Chapter

How to Reduce Sedentary Behavior at All Life Domains

Olga López Torres, Pablo Lobo, Valeria Baigún and Gabriela F. De Roia

Abstract

Lifestyle has changed in the last century increasingly promoting sedentary behaviors. Prolonged sitting time is related to increased all-cause mortality risk. Therefore, scientific research aimed at understanding the effects of sitting on health has increased to find effective interventions that can be carried out in life domains (study, work, transport, and free time). The interaction between physical activity and sitting time plays a key role in the development of strategies to promote physical activity practice and reduce sedentary behavior. Accepting that the modern societies incite to spend long periods seated, the aim seems to find a balance between all the areas during the 24 h of the day. Maintaining sleep time, reducing screen leisure time to 3 h/day, and breaking prolonged sedentary time for 2–3 min every 30 min-1 h of sitting, as well as reaching the physical activity recommendation may help counteract the potential negative effect of too much sitting time. Governments must provide active free time options to promote active leisure time and help reduce screen time. At workplaces, managers and companies should encourage sitting breaks and work standing options, and for the special population such as children or older adults, new strategies must be considered to reduce sitting time.

Keywords: sitting time, exercise, older adults, children, work time, leisure time, sedentary breaks

1. Introduction

Lifestyle has changed over the world in the past decades. The industrialization process and technological advances have simplified the physical work of human beings and changed the lifestyle of the last generations. Not that long ago, most of the jobs required physical activity and some energy expenditure. Nowadays the percentage of work sectors demanding high levels of physical activity has reduced drastically. This new reality derives in many people forced to spend at more than 8 h/day sitting and having difficulties to reach the physical activity recommendations [1]. Sedentary lifestyles have become a significant public health issue spreading worldwide, although there is evidence of being linked to a range of chronic health conditions [2]. Extended periods of inactivity can produce metabolic dysfunction and impair blood sugar regulation [3], elevate blood pressure [4], and make it difficult to use fat as a metabolic substrate, as well as increase the risk of early death regardless of physical activity levels [5]. Therefore, it seems crucial to find strategies that can be applied in all life domains to be able to reduce sedentary behavior, as well as

to increase physical activity. Including regular and well-structured sedentary breaks during long sitting periods could help reduce the negative effects of a sedentary lifestyle.

This chapter aimed, firstly, to provide scientific evidence of the need to reduce sedentary behaviors as well as to include regularly sedentary breaks. Secondly, to show some possibilities and examples of how to break sedentarism in daily life. We believe that introducing these practices in workspaces, schools, leisure time, and in the daily activities of older adults might help control the negative effects derived from sedentary lifestyles.

2. Sedentary behavior

2.1 Evolution of lifestyle and the concept of sedentary behavior

Historically, exercise physiologists have studied sedentary lifestyle as the opposite of physical activity. The terms that have been used for research in this area have been confusing, which makes it difficult to compare clinical trials. Already in the 1950s, Morris et al. [6] concluded that sedentary work increased cardiovascular risk compared to those who worked more physically active. That study, among others, resulted in a strong area of research focused, for over 60 years, on quantifying the level of physical activity necessary to reduce morbidity and mortality [6]. These investigations provided recommendations on physical activity and the implementation of public policies to promote physical activity practice.

Despite the efforts, a high percentage of the population (mostly from countries that suffered rapid urbanization and industrialization) do no reach the physical activity recommendations and the tendency is that this number increases [1] Office works, school, screen games, technology, passive transportation and sedentary leisure time have had a strong impact on reducing the opportunities to perform physical activity at the same time that promote opportunities for sedentary behavior in all the life domains.

For the past two decades, the number of studies focused on sedentary behavior has grown exponentially, and physical activity and sedentary behavior can be considered as an independent research field. The term sedentary behavior comes from Latin “sedere” which means “to sit”. But not only the “position” determines what is currently conceived as sedentary behavior. Sedentary behavior is defined as any waking behavior characterized by the expenditure of 1.5 metabolic equivalents of task (MET)s or less of energy while in a sitting, reclining, or lying posture [7]. Sedentary behavior, like physical activity, can be found in all life domains (work, study, transport, and free time). Although research in this field has increased notably in the last decade, there is still confusion in the terminology and the scientific community has not reached a consensus in some terms and concepts yet. Many definitions of sedentary behavior can be found in the literature but some common concepts are repeated, such as low energy expenditure, mostly under 1.5 METs, activities performed in sitting, lying or reclining position and while the person is awake [7]. Besides, some other concepts associated with sedentary behavior have aroused the interest of the scientific community. Sedentary bouts, breaks of sitting, sedentarism, sedentary lifestyle vs. inactivity, among others, are related terms that could help deeply understand this problem.

Sedentary Behavior Concept has suffer an evolution over the years. Although the distinction between sedentarism and physical inactivity (not meeting worldwide recommendations for physical activity) has already been settled [7], it is still common to find some confusion in terms such as sedentary time, sitting time, screen

time and stationary time; which, although in some cases are overlapping concepts, refer to different behaviors [7]. Because they refer to different aspects of behavior (position, movement, effort and the use of digital implements), these traits can be blended in different ways, so that some criteria are met but others are not. For example, one can be seated but doing physical activity (cycloergometer), so it's not a sedentary behavior; one could be stationary, but not sitting (e.g., waiting in line); one may be in sedentary behavior, but not sitting (instead lying down watching TV), which in turn is independent of screen usage (reading a book); among other examples.

2.2 Using bed rest models

Studies on bed rest [8–13] provided useful information on the consequences of inactivity and low energy expenditure for long periods. Thanks to these studies, a lot is known about the effects of prolonged inactivity in metabolism and organ systems. Different studies focused on the effects of bed rest on metabolic function, found peripheral insulin resistance in skeletal muscle and adipose tissue, hepatic insulin resistance and a dyslipidemia [10], as well as a decline in function, muscle mass, and muscle strength [12] and a reduction in cardiorespiratory capacity after one-week