Int J Sport Stud Hlth. 2021 April; 4(1):e122900. doi: 10.5812/intjssh.122900.

Published online 2022 February 2. **Review Article**

Is It Possible to Age Healthy Performing Ultra-endurance Exercises?

Rodrigo Luiz Vancini [1,*], Marilia dos Santos Andrade [2], Claudio Andre Barbosa de Lira [3], Pantelis Theodoros Nikolaidis [4] and Beat Knechtle [5,6]

[1] Centro de Educação Física e Desportos (CEFD), Universidade Federal do Espírito Santo (UFES), Espírito Santo (ES), Brasil
[2] Departamento de Fisiologia, Universidade Federal de São Paulo (UNIFESP), São Paulo (SP), Brasil
[3] Setor de Fisiologia Humana e do Exercício, Faculdade de Educação Física e Dança, Universidade Federal de Goiás (UFG), Goiânia, Goiás (GO), Brasil
[4] Exercise Physiology Laboratory, Nikaia, Greece
[5] Medbase St. Gallen Am Vadianplatz, St. Gallen, Switzerland
[6] Institute of Primary Care, University of Zurich, Zurich, Switzerland

[*] *Corresponding author*: Centro de Educação Física e Desportos (CEFD), Universidade Federal do Espírito Santo (UFES), Espírito Santo (ES), Brasil. Email: rodrigoluizvancini@gmail.com

Received 2022 January 25; **Accepted** 2022 January 25.

Abstract

Context: The process of decline in endurance capacity is particularly insidious over age 60 and varies considerably with sex, task specificity, and individual training status. Around 50 years of age, aging also implies deterioration of neuromuscular function, affecting muscle strength and power. The aim of the present article was to perform a mini-review to verify how ultra-endurance exercises impact the aging process.
Evidence Acquisition: For this, we reviewed the PubMed database (on 20/01/2022) by crossing the key terms, in the simple form, "ultra AND endurance AND exercise AND aging". This research provided 25 articles from which we made a selection.
Results: We observed that the number of articles on the topic is low. The main findings showed that ultra-endurance exercise, high volume physical exercise (six-hours or more) with peak intensity moments, in long-term, is associated with increased risk of heart disease, sudden death, shortening of telomeres, accelerating aging cell, and harm to the healthy aging process and longevity.
Conclusions: There is still little literature about the impacts of ultra-endurance practice on the aging process. Although there are indications that this may happen, such as shortening of telomeres and cellular aging, it is still not possible to establish a cause-effect relationship. Furthermore, it is not just about physical exercise, it is necessary to take into account individual factors (intrinsic and extrinsic) that interact with the sports trajectory, life habits, biology, and genetics.

Keywords: Aging, Longevity, Ultra-endurance, Physical exercise, Health

1. Context

The process of decline in endurance capacity is particularly insidious over age 60 and varies considerably with sex, task specificity, and individual training status. Around 50 years of age, aging also implies deterioration of neuromuscular function, affecting muscle strength and power (1).

Regarding to the musculoskeletal system, with the aging process, there is a significant loss of muscle mass and strength (sarcopenia), of the regenerative and recovery capacity to training stimuli and physical and sports performance. These changes are also accompanied by impairment of muscle metabolism, including mitochondrial dysfunction and insulin resistance. Notably, physical exercise is a well-established strategy against muscle aging and has been shown to attenuate age-related losses in muscle mass, strength, and regenerative capacity and to delay or prevent deficiencies in muscle metabolism (2).

As for endurance exercise, with the aging process, there is an increase in the use of endogenous fuels to provide energy for working muscles, causing older people to oxidize more glucose and less fat during moderate-intensity exercise. This shift in substrate use is likely caused by changes related to "muscle age" including decreased respiratory and oxidative capacity of skeletal muscle. On the other hand, endurance training in the aging process increases muscle oxidative capacity, decreases glucose production and oxidation, and increases fat, correcting or compensating for changes in substrate oxidation associated with aging (3).

In recent decades, the participation of older athletes, that is, aged 40 years or older, in endurance and ultra-endurance competitions has increased (4). This was also accompanied by an improvement in the performance of older athletes compared to younger athletes. The fact is

that age and the aging process result in a decrease in endurance performance and this depends on the mode and biomechanics of locomotion, the duration of the event, and the gender of the participant (5). For example, currently, Knechtle and Nikolaidis showed that the peak age of running speed in ultramarathoners of 50 km is higher than in the past. Women seem to achieve the best run time in a 50 km ultramarathon later in life compared to men (6).

Based on the above arguments, The aim of the present article was to make a brief review about how ultra-endurance exercises could impact health status and quality of life and consequently on the aging process of practitioners.

