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Exercise snacks and physical fitness in sedentary populations

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ABSTRACT

Physical inactivity remains a pressing global public health concern. Prolonged periods of sedentary behavior have been linked to heightened risks of non-communicable diseases such as cardiovascular diseases and type 2 diabetes, while engaging in any form of physical activity can elicit favorable effects on health. Nevertheless, epidemiological research indicates that people often struggle to meet recommended physical activity guidelines, citing time constraints, lack of exercise equipment, and environmental limitations as common barriers. Exercise snacks represents a time-efficient approach with the potential to improve physical activity levels in sedentary populations, cultivate exercise routines, and enhance the perception of the health benefits associated with physical activity. We review the existing literature on exercise snacks, and examine the effects of exercise snacks on physical function and exercise capacity, while also delving into the potential underlying mechanisms. The objective is to establish a solid theoretical foundation for the application of exercise snacks as a viable strategy for promoting physical activity and enhancing overall health, particularly in vulnerable populations who are unable to exercise routinely.

1. Introduction

Physical activity provides several physiological and psychological benefits. A lack of exercise can lead to various health issues, including obesity, muscle weakness, and decreased cardiorespiratory fitness, which are contributors of various chronic diseases. Current physical activity guidelines recommend that adults complete a minimum of 75 minutes (min) of vigorous-intensity or 150 min of moderate-intensity aerobic exercise per week, accompanied by at least two sessions of muscle-strengthening exercises.[1] Despite the widely acknowledged positive impacts of regular exercise on physiological adaptations, many individuals struggle to meet these guidelines due to time constraints, limitations imposed by ongoing health conditions and limited access to sports facilities.[2,3]

The concept of *"Exercise Snacks"* refers to engaging in multiple brief exercise sessions, each lasting less than or equal to 1 min, spaced at intervals of 1–4 hours (h) throughout the day. This approach allows individuals to seamlessly integrate physical activity into their daily routines without the necessity for dedicated exercise periods or specialized facilities.[4] Exercise snacks can be enjoyed during routine activities or daily tasks, rendering them easy to implement in a variety of settings, including offices, homes, and schools.[5] Importantly, they serve to reverse some of the harms of prolonged periods of sedentary behavior, for example by mitigating the health risks associated with extended periods of sitting (Fig. 1).[6]

In recent years, research on exercise snacks has primarily focused on their effects on cardiovascular health, insulin sensitivity, and muscle strength. It also highlights their potential value as a novel exercise strategy in improving the physical fitness of sedentary individuals. This article aims to review the main findings of these studies, emphasizing that exercise snacks are a time-efficient, effective, and safe form of exercise that can enhance the physical fitness of sedentary populations.

2. Overview of exercise snacks

The term "Exercise Snacks" was first introduced by Howard Hartley in 2007[7] but did not receive much attention until 2014 when it was investigated by in more detail by Francois et al.[8] "Exercise Snacks" is an emerging concept in sports science, which aims to re-evaluate the conventional emphasis on accumulating a weekly total of 150 min of physical exercise. Instead, exercise snacks concentrate on frequent yet shorter-durations exercise sessions throughout the day, such as 1-min stair climbing or 20-second (s) sprints. Recent research demonstrates that regardless of the duration, every engagement in physical activity can positively impact overall physical health. Furthermore, these studies

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Abbreviations

RPE	Rating of perceived exertion
MTEs	Metabolic equivalents
TG	Triglyceride
HIIT	High-intensity interval training
HbA1c	Hemoglobin A1c
GLUT4	Glucose transporter type 4
MAPK	Mitogen-activated protein kinase
AMPK	AMP-activated protein kinase
CaMK II	Calcium/calmodulin-dependent protein kinase type II
LPL	Lipoprotein lipase
VLDL	Very low-density lipoprotein
CRF	Cardiorespiratory fitness
VO_{2max}	Maximal oxygen consumption
VO_{2peak}	Peak oxygen consumption
SIT	Sprint interval training

reveal that when the total time spent on physical activity is held constant, there is no significant disparity in cardiovascular health and other health-related outcomes between prolonged, continuous activity and accumulated, intermittent physical activity.[9] Notably, this concept has garnered support from the recommendations of the World Health Organization on sedentary behavior guidelines. These guidelines have eliminated the previous requirement for adults to engage in continuous physical activity lasting at least 10 min per session.[1] The emergence of the "Exercise Snacks" concept offers a practical and viable approach for individuals who find it challenging to allocate longer periods for exercise or those seeking to seamlessly integrate physical activity into their daily routines.

