Aging Clinical and Experimental Research (2023) 35:1401–1403
https://doi.org/10.1007/s40520-023-02448-1

EDITORIAL

How much sport is too much? A focus on musculoskeletal health of the adult

Olivier Bruyère[1] · **Jean-François Kaux**[2]

Received: 28 March 2023 / Accepted: 17 May 2023 / Published online: 27 May 2023

A large body of research has shown that physical activity has a positive effect on physical and mental health [1, 2]. In particular, regular aerobic and resistance training is associated with a reduced risk of cardiovascular morbidity, cancer, neuro-degenerative diseases and mortality. Updated World Health Organization (WHO) recommendations for 2020 emphasize that adults should engage in at least between 150 and 300 min/week of moderate-intensity aerobic activity or at least between 75 and 150 min/week of vigorous-intensity aerobic activity, or an equivalent combination. In addition, adults aged 65 years and over should engage in complementary muscle-strengthening and body-balancing activities on two or more days a week. The four domains of physical activity are work, active transport, household and leisure. Sport, a type of leisure-time physical activity, has been shown to improve cardiorespiratory fitness, physical function and mental health in people aged 60 and over in a recent meta-analysis of randomised controlled trials (RCTs) [3].

However, the WHO does not clearly recommend upper limits for the intensity and amount of physical activity. However, the health effects of exercise volumes beyond the "optimal dose" are currently under debate. Of course, some cases of sudden death have been reported in athletes under 40 years of age, usually due to a prevalent heart defect, but also in athletes over 40 years of age, mainly due to acquired atherosclerotic coronary disease. However, it was not directly related to the intensity and amount of physical activity, although there is limited evidence that some cardiac biomarkers or coronary atherosclerosis is altered under certain sporting conditions. On the other side, the controversial "extreme exercise hypothesis", based on limited epidemiological or experimental studies, suggests an increased risk of cardiovascular disease at the highest exercise volumes, but no well-conducted epidemiological studies have confirmed this hypothesis [4]. Anyway, excessive exercise can indeed have potentially harmful effects on both physical and mental health. Regarding mental health, a meta-review has suggested that excessive exercise may constitute a behavioural addiction, based on the criteria of the DSM-5, the standard classification of mental disorders used by mental health professionals [5].

With regard to the musculoskeletal system, data on how much sport is too much is limited, especially in adults. However, the following points may be of some interest in understanding whether too much sport can really be too much for the musculoskeletal system:

- Some meta-analyses have assessed the adverse effects observed in randomised controlled trials evaluating the effects of physical activity programmes in older people. Amongst them, one from 93 RCTS highlighted that long-term exercise training (> 1 year) did not influence the risk of dropout due to health problems overall [6]. A recent systematic review showed that serious adverse events were not common in resistance training trials, but the authors also noted that adverse events were not consistently monitored or reported [7]. In addition, a relevant paper has shown that there are sources of bias and heterogeneity in the reporting of adverse events in resistance training trials, which may be the reason why adverse events are not consistently monitored or reported [8]. Anyway, as noted in a study performed in an emergency department, whilst injuries such as fractures can happen during exercise, they can also happen during daily activities [9].

✉ Olivier Bruyère
olivier.bruyere@uliege.be

[1] WHO Collaborating Center for Public Health Aspects of Musculoskeletal Health and Ageing, University of Liège, Liège, Belgium

[2] Physical and Rehabilitation Medicine & Sports Traumatology, FIFA Medical Centre of Excellence, IOC Research Centre for Prevention of Injury and Protection of Athlete Health, FIMS Collaborative Center of Sports Medicine, University and University Hospital of Liège, Liège, Belgium