2. Evidence Acquisition

We reviewed the PubMed database by crossing the key terms "ultra AND endurance AND exercise AND aging (on 20/01/2022)". This research provided the finding of 25 articles from which we made a selection and we will bring some findings for discussion.

2.1. Ultra-endurance Exercise Characterization

Ultra-endurance modalities are defined as those that exceed 6 hours in duration (for example, any walking, running, swimming, kayaking and/or cycling competition; a classic example is the Ironman triathlon and ultra-marathon races), that is, of high volume and duration of physical exertion and most likely with some peaks of physical effort intensity (7).

To prepare for events of this nature, the participant needs long-term physical and mental preparation, adequate (quality) and sufficient (quantity) nutrition, proper hydration, adequate physical recovery between training sessions, implement strategies to prevent injuries, and competitions ambiance regarding possible environmental stressors and variations (cold, heat, and high altitudes), and a lot of psychological resilience (7).

Ultra-endurance performance, when successful and planned, is characterized by the ability to sustain physical effort, for example, at the highest absolute speed possible for a given distance to be covered. In this context, the main factor to be avoided, during and after months of high volume and intensive training, are excessive physical and mental stress and recurrent musculoskeletal injuries and, in extreme cases, the overtraining syndrome and chronic organic inflammation (7).

3. Discussion

In the context of our aim the first relevant article is entitled "Training for Longevity: The Reverse J-Curve for Exercise". In this study, O'Keefe et al. pointed out that there is a vast scientific literature on the benefits for health, quality of life, physical fitness, and therapeutics of the systematic practice of physical exercise, particularly of moderate intensity, for different physiological systems (cardiorespiratory, neuromuscular, immunoendocrine systems, for example) as well as for the longevity and successful and healthy aging. However, as far as ultra-endurance exercise and aging are concerned, studies are scarce (8).

When talking about the dose-response relationship regarding the amount of exercise many people think that the more quantity the better and the more benefits will be achieved. With the increasing popularization of chronic excessive resistance exercise (long-duration running, road cycling, distance and open-water swimming, and triathlon) there could be an adverse impact on overall body health and quantity and quality aging process, especially in the health of the cardiovascular system. Furthermore, ultra-resistance exercises could cause acute myocardial damage. Also, sudden cardiac arrest occurs more often in marathon races and triathlon competitions than in shorter running and volume events. In the case of older athletes, who practice endurance and ultra-endurance events, abnormal cardiac remodeling and a greater propensity for myocardial fibrosis and coronary calcification are commonly observed. Moreover, excess physical exercise on volume and intensity in the long-term is associated with an increased risk of cardiac arrhythmias and attenuation of benefits for the healthy aging process and longevity (8).

In other words, it could have the opposite effect of what is intended for most people. This overcoming physical and mental limits and challenges is noble, but how much is this valid for the worsening of the state of physical and mental health?

However, the ideal dose (volume, intensity and frequency) of physical exercise for each person is difficult to be determined and is still a mystery to be solved as there are no precise biological markers for this intent. In the general lines, it is suggested that 2.5 to 5 hours per week of moderate and/or vigorous physical activity would provide maximum benefits; and more than 10 hours a week could reduce health benefits. But this is something very difficult to quantify. In addition, people need to take into account individual preferences such as the option of being a recreational and/or competitive practitioner (8) and thus reaching the limits of human biology in terms of physical effort.

Another point to be considered when talking about excessive physical exercise, in volume and intensity, throughout the aging process would be the issue of lengthening or shortening of telomeres (9). Telomeres play a central role in cell aging and adjust the cell's response to stress

and stimulation of cell growth based on the process of cell division throughout life. Its function is to "encapsulate" each end of the chromosome to prevent activation of deoxyribonucleic acid repair pathways (10). The lengthening and/or shortening of telomeres could be a biological marker of the aging process, which in itself is a complex path that is influenced by multiple intrinsic factors (genetic and chronological age) and extrinsic factors associated with lifestyle (stress level, diet, and physical activity levels). Although regular and moderate physical exercise promotes telomere length maintenance, extreme endurance exercises are associated with increased free radical production and consequent oxidative stress and inflammation and decreased antioxidant reserve, being one of the main factors in its shortening (9). However, Borghini et al. showed that chronic endurance training could provide protective effects at telomere length by attenuating biological aging (11). On the other hand, acute exposure to an ultra-endurance run implies telomere shortening probably caused by oxidative DNA damage.

