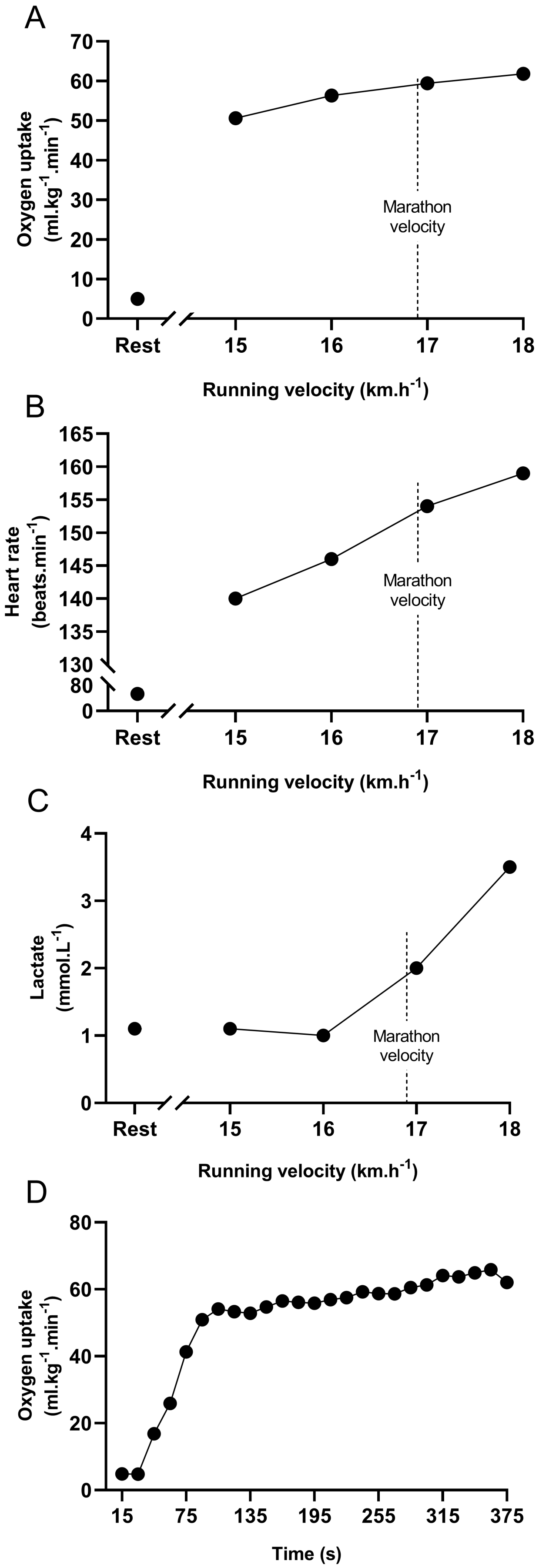
Figure Caption

Figure 1

Physiological characteristics of the marathoner

Oxygen uptake (Panel A), heart rate (Panel B) and blood lactate values (Panel C) obtained at different running velocities during the running economy test. Panel D: Oxygen uptake during the incremental running test. The dashed line represents the average speed of this runner during his record-breaking marathon performance (16.85 $km.h^{-1}$).


A
Oxygen uptake (ml.kg-1.min-1)
70
60
50
40
30
20
10
0
Rest
15
16
17
18
Marathon velocity
Running velocity (km.h-1)
B
Heart rate (beats.min-1)
165
160
155
150
145
140
135
130
80
0
Rest
15
16
17
18
Marathon velocity
Running velocity (km.h-1)
C
Lactate (mmol.L-1)
4
3
2
1
0
Rest
15
16
17
18
Marathon velocity
Running velocity (km.h-1)
D
Oxygen uptake (ml.kg-1.min-1)
80
60
40
20
0
15
75
135
195
255
315
375
Time (s)

268