– There is growing evidence that poor load management (i.e. volume, intensity) is a major risk of injury in athletes, as well documented by the International Olympic Committee [10]. However, data in a more global population are more limited. However, an interesting study combining three cohorts showed that physical activity, ranging from sedentary to elite athlete levels, was non-linearly associated with fracture risk, and the association differed by fracture site [11]. In particular, at an average level of physical activity equivalent to 20–40 min of walking or cycling per day or 2–3 h of exercise per week, exercise may be beneficial in preventing hip fractures, but may increase the risk of distal forearm fractures. However, for forearm fractures, the hypothesis is an increase in the number of injuries rather than a direct effect on bone quality. Another German study showed that 3.1% of adults reported sports injuries in the previous year and that time spent exercising was an independent determinant of injury [12]. The data on specific diseases is also reported in the literature. In the musculoskeletal area, osteoarthritis is the most studied condition. All meta-analyses clearly show that recreational running reduces the incidence of osteoarthritis compared to non-active individuals, but some meta-analyses also suggest that competitive runners may also experience an increased risk, suggesting a U-shaped relationship [13]. However, it is important to note that not all radiographic signs of osteoarthritis lead to symptomatic disease. With regard to quadriceps muscle strain, a systematic review has shown that it is associated with the level of competition and the duration of the match [14]. On the other side, Achilles tendon overuse injury was not associated with the distance of running per week, according to a systematic review published in 2014 but numerous other risk factors have been noted [15]. In another systematic review of 2017, calf muscle strain was not associated with the level of competition [16]. For lower limb bone stress injuries, it has been associated with mileage, number of training cycles, inadequate recovery period, high impact loading, training with fatigued muscles and running pace [17, 18]. In the field of bone disease (and associated stress fractures), the concept of load tolerance is important. Indeed, as nicely reviewed by Hart et al., the anabolic stimulus required to strengthen bone in the long-term temporarily creates structural vulnerability through acute musculoskeletal fatigue in the short term, implying muscle fatigue as a covariate of bone fatigue [19]. However, the principles of bone fatigue, bone micro-damage or muscle fatigue highlight the importance of the gradual increase in physical activity and of incorporating rest periods into sport programmes.
– The "weekend warrior" behaviour, i.e. a person who only exercises at the weekend, is of interest. It was shown, in a recent meta-analysis, that weekend warrior and regular active physical activity patterns confer similar benefits in term of cardiovascular health and mortality [20]. In theory, however, the combination of high-intensity physical activity and relative deconditioning may predispose these weekend warriors to a variety of sports injuries. However, good-quality evidence is scarce. A Canadian retrospective study using a medical centre registry of severely injured adults showed that significantly more subjects were injured over the weekend than during the week, leading the authors to conclude that "the weekend warrior concept may be a validated entity for major trauma" [21]. However, to our knowledge, no well-conducted epidemiological studies are available regarding the incidence of minor musculoskeletal disorders.
– It is well known that patients with anorexia nervosa, a disorder characterized by severe fear of weight gain, food restriction and pathologically low body weight, will experience a decreased bone mineral density and an increased risk of fractures [22]. Interestingly, excessive exercise is a common feature of anorexia nervosa. In female athletes, a reduced rate of bone formation in adolescence, often as a result of eating disorders, hormone deficiency and/or excessive exercise, can be particularly challenging as it predisposes to stress-related bone injury and increases the risk of osteoporosis and fractures with age [23]. A systematic review of four studies showed that both female athletes and non-athletes are prone to low energy availability and subsequent menstrual dysfunction and low bone mineral density or osteoporosis, the famous but unrecognised "female athlete triad", defined as the combination of disordered eating, amenorrhoea and osteoporosis [24]. In connexion with this but in a more global way, a concept that is being used more and more in the scientific literature is the principle of non-functional overtraining leading to the overtraining syndrome, a long-term reduction in performance capacity observed over a period of several months [25]. Also, in recent years, there has been more discussion of relative energy deficiency in sport (RED-S), a complex syndrome caused by low energy availability that leads to impaired physiological function and negatively affects aspects of health and performance [26].

At present, there is a lack of good data to suggest a limit to the amount or intensity of exercise that may be harmful to health. It is clear that the WHO recommendations can be seen as a minimum level of activity. However, it should also be noted that certain sports activities may increase the risk of injury, especially during the activity. Data on the long-term effects of too much sport are very limited. Finally, as overuse muscle strain is the most common complaint amongst previously sedentary older adults following

exercise intervention, new patients who are ready to start exercise should be educated about what to expect and what types of pain or soreness are normal [27, 28].

Acknowledgements The authors would like to thank Professors Robin Daly, Gustavo Duque, Lora Giangregorio and David Scott for the very useful and interesting discussions with them and for the important scientific papers they provided.

Funding No funding was received to assist with the preparation of this manuscript.

Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

Ethical approval Our work is based on a literature search and does not need any ethical approval.

Statement of human and animal rights This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent Not applicable—this work is based on a literature search and does not contain any images.