Exercise snacks can be broadly organized into two categories: vigorous intermittent exercise and moderate intermittent exercise.[10] Vigorous intermittent exercise involves the brief and intense activities such as stair climbing or sprinting, performed safely and rapidly 3–8 times per day, with each bout lasting less than 1 min. This approach is particularly well-suited for adults, especially those grappling with obesity or diabetes.[11,12] On the other hand, moderate intermittent exercise is better suited for older adults, entailing intermittent resistance exercises lasting 10 min per session and conducted twice daily to enhance skeletal muscle mass and strength.[13] During vigorous intermittent exercise snacks, the exercise intensity is approximately 76%–90% of the maximum heart rate, with an average rating of perceived exertion (RPE) value indicating "hard" or "very hard".[8,11,14] However, specific parameters regarding exercise intensity during moderate-intensity intermittent exercise snacks have not been reported. Furthermore, it is important to recognize that these two forms of exercise are not set in stone and can be adjusted flexibly to accommodate individual needs and abilities.

3. Impact of exercise snacks on physical fitness and exercise capacity: possible mechanisms

3.1. Exercise snacks and energy metabolism

3.1.1. Effects of exercise snacks on energy metabolism

Prolonged sedentary behavior is characterized by low energy expenditure, typically requiring approximately 1.5 metabolic equivalents (METs), which is equivalent to the energy expenditure while sitting or lying down.[15] Epidemiological studies indicate that adults spend approximately 55%–60% of their time, engaged in sedentary behaviors, which is an important risk factor for diseases such as cardiovascular diseases and metabolic syndrome.[16,17] For instance, extended sedentary periods decreases insulin requirements for glucose clearance.[18] These findings stress the need for effective interventions to break the spiral of prolonged sedentary behavior and modulate energy metabolism, thereby mitigating the risk of disease development. Physical activity following prolonged sedentary behavior is associated with reduced postprandial blood glucose, insulin, and triglyceride (TG) levels.[19] Breaking sedentary behaviors with brief high-intensity sprint interventions, lasting only 4 s per hour, can significantly reduce plasma TG concentrations and enhance fat oxidation the following day,[20] suggesting that exercise snacks may impact metabolic conditions in sedentary populations.

When individuals accumulate approximately 8 000 daily steps and engage in 1 h of running or high-intensity interval training (HIIT) exercise, postprandial plasma TG levels are reduced while fat oxidation is increase on the next day, a phenomenon known as the 'exercise response.' Conversely, individuals accumulating only 2 000–4 000 daily steps and engaging in 1 h of running exercise do not experience reductions in postprandial plasma TG levels or increases in fat oxidation on the following day, a phenomenon referred to as 'exercise resistance'.[20,21] Therefore, prolonged sedentary behavior appears to be an obstacle to improving fat metabolism after 1 h running exercise. Remarkably, this