Although it seems contradictory according to the previous argument, Denham et al. showed that regular practice of ultra-resistance aerobic exercise attenuates cell aging (12) and Hernando et al. demonstrated that the usual ultra-resistance exercise seems to promote telomere length maintenance, especially for older people and for those individuals who have been training for many years (9). Another argument that supports this idea is that the ability to maintain a high physical training stimulus with advancing age could be a way to limit the rate of decline in endurance performance. Thus, by constantly pushing the limits of ultra-endurance, older athletes show the ability of human beings to maintain physical performance, physiological function, and a high level of physical fitness with the aging process (5). In other words, it is necessary to be careful about generalizations when talking about the interaction between genetics and environment and to consider each person individually.

Despite all this discussion, the fact is that people who get older doing some type of physical exercise and/or sport, whether of moderate or very high intensity, mostly age with high levels of functional capacity as demonstrated by Taveira et al. (13).

Now, whether your life expectancy will be increased by it, that's another question. Teramoto and Bungum showed that it appears that elite endurance athletes (aerobic) and mixed sports athletes (aerobic and anaerobic) survive longer than the general population, as indicated by lower mortality and greater longevity (14). The lower mortality from cardiovascular disease is probably the main reason for their better survival rates. Furthermore, when elite athletes who play multiple sports are analyzed together, their mortality is lower than that of the general population. In conclusion, long-term vigorous exercise training is associated with increased survival rates for specific groups of athletes.

There is robust epidemiological evidence that regular exercise throughout life contributes to increased longevity. Conservatively, it is proposed that meeting the minimum recommended amounts of aerobic physical activity of moderate intensity and at least 150 minutes per week provides most of the benefits for increasing life expectancy. However, longer duration and intensity increase the beneficial effect of exercise on cardiovascular health and metabolism. Engaging in physical activity three to five times a week is the minimum to achieve maximum longevity benefits. While it is not dangerous (although it is necessary to evaluate each case), there is some orthopedic and cardiovascular risk to perform an even greater amount of exercise, and the benefit may diminish. A high maximal oxygen uptake in midlife is a strong marker of longevity, while low muscle mass is a critical prognostic factor in aging and cancer. Physical training above public health recommendations offers additional benefits in terms of protection from disease and longevity. Endurance exercise, including high-intensity training to improve cardiorespiratory fitness, promotes longevity and delays aging. However, when it comes to ultra-endurance exercises, further studies are needed on the real benefits and/or possible harms for the general state of health and optimization of the aging process (15). However, Knechtle and Nikolaidis pointed out in an elegant review that an ultramarathon race, for example, could have the following negative impacts on the body: energy deficit with reduced body fat and muscle mass; hyponatremia; musculoskeletal disorders; negative changes in cardiac biomarkers such as creatine kinase; digestive problems and gastrointestinal bleeding; temporary reduction in kidney function; and upper respiratory tract respiratory infections (6). Most of these changes are transitory. But just imagine having these negative changes chronically during the aging process?

The fact is that the practice of physical activity, in the right dose, can interrupt the biological aging process and minimize the physiological effects of a sedentary lifestyle and increase active life expectancy, limiting the development and progression of chronic diseases and disabling conditions. There are also significant psychological and cognitive benefits from regularly participating in exercise during the aging process and improving mental health. To slow down the aging process, ideally, exercise prescriptions for older people should include aerobic, muscle-strengthening, and flexibility exercises. All elderly people should engage in regular physical activity and avoid an inactive lifestyle in the course of the aging process (16).

Thus, to try to project and understand the life expectancy of an athlete, it is necessary to know before, during, and after your sportive career. It's not just about physical exercise (17) even more when it comes to physical exercises that demand a high physical and psychological overload during the aging process, such as ultra-endurance exercises (16). However, it is necessary to know the exaggerated exercises such as ultra-endurance exercises can even accelerate the biological aging process.

Footnotes

Authors' Contribution: Study concept and design: Rodrigo L. Vancini; Acquisition of data: Marilia S. Andrade, Analysis and interpretation of data: Claudio A. B. de Lira; Drafting of the manuscript: Rodrigo L. Vancini; Critical revision of the manuscript for important intellectual content: Pantelis T. Nikolaidis; Administrative, technical, and material support: Rodrigo L. Vancini; Study supervision: Beat Knechtle.

Conflict of Interests: There is no conflict of interests.

Funding/Support: RLV is a productivity fellowship at the Espírito Santo Research and Innovation Support Foundation (FAPES) agency (Public Notice N° 18/2018-Bolsa Researcher Capixaba).

