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Review article

Exercise prescription for the older population: The interactions between physical activity, sedentary time, and adequate nutrition in maintaining musculoskeletal health

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ABSTRACT

Regular physical activity (PA) promotes musculoskeletal health in older adults. However, the majority of older individuals do not meet current PA guidelines and are also highly sedentary. Emerging evidence indicates that large amounts of sedentary time accelerate the loss of skeletal muscle mass (i.e., sarcopenia) and physical function with advancing age. However, current PA recommendations for sedentary time are non-specific (i.e., keep sedentary time to a minimum). Research indicates that physical inactivity and large amounts of sedentary time accelerate sarcopenic muscle loss by inducing skeletal muscle 'anabolic resistance'. These findings suggest a critical interaction between engaging in 'sufficient' levels of PA, minimising sedentary time, and consuming 'adequate' nutrition to promote optimal musculoskeletal health in older adults. However, current PA recommendations do not take into account the important role that nutrition plays in ensuring older adults can maximise the benefits from the PA in which they engage. The aim of this narrative review is: (1) to briefly summarise the evidence used to inform current public health recommendations for PA and sedentary time in older adults; and (2) to discuss the presence of 'anabolic resistance' in older adults, highlighting the importance of regular PA and minimising sedentary behaviour. It is imperative that the synergy between PA, minimising sedentary behaviour and adequate nutrition is integrated into future PA guidelines to promote optimal musculoskeletal health and metabolic responses in the growing ageing population.

Contents

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1. Introduction

Benefits of physical activity (PA) for older adults, particularly in the forms of resistance (e.g., muscular contraction using free-weights) and endurance (e.g., running or cycling) types of exercise are widely recognised. Regular PA has been shown to improve physical function and quality of life [1,2], prevent sarcopenia, frailty and decrease the risk for cognitive decline [3–5], reduce the risks for obesity, coronary heart disease, and type 2 diabetes [6] and is associated with lower rates of all-cause mortality and diagnosis of new diseases [7].

PA guidelines recommend that older adults engage in a minimum of 150 min per week of moderate-to-vigorous intensity PA (MVPA) accumulated in bouts of at least 10 min, in addition to some resistance and flexibility exercises at least two days per week to maintain or improve strength and balance [8–11]. MVPA is typically defined as any form of PA with a metabolic equivalent (MET) of ≥3 METs. Studies that have objectively measured MVPA in community-dwelling older adults indicate that a very small percentage (<5%) of this population meet the current guidelines [12–16], suggesting that these recommendations may not be realistic or attainable for the majority of older adults. For an in-depth overview of accelerometer-derived physical activity levels in older adults, interested readers are referred to a recent systematic review conducted by Sun and colleagues [16].

In addition to low levels of engagement in PA, sedentary behaviour is highly prevalent in older adults, with objective measures indicating that older adults may spend up to 85% of their waking hours being sedentary [12,13,17,18]. Although emerging cross-sectional evidence suggests that increased time spent sedentary is a risk factor for development of chronic diseases, skeletal muscle loss (i.e., sarcopenia), functional disability, and premature mortality independent of physical activity [19–22], the lack of evidence identifying the specific amount of time spent sedentary that increases one's risks for diseases and functional disability has resulted in current recommendations for sedentary time being non-specific (i.e., keep sedentary time to a minimum) [9]. It has been argued that it may be easier to intervene to decrease sedentary time within older adults than increase PA to recommended levels, and emerging cross-sectional and experimental evidence highlights the beneficial effect that breaking up prolonged sedentary time can exert on both physical function and metabolic health [23,24].

Recent evidence suggests the presence of 'anabolic resistance' in older adults, which has been proposed as an important underlying mechanism in the progression of sarcopenia [25,26]. 'Anabolic resistance' refers to the dysregulation of the muscle protein synthetic response to anabolic stimuli (i.e., exercise and/or protein/amino acid-based nutrition). This research suggests a critical interaction between 'sufficient' levels of exercise and 'adequate' nutrition that promotes optimal physical function and metabolic health in older adults. However, current PA recommendations do not take into account the important role that nutrition plays in ensuring older adults can maximise the benefits from the exercise in which they engage.

The aims of this narrative review are to: (i) briefly summarise the evidence used to inform current public health recommendations for PA and sedentary time in older adults; (ii) examine what is currently known about the beneficial effects of PA and reduced sedentary time on musculoskeletal health in older adults; (iii) discuss the presence of 'anabolic resistance' in older adults, highlighting the interactions between PA and nutritional intake in optimising functional and metabolic responses in older adults; and (iv) re-examine the current recommendations for PA and sedentary time in light of the evidence presented.

2. Methods

A narrative review was conducted, drawing upon the international English-language literature published up to April 2016, using the Ovid MEDLINE (1946 to April 2016) and EMBASE (1974 to 10th, April 2016) databases. Search terms were: "human/humans," "old," "elder," "physical activity," "exercise," "physical activity recommendations," "physical activity guidelines," "physical inactivity," "sedentary behaviour," "sedentary time," "musculoskeletal," "health," "protein synthesis," "muscle protein synthesis," "fractional synthetic rate," "muscle protein accrual," "protein balance," "amino acid," "essential amino acid," "dietary protein," "muscle disuse," and "anabolic resistance." Boolean operators "and" and "or" were used to combine search terms. Additional studies were identified through the reference lists of articles (e.g., reviews) from relevant fields of study.

3. Evidence informing current guidelines on physical activity and sedentary behaviour

There is consistently strong evidence indicating a positive association between increased PA and reduced risks for all-cause mortality, cardiovascular disease (CVD), type 2 diabetes, metabolic syndrome, and falls [8,9]. The cross-sectional evidence linking increased sedentary time with elevated risk for all-cause mortality, CVD and metabolic diseases is relatively recent [19–21] and not without controversy [27]. Although the health benefits of regular PA are well documented, the exact amount and type of PA needed to achieve the greatest benefits in older adults is not clear, and how this may differ for various diseases and functional conditions is not known. In addition, most of the evidence used to develop current PA guidelines from various countries [8–11] is based on self-reported data from young and middle-aged adults, is predominantly observational in nature, and as such is subject to limitations such as self-report bias, poor generalizability to older adults, and lack of precision regarding the minimum amount of PA needed to optimise musculoskeletal health and function.

It is important to recognise that older adults are not functionally, cognitively or metabolically homogeneous, and as such the levels of PA needed to optimise musculoskeletal health and function will vary widely, which draws into question the usefulness of a one-size-fits-all set of recommendations for this growing segment of the global population. Current PA guidelines recognise this diversity across the older population, and have included caveats such as: (1) being as physically active as possible when one cannot meet recommendations due to chronic conditions; (2) determining the appropriate level of effort for PA relative to one's level of fitness and functional capacity; and 3) for those with chronic conditions, understanding how their condition may affect their ability to do PA safely [8,9]. However, the predominant message communicated to older adults via public health and clinical settings is that they should be striving to engage in a minimum of 150 min per day of MVPA and engage in strength exercises twice per week.

4. Physical activity, sedentary time, and musculoskeletal health

Evidence generated from experimental studies at the whole-body and cellular level indicates that regular participation in MVPA is fundamental to the preservation of skeletal muscle mass, strength, and physical function with advancing age [28,29]. Though some loss of muscle mass and strength (i.e., sarcopenia) in later life may be inevitable, regular PA provides an effective means of slowing the progression of this debilitating condition [28]. The skeletal muscle adaptive response to regular participation in PA

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