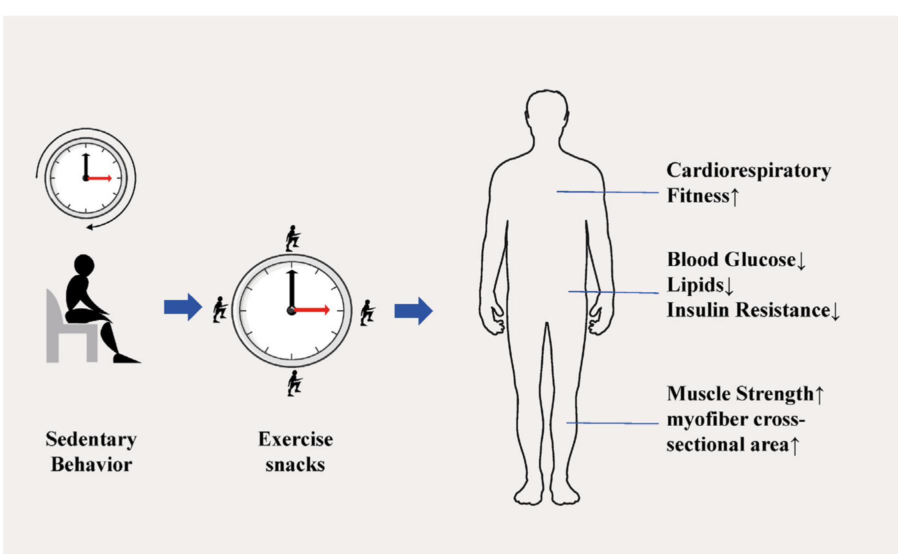

Fig. 1. Schematic representation of improved function produced by exercise snacks in sedentary individuals.

'exercise resistance' can be overcome by accumulating 8 500 daily steps by walking or by interrupting 8 h of sedentary behavior with hourly sprint exercises.[22] Their findings were confirmed independently by Wolfe et al., who employed an experimental design involving an 8 h sedentary control group and a sprint exercise group performing 5 bouts of 4 s bicycle sprints every hour for 8 h.[20] The exercise group exhibited a 43% increase in fat oxidation rate and a 31% reduction in plasma TG levels after consuming a high-fat meal the next morning. It is worth noting that although the trial involved 20 s of exercise per hour, the actual exercise duration was approximately 5 min per hour, as each 4 s sprint was followed by a 45 s rest period.[20] A later study also reported that hourly stair-climbing exercise snacks reduced postprandial free fatty acid concentrations.[6]

Physical inactivity disrupts metabolic function, marked by elevated postprandial blood glucose and abnormal insulin responses. Concurrently, these aberrant post-meal blood glucose and insulin surges have been identified as pivotal factors in the genesis and progression of type 2 diabetes and its many complications.[23] Interventions aimed at breaking the sedentary cycle are positively correlated with reduced cardiovascular events. For example, engaging in short bouts of moderate to high-intensity physical activity mitigates the post-meal surges in blood glucose and insulin levels,[24] while brief periods of walking every 30 min to interrupt prolonged periods of sitting also reduces postprandial blood glucose and insulin levels; these approaches hold appeal for individuals grappling with obesity or insulin resistance.[25,26]

Engaging in HIIT also has benefits in the management of blood glucose levels in type 2 diabetes.[27] HIIT involves brief yet intense exercise bouts, stimulating a myriad of physiological systems. Given the resemblance between exercise snacks and HIIT, some studies explored whether exercise snacks could also modulate blood glucose concentrations in people with diabetes. For example, Francois et al. randomly assigned nine participants to a cross-over exercise intervention, with the exercise snacks group engaging in 6 bouts of 1 min uphill walking (performed at 90% of their maximum heart rate) before meals, and reported that pre-meal exercise snacks reduced post-breakfast and post-dinner blood glucose concentrations within 3 h, with these benefits persisting for up to 24 h post-exercise.[8] These results suggest that exercise snacks attenuate the postprandial surges in blood glucose in insulin-resistant individuals, potentially diminishing their susceptibility to diabetes. A study by Hasan et al. evaluated the impact of exercise snacks in sedentary adolescents with type 1 diabetes; however this intervention did not alter either blood glucose or hemoglobin A1c (HbA1c) levels, although the daily engagement in exercise snacks reduced insulin requirements, signaling the potential for exercise snacks to enhance insulin sensitivity.[28] In addition, exercise snacks also reduced body fat, particularly in the trunk region, an area known to be an important contributing to insulin resistance (Table 1).[29]