References

1. Szychowska A, Drygas W (2022) Physical activity as a determinant of successful aging: a narrative review article. Aging Clin Exp Res 34:1209–1214
2. Huang TY et al (2023) Physical activity plays a crucial role in multidomain intervention for frailty prevention. Aging Clin Exp Res 35:1283–1292
3. Oliveira JS et al (2023) Effect of sport on health in people aged 60 years and older: a systematic review with meta-analysis. Br J Sports Med 57:230–236
4. Eijsvogels TMH, Thompson PD, Franklin BA (2018) The "extreme exercise hypothesis": recent findings and cardiovascular health implications. Curr Treat Options Cardiovasc Med 20:84
5. Colledge F et al (2020) Excessive exercise-a meta-review. Front Psychiatr 11:521572
6. García-Hermoso A et al (2020) Safety and effectiveness of long-term exercise interventions in older adults: a systematic review and meta-analysis of randomized controlled trials. Sports Med 50:1095–1106
7. El-Kotob R et al (2020) Resistance training and health in adults: an overview of systematic reviews. Appl Physiol Nutr Metab 45:S165-s179
8. El-Kotob R et al (2022) Researchers' perspectives on adverse event reporting in resistance training trials: a qualitative study. Appl Physiol Nutr Metab 47:893–902
9. Falvey EC et al (2009) Sport and recreation-related injuries and fracture occurrence among emergency department attendees: implications for exercise prescription and injury prevention. Emerg Med J 26:590–595
10. Soligard T et al (2016) How much is too much? (Part 1) International Olympic committee consensus statement on load in sport and risk of injury. Br J Sports Med 50:1030–1041
11. Stattin K et al (2021) Fracture risk across a wide range of physical activity levels, from sedentary individuals to elite athletes. Bone 153:116128
12. Schneider S et al (2006) Sports injuries: population based representative data on incidence, diagnosis, sequelae, and high risk groups. Br J Sports Med 40:334–339
13. Alentorn-Geli E et al (2017) The association of recreational and competitive running with hip and knee osteoarthritis: a systematic review and meta-analysis. J Orthop Sports Phys Ther 47:373–390
14. Pietsch S, Pizzari T (2022) Risk factors for quadriceps muscle strain injuries in sport: a systematic review. J Orthop Sports Phys Ther 52:389–400
15. Lorimer AV, Hume PA (2014) Achilles tendon injury risk factors associated with running. Sports Med 44:1459–1472
16. Green B, Pizzari T (2017) Calf muscle strain injuries in sport: a systematic review of risk factors for injury. Br J Sports Med 51:1189–1194
17. Pegrum J, Crisp T, Padhiar N (2012) Diagnosis and management of bone stress injuries of the lower limb in athletes. BMJ 344:e2511
18. da Rocha Lemos Costa TM et al (2022) Stress fracture. Arch Endocrinol Metab 66:765–773
19. Hart NH et al (2017) Mechanical basis of bone strength: influence of bone material, bone structure and muscle action. J Musculoskelet Neuronal Interact 17:114–139
20. Kunutsor SK, Jae SY, Laukkanen JA (2023) 'Weekend warrior' and regularly active physical activity patterns confer similar cardiovascular and mortality benefits: a systematic meta-analysis. Eur J Prev Cardiol 30:e7–e10
21. Roberts DJ et al (2014) The "weekend warrior": fact or fiction for major trauma? Can J Surg 57:E62–E68
22. Hung C, Muñoz M, Shibli-Rahhal A (2022) Anorexia nervosa and osteoporosis. Calcif Tissue Int 110:562–575
23. MacKnight JM (2017) Osteopenia and osteoporosis in female athletes. Clin Sports Med 36:687–702
24. Skarakis NS et al (2021) Energy deficiency, menstrual disorders, and low bone mineral density in female athletes: a systematic review. Hormones (Athens) 20:439–448
25. Bell L et al (2020) Overreaching and overtraining in strength sports and resistance training: a scoping review. J Sports Sci 38:1897–1912
26. Stellingwerff T et al (2021) Overtraining syndrome (ots) and relative energy deficiency in sport (RED-S): shared pathways, symptoms and complexities. Sports Med 51:2251–2280
27. Giangregorio LM, Ponzano M (2022) Exercise and physical activity in individuals at risk of fracture. Best Pract Res Clin Endocrinol Metab 36:101613
28. Little RM et al (2013) A 12-month incidence of exercise-related injuries in previously sedentary community-dwelling older adults following an exercise intervention. BMJ Open 3:e002831