References

1. Mendonca GV, Pezarat-Correia P, Vaz JR, Silva L, Heffernan KS. Impact of Aging on Endurance and Neuromuscular Physical Performance: The Role of Vascular Senescence. *Sports Med*. 2017;**47**(4):583–98. doi: 10.1007/s40279-016-0596-8. [PubMed: 27459861].
2. Distefano G, Goodpaster BH. Effects of Exercise and Aging on Skeletal Muscle. *Cold Spring Harb Perspect Med*. 2018;**8**(3). doi: 10.1101/cshperspect.a029785. [PubMed: 28432116]. [PubMed Central: PMC5830901].
3. Mittendorfer B, Klein S. Effect of aging on glucose and lipid metabolism during endurance exercise. *Int J Sport Nutr Exerc Metab*. 2001;**11 Suppl**:S86–91. doi: 10.1123/ijsnem.11.s1.s86. [PubMed: 11915933].
4. Nikolaidis PT, Knechtle B. Age of peak performance in 50-km ultramarathoners - is it older than in marathoners? *Open Access J Sports Med*. 2018;**9**:37–45. doi: 10.2147/OAJSM.S154816. [PubMed: 29535560]. [PubMed Central: PMC5840300].
5. Lepers R, Stapley PJ. Master Athletes Are Extending the Limits of Human Endurance. *Front Physiol*. 2016;**7**:613. doi: 10.3389/fphys.2016.00613. [PubMed: 28018241]. [PubMed Central: PMC5149541].
6. Knechtle B, Nikolaidis PT. Physiology and Pathophysiology in Ultra-Marathon Running. *Front Physiol*. 2018;**9**:634. doi: 10.3389/fphys.2018.00634. [PubMed: 29910741]. [PubMed Central: PMC5992463].
7. Zaryski C, Smith DJ. Training principles and issues for ultra-endurance athletes. *Curr Sports Med Rep*. 2005;**4**(3):165–70. doi: 10.1097/01.csmr.0000306201.49315.73. [PubMed: 15907270].
8. O'Keefe EL, Torres-Acosta N, O'Keefe JH, Lavie CJ. Training for Longevity: The Reverse J-Curve for Exercise. *Mo Med*. 2020;**117**(4):355–61. [PubMed: 32848273]. [PubMed Central: PMC7431070].
9. Hernando B, Gil-Barrachina M, Tomas-Bort E, Martinez-Navarro I, Collado-Boira E, Hernando C. The effect of long-term ultra-endurance exercise and SOD2 genotype on telomere shortening with age. *J Appl Physiol (1985)*. 2020;**129**(4):873–9. doi: 10.1152/japplphysiol.00570.2020. [PubMed: 32881625].
10. Aubert G, Lansdorp PM. Telomeres and aging. *Physiol Rev*. 2008;**88**(2):557–79. doi: 10.1152/physrev.00026.2007. [PubMed: 18391173].
11. Borghini A, Giardini G, Tonacci A, Mastorci F, Mercuri A, Mrakic-Sposta S, et al. Chronic and acute effects of endurance training on telomere length. *Mutagenesis*. 2015;**30**(5):711–6. doi: 10.1093/mutage/gev038. [PubMed: 26001753].
12. Denham J, Nelson CP, O'Brien BJ, Nankervis SA, Denniff M, Harvey JT, et al. Longer leukocyte telomeres are associated with ultra-endurance exercise independent of cardiovascular risk factors. *PLoS One*. 2013;**8**(7). e69377. doi: 10.1371/journal.pone.0069377. [PubMed: 23936000]. [PubMed Central: PMC3729964].
13. Taveira HV, de Lira CAB, Andrade MS, Viana RB, Tanaka H, Hill L, et al. Isokinetic Muscle Strength and Postural Sway of Recreationally Active Older Adults vs. Master Road Runners. *Front Physiol*. 2021;**12**:623150. doi: 10.3389/fphys.2021.623150. [PubMed: 33815138]. [PubMed Central: PMC8012768].
14. Teramoto M, Bungum TJ. Mortality and longevity of elite athletes. *J Sci Med Sport*. 2010;**13**(4):410–6. doi: 10.1016/j.jsams.2009.04.010. [PubMed: 19574095].
15. Pedersen BK. Which type of exercise keeps you young? *Curr Opin Clin Nutr Metab Care*. 2019;**22**(2):167–73. doi: 10.1097/MCO.0000000000000546. [PubMed: 30640736].
16. Chodzko-Zajko WJ, Proctor DN, Fiatarone Singh MA, Minson CT, Nigg CR; American College of Sports Medicine, et al. American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Med Sci Sports Exerc*. 2009;**41**(7):1510–30. doi: 10.1249/MSS.0b013e3181a0c95c. [PubMed: 19516148].
17. Lemez S, Baker J. Do Elite Athletes Live Longer? A Systematic Review of Mortality and Longevity in Elite Athletes. *Sports Med Open*. 2015;**1**(1):16. doi: 10.1186/s40798-015-0024-x. [PubMed: 26301178]. [PubMed Central: PMC4534511].