3.1.2. Possible mechanisms for the improvement of energy metabolism by exercise snacks

Skeletal muscle is the largest glycogen reservoir in the human body and plays an important role in insulin-mediated regulation of blood glucose concentrations.[30] However, exercise enhances insulin sensitivity in skeletal muscle (leading to improved blood glucose control) through complex mechanisms.[31] Recent studies have demonstrated that brief, intense bouts of exercise can markedly increase muscle glycogen consumption and activate skeletal muscle insulin-related signaling pathways, leading to enhanced insulin sensitivity.[32] Additionally, the decrease in muscle glycogen by 20%–30% triggered by such short, intense activities is likely to contribute to reductions in blood sugar levels and insulin resistance.[33] To meet these outcomes, it's essential for participants to sustain a high-intensity state throughout the exercise, a requirement that is fully in line with the principles of exercise snacks.[12] Furthermore, short-duration, high-intensity exercise activates intracellular signaling pathways associated with glucose transporter type 4 (GLUT4) translocation, including mitogen-activated protein kinase (MAPK), AMP-activated protein kinase (AMPK), and calcium/calmodulin-dependent protein kinase type II (CaMK II), all of which contribute to the transient hypoglycemic effects of acute intense interval exercise (Fig. 2).[34] In addition to these molecular signaling pathways, the upsurge in skeletal muscle microvascular density due to exercise also aids in glucose transport (See Table 2).[35]

Alterations in glucose and insulin levels typically occur on the day of the exercise or within a limited period post-meals, while changes in blood lipids are of commonly observed on the subsequent day.[36] This phenomenon correlates with lipoprotein lipase (LPL) activity, a primary mechanism responsible for the postprandial reduction in plasma TG, and which typically reaches its zenith approximately 8 h after exercise.[37] In actuality, prolonged sedentary behavior inhibit LPL activity, while a single bout of rigorous exercise increases LPL activity by augmenting TG clearance.[38] Furthermore, the hydrolysis of triglycerides in very low-density lipoprotein (VLDL) reduces the rate of VLDL-TG secretion from the liver in sedentary men, resulting in a reduction in intra-organ TG content (Fig. 2).[39–41] Gabriel et al. have proposed that LPL activity might be contingent on skeletal muscle fiber type, while the swift recruitment of fibers during short-duration, high-intensity physical activity could be a contributing factor to heightened LPL expression and hastened TG clearance.[42]

In summary, the potential mechanisms underlying the impact of exercise snacks on energy metabolism involve adaptive changes in skeletal muscle which are closely related to muscular responses observed during high-intensity exercise (Table 1).

Table 1
Effects of exercise snacks on physical fitness and exercise performance.

Aspects	Indicators	Possible Mechanisms	References
Increased Energy Metabolism	↓Blood glucose	↑GLUT4 translocation; ↑Skeletal muscle microvascular density	34, 35
	↓Triglycerides	↑LPL activity; ↓VLDL concentration; ↑Recruitment of fast muscle fibers	39, 40, 42
Increased Aerobic Capacity	↑Peak oxygen consumption ↑Peak power output	↑Blood flow; ↑Skeletal muscle oxygen uptake capacity	4, 48
Increased Muscle Strength	↑Maximum leg press strength ↑Muscle cross-sectional area	↑Muscle fiber satellite cells; ↑Synthesis of myofibrillar proteins; ↑Conduction velocity of muscle fibers; ↑AMPK and PPARγ/PGC1-α signaling pathways	5, 58, 59, 60

Abbreviations: GLUT4, Glucose transporter type 4; LPL, Lipoprotein lipase; VLDL, very low-density lipoprotein; AMPK, AMP-activated protein kinase; PPARγ/PGC1-α, Peroxisome proliferator-activated receptor gamma coactivator 1-alpha.

Table 2
Comparing different exercise modalities.

Exercise Modalities	Exercise Duration	Exercise Environment
Aerobic Exercise	Longer (30–60 min)	Specific exercise Setting/Equipment (e.g., sports field, treadmills)
Resistance Training	Longer	Specific Exercise Setting/Equipment (e.g., barbells, dumbbells)
HIIT	Moderate	Specific Exercise Setting/Equipment (e.g., yoga mat, resistance bands)
Exercise Snacks	Very Short (< 1 min)	No Specific Exercise Setting/Equipment

Abbreviations: HIIT, High-intensity interval training.

