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Review/Original Article

Physical performance in aging elite athletes – Challenging the limits of physiology

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Introduction: Veteran athletes as a paradigm of study

Age-associated frailty, as any other age-related change, is potentially due to three theoretically independent, but actually interwoven factors. These factors are: (i) aging *per se* acting as a biologic, irreversible process[1,2], (ii) deconditioning due to the more sedentary lifestyle found in most elderly people, and (iii) effects of co-morbidity, i.e., of primary diseases or injuries that are in principle independent of age, but which accumulate during the lifespan.

Exercise – or the discontinuation of sedentarism – has been opted for as a countermeasure to age-related frailty. It has been shown that nonagenarians profit from resistive exercise quite as much as, or even more than, younger people[3]. It has also been shown that exercise in the elderly can reduce the number of falls[4].

Considering these positive effects of exercise, it is interesting to study the physiological limits of physical performance in the elderly under ideal conditions. The present article tries to address this question, basing its discussion on the physical performance of veteran athletes.

Veteran athletes continue their sportive career throughout life, often adhering to training regimes of 20 hours and more per week. As a consequence, age-related sedentarism should not contribute to age-related frailty in these athletes. Furthermore, any disease that would affect the athletic performance will lead to a deterioration in results or even in discontinuing sportive activity. Therefore, veteran athletes provide a unique opportunity to study the question pointed out.

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Results: performance in veteran athlete records.

In 1975, Moore[5] studied the change of running speed in records obtained between age 1 and 78. In that study, speed deteriorated with age more slowly for longer distances than at shorter ones. This was true whether the decay was expressed in absolute terms (m/s), or in percent relative to the world record over that distance. At that time, the author concluded that ‘strength deteriorates faster than stamina’. Unfortunately, this study has two limitations. Firstly, it does not contain a comparison of different kinds of track and field records at ages greater than 60 years that might underpin the above conclusion. Secondly, it is not clear what is actually meant by the term ‘strength’: peak force, peak power, or peak velocity.

Another analysis of the veteran athlete world records has been published by Baker and co-workers[6]. In agreement with Moore, the authors found that the age-related decline in running speed is best approximated by an exponential decay function. In contradiction with Moore, however, they found that the performance for longer distances declined marginally faster than for shorter events. In an attempt to quantify the average decline for all track events, an equation was obtained that indicates a reduction by ~70% in women and ~60% in men in running speed from age 40 to age 90. The intercepts of the obtained decay functions, i.e., the theoretical age where speed equals 0 ranged between 95 years (marathon) and 104 years (100 m) for the men and between 92 years (marathon) and 106 years (100 m) for the women.

A more detailed analysis of the veteran athlete world records relies on the so-called power function of running performance. It has been shown that for running distances between 100 m and 200 km, the performance time τ is a power function of D (D is the distance covered)[7,8]. Obviously, the characteristic relationship $\tau = c \cdot D^n$ is broken[9] at D_0 = 1000 m, or τ ~160 s. Applying the ‘broken power law’ analysis to veteran record data revealed that the age-related decline of speed is more than proportional for long distance running as compared to sprinting, and that this effect may be attributed to a disruption in metabolic power generation[10].

Contrasting with the exponential decline of running speed with age, Baker et al. found a linear decrease of performance in walking, in the throwing disciplines (shot put, discus, hammer, javelin), and in the jumping disciplines[6]. The scientific value of this observation, however, is corroborated by the facts that the jumping strategy changes with age with, for example, most veteran athletes younger than 80 years doing the long jump off running, and older athletes generally off standing. Likewise the weight of, for example, the javelin, changes from 800 g in men below 60 years to 600 g above that age.

We therefore measured the peak power together with the jumping height during a single vertical jump (jumping mechanography) in participants of the European Veteran Athlete Championships that took place in Potsdam in 2002. In sprinters, in medium distance and in long distance runners, peak power declined linearly with age. Although sprinters had a higher peak power relative to body weight than medium or long distance runners at any age investigated, they also depicted a greater rate of decline than the latter groups.

These findings are complementary to those of Pearson et al. in elite weightlifters, assessed during the World Masters Weightlifting Championships in 1999[11]. Compared to age-matched control subjects, the weightlifters depicted no differences in leg volume (assessed anthropometrically), and comparable rates of decline in peak power (1.2% per year in athletes and 1.3% per year in controls) and in peak isometric torque (0.6% per year in athletes and 0.5 % per year in controls). This again suggests that the decline in power is a key feature in the age-related decay of physical competence.

Discussion and conclusion

Physical performance can be assessed in physical terms of force, velocity, power, and endurance, the latter being understood as the time over which a given power output can be maintained. The dynamometric measurements show that force and power tend to decline with age in a linear way, but the recorded data suggest that velocity and even more so, endurance, decline more than proportionally.

It could be argued that all the above results are biased by a selection effect, given that the number of veteran athletes also declines with age. While this is certainly true, such bias probably is small. This becomes clear from the simple fact that variation of performance in young athletes at national levels is usually less than 10% (e.g. 10-11 seconds for the 100 m dash), but that much a bigger decline is due to age (e.g., by 80% for the 100 m by age 90). It should also be realized that the potential ‘age selection bias’ would under- rather than overestimate the age-related decline in physical performance.

In consequence, the available data indicate that physical competence declines even in the presence of lifelong, meticulous and demanding exercise. Obviously, veteran athletes are superior to non-athletes in terms of physical competence. This advantage, however, melts away with increasing age.

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