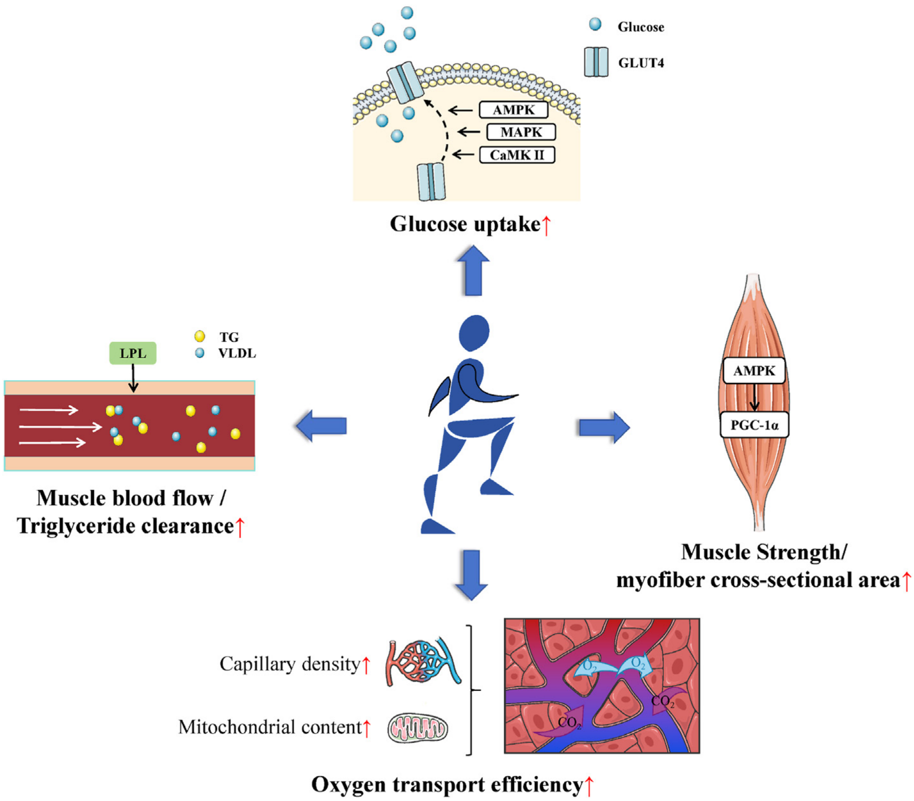

Fig. 2. The potential mechanisms by which exercise snacks improve physical fitness. Exercise snacks have the ability to lower blood glucose and accelerate fatty acid oxidation. Exercise regulates the translocation of glucose transporter type 4 (GLUT4) through AMP-activated protein kinase (AMPK), mitogen-activated protein kinase (MAPK), and calcium/calmodulin-dependent protein kinase type II (CaMK II), speeding up the absorption of glucose by skeletal muscles, thereby improving insulin sensitivity and lowering blood glucose. Additionally, exercise snacks can increase the level of lipoprotein lipase (LPL) in the serum. The elevation of LPL can enhance the breakdown of very low-density lipoprotein-TG (VLDL-TG) in the body, accelerating the clearance of TG. High-intensity exercise snacks increase the density of capillaries and the content of mitochondria in the body, leading to an increased rate of gas exchange in skeletal muscles and ultimately resulting in an increased peak oxygen consumption (VO_{2peak}). Lastly, exercise snacks can increase muscle strength and muscle cross-sectional area, possibly due to the regulation by the AMPK/PGC-1α signaling pathway.

3.2. *Exercise snacks and aerobic capacity*

3.2.1. *Effects of exercise snacks on aerobic capacity*

Cardiorespiratory fitness (CRF) describes the maximum volume of oxygen absorbed, transported, and utilized in the bloodstream during intense physical activity,[43] and is an indicator of an individual's aerobic capacity, commonly quantified by maximal oxygen consumption (VO_{2max}) or peak oxygen consumption (VO_{2peak}). There is a robust inverse correlation between CRF and mortality from cardiovascular diseases, surpassing the well-known positive associations of conventional risk factors such as smoking and type 2 diabetes.[44] CRF can be improved by structured exercise training or regular physical activity, as shown in recent studies on the potential ability of exercise snacks to enhance CRF in sedentary populations. While the corpus of research on this topic remains somewhat limited, these studies highlight the potential of exercise snacks as an additional strategy to improve cardiovascular health in sedentary adults.[5]

A pioneering study by Jenkins et al. used exercise snacks intervention to monitor changes in cardiorespiratory fitness in sedentary individuals.[11] This study divided sedentary participants into two cohorts: a control group maintaining their pre-existing activity levels and an exercise group engaging in a program of exercise snacks. The exercise group partook in three daily bouts of exercise snack sessions, each separated by intervals lasting 1–4 h. Prior to engaging in exercise, participants completed a warm-up routine comprising 10 jumping jacks, 10 squats, and 10 lateral lunges. Following this warm-up, participants underwent 1-min of low-intensity walking, then ascending as many as 60 flights of stairs in a three-story building. After the 6-week intervention period, the exercise group improved their VO_{2peak} (by 5%) and peak power output (by 12%). These findings were supported by another study in which 12 sedentary subjects who performed 3 sets of 20-s all-out sprint cycling sessions, spaced 1–4 h apart, over a 6-week period had improvements in VO_{2peak} (by 4%) and peak power output (by 15 W).[14] Remarkably, the benefits derived from a conventional sprint interval training (SIT) session did not differ from the exercise snacks group, suggesting that the effectiveness of multiple dispersed exercise sessions throughout the day may be sustained.[5] Multiple studies indicate that exercise intensity may be closely linked to CRF.[45,46] Compared to moderate intensity, high-intensity exercise methods might more effectively stimulate vascular function, thereby improving the CRF of the exercising population. Both of the aforementioned trials met the criteria for vigorous exercise snacks (~85% of maximum heart rate), and there was no difference in CRF indicators between the SIT and exercise snack groups. This suggests that high-intensity exercise snacks could be one of the reasons for improvements in CRF.

In summary, vigorous exercise snacks regimens have the potential to enhance CRF and exercise capacity in infrequently active adult populations. Although they may not strictly adhere to established physical activity guidelines, the accrued benefits of integrating exercise snacks into a weekly exercise regimen improves overall health.

3.2.2. *Possible mechanisms of enhanced aerobic capacity by exercise snacks*

The physiological mechanisms underlying the changes in VO_{2peak} following short-term high-intensity exercise remain unclear, and may be associated with the nature and duration of the exercise intervention.[12] Engaging in low-intensity exercise for 150 min per week for 24 weeks may not yield notable improvements in cardiorespiratory fitness for adults, whereas low-volume, high-intensity exercise interventions improves peak oxygen consumption in sedentary individuals.[47] Furthermore, some studies suggest that the augmentation of peak oxygen consumption by sprint interval exercise may be attributed to the peripheral muscle's capacity for oxygen uptake, a portion of which is facilitated by increased blood flow.[48]

Prolonged periods of sedentary behavior, characterized by extended periods of sitting, often leads to vascular dysfunction, and reduced peripheral blood flow,[49] while there is a 32% increase in blood flow velocity in the femoral artery of individuals engaging in daily fragmented stair climbing exercise compared to their sedentary counterparts.[4] The augmentation of blood flow aligns with exercise intensity implies that improvements in peak oxygen consumption with high-intensity exercise snacks may be attributed to greater peripheral blood flow, which in turn facilitates the delivery of oxygen to the skeletal muscles (Table 1).[45,50] The mechanism behind this phenomenon may be related to an increase in capillary density and mitochondrial content.[51] Furthermore, the increase in VO_{2max} after high-intensity exercise is largely due to an increase in red blood cell volume and stroke volume.[52] However, it is challenging to closely link exercise intensity with cardiovascular adaptation, primarily due to factors such as the subjects involved in the study, the research plan, and the training methods used during the experimental process.[53]

3.3. Exercise snacks and muscle strength

3.3.1. Effects of exercise snacks on muscle strength

Prolonged periods of sedentary behavior are associated with decreases in skeletal muscle mass, which is particularly evident when total daily sitting time exceeds 360 min; nevertheless, regular physical exercise improves skeletal muscle mass.[54] While consistent physical activity can improve muscle mass, older adults often face challenges due to lower physical fitness and several risk factors associated with chronic diseases.[13] These challenges can potentially hinder their participation in activities tailored for adults, underscoring the urgency of identifying exercise strategies suitable for older adults aimed at enhancing their muscle function.

A growing body of evidence suggests that compared to traditional training modalities, low-dose exercise patterns (i.e., high volume, low load), particularly when conducted without exercise equipment, enhances muscle strength in older adults. This approach help to mitigates various barriers to exercise participation by the elderly, while simultaneously enhancing the flexibility and feasibility of exercise programs.[55]

A study of the suitability of a 4-week resistance-based exercise snacks program (administered once, twice, or thrice daily; compliance rate of 87%) in older adults that included balance tests, sit-to-stand tests, and 30 s sit-to-stand tests, reported that 75% of the participants in the exercise group found the exercise snacks regimen acceptable, indicating its feasibility among older adults.[56] However, there were no significant changes in the physical function of older adults after the 4-week exercise snacks program, indicating the need for further studies of optimal conditions for the use of resistance-based exercise snacks to improve physical function in older adults.

In contrast, another study examined the effects of exercise snacks in older participants performing 5 sets of 1 min exercise interventions in the morning and evening (with a 1 min intervals between exercises).[13] The exercise-snacks included 1 min sit-to-stand tests, seated knee extensions of alternating legs, standing knee bends of alternating legs, marching on the spot, and standing calf raises. The exercise group had a 31% improvement in the 1 min sit-to-stand test, along with a 6% increase in maximum leg lift strength and a 2% increase in thigh muscle cross-sectional area, indicating that 4 weeks of resistance-based exercise snacks performed twice daily can enhance leg muscle strength and increase muscle size in older adults. Additionally, there was no significant change in the RPE values of the subjects before and after exercise, indicating that resistance exercise snacks, as compared to traditional resistance exercises, have a lower intensity. However, this does not affect their effectiveness in improving muscle mass. While the underlying mechanisms of these changes remain unclear, it is evident that high-frequency, short-duration exercise snacks can improve exercise feasibility in older adults, with the added benefit of ensuring their safe participation in physical activities.

3.3.2. Possible mechanisms of enhanced muscle strength by exercise snacks

Resistance exercise is regarded as the “gold standard” for promoting muscle mass and strength. It involves repetitive contractions against external resistance, which increases myofiber satellite cell populations and the synthesis of myofibrillar proteins. This, in turn, leads to an enlargement of myofiber cross-sectional area and increased muscle strength.[57] However, the specific mechanisms underlying muscle hypertrophy and strength gains resulting from resistance-based exercise snacks patterns remain unclear. Some studies suggest that short-duration, high-intensity exercise differs in its neuromuscular characteristics from traditional aerobic exercise, as short-duration, high-intensity exercise increase conduction velocity of muscle fibers more effectively. Furthermore, as exercise intensity escalates, the activation of type II muscle fibers is heightened, leading to a more pronounced myofiber hypertrophy.[58–60] However, it must be noted that while brief high-intensity exercise is very important for stimulating muscle growth, there is still a lack of understanding and research regarding the frequency of such activities. This lack of knowledge might lead to a potential “threshold” in assessing the volume of resistance exercise.[61] Therefore, in resistance exercise, giving each skeletal muscle excessive repetitions and sets, thereby increasing the total volume of exercise, might not provide additional benefits to the body.[55] In this context, exercise snacks, characterized by high frequency and low volume, could be an effective alternative to traditional resistance exercises for stimulating physiological adaptations in the body. Thus, the improvement in muscle mass from resistance exercise snacks might benefit from the characteristics of this training method, namely, its higher frequency and the cumulative effect of training volume on the body.

It is well-known that in response to resistance exercise, skeletal muscle protein synthesis significantly increases and this response can persist for a long duration, possibly up to 24 h post-exercise. Subsequently, the magnitude of protein synthesis begins to decrease.[62] Current physical activity guidelines recommend that adults engage in resistance exercises at least twice a week.[1] However, with a longer interval between these bi-weekly sessions, it is hypothesized that more frequent repetitions of resistance exercise could lead to more prolonged periods of net protein accretion in skeletal muscles.[61] Resistance exercise snacks, typically performed once or twice daily, may help maintain this increase in muscle protein. Although increasing the frequency of exercise may enhance skeletal muscle protein synthesis, due to the body's adaptability, it might be necessary to further increase the frequency to achieve greater muscle growth. Whether this hypothesis applies to older adults requires further research.

Further research is needed to explore the effects of exercise snacks on muscle morphology and function, particularly in sedentary adult populations. Similar to other forms of short-duration, high-intensity exercise, despite its brevity, exercise snacks may involve the activation of classic intracellular signaling pathways (such as AMPK) and transcriptional regulator factors (such as peroxisome proliferator-activated receptor gamma coactivator 1-alpha) involved in muscle oxidative remodeling, as is the case forms of short-duration, high-intensity exercise (Table 1) (Fig. 2).[5,63]

4. Comparing exercise snacks to traditional exercise

Traditional exercise interventions typically involve sustained aerobic and resistance training, which often is impractical for individuals facing health issues or time constraints. Approximately 50% of individuals tend to discontinue exercise programs within six months due to time limitations, motivational levels, and access to exercise equipment.[64] However, ‘lack of time’ consistently emerges as a primary reason for reduced exercise participation and volume.[10]

HIIT is a convenient and effective alternative approach for sustaining physical activity, with a demonstrated ability to enhance cardiovascular health, leading to health benefits that surpasses gained from traditional aerobic exercise.[65] It is important to recognize that HIIT necessitates specific free time and access to specialized exercise facilities, and that adherence to standard HIIT routines can be demanding, and suboptimal intensity levels could compromise its effectiveness. Therefore, a key distinction between exercise snacks and HIIT sessions appears to be that exercise snacks can be performed more repetitively or frequently throughout the day, without the need for any equipment.

In contrast, exercise snacks involve shorter, more frequent bouts of physical activity dispersed throughout the day. This approach offers a pragmatic strategy for augmenting overall physical activity while simultaneously reducing sedentary behavior.[66] To evaluate the viability of exercise snacks regimens, a study that spanned 12 weeks involving 15 older adults aged between 60 and 89 years (all of whom had at least one chronic condition) reported that the flexibility of exercise snacks (consisting of 2–4 brief bouts of physical activity, each lasting no more than 10 min per day) was a compelling feature as it seamlessly integrated into their daily routines due to its manageable time commitment. Additionally, participants reported experiencing gains in strength, flexibility, and balance, which served as motivational factors for sustained engagement in the exercise snacks program.[66]

5. Conclusion and remaining issues

In comparison to traditional forms of exercise, exercise snacks is a viable, time-efficient, and convenient strategy that lead to improvement in cardiovascular fitness, metabolic capacity, and muscular function in sedentary individuals. The mechanisms underlying the benefits of exercise snacks on physical function and exercise capacity are likely related to its short duration and high intensity, allowing for the rapid mobilization of various organ systems that fosters enhanced utilization of oxygen and glucose by skeletal muscles, promotes muscle protein synthesis, and augments muscle fiber conduction velocity.

However, we must acknowledge that there are still some unresolved issues with exercise snacks. Research on exercise snacks interventions has predominantly been conducted in controlled environments, such as laboratories or homes. However, there remains a dearth of data from communal settings such as educational institutions, retirement homes for the elderly and workplaces where sedentary populations typically gather. Secondly, the concept of exercise snacks lacks a universally accepted and standardized definition. Given the parallels between exercise snacks and other brief, high-intensity exercise modalities, future efforts should concentrate on establishing criteria based on time and intensity factors. This will serve to effectively differentiate exercise snacks from other exercise forms. Finally, while an abundance of studies have attested to the efficacy of exercise snacks in augmenting physical function and exercise capacity, current investigations primarily operate at the macroscopic level. Regrettably, there exists a paucity of research delving into molecular mechanisms that underlie adaptive changes in physical function resulting from exercise snacks.

Submission statement

All authors have read and agree with manuscript content. The manuscript has not been published and is not under consideration for publication elsewhere.

Authors' contributions

Tutu Wang: Writing – original draft, Visualization, Resources, Methodology, Data curation. **Ismail Laher:** Writing – review & editing, Validation. **Shunchang Li:** Writing – review & editing, Supervision, Project administration, Conceptualization.

Conflict of interest

Ismail Laher and Shunchang Li are editorial board members for Sports Medicine and Health Science and were not in the editorial review or the decision to publish this article. Otherwise the authors have no conflicts of interest to declare.

Acknowledge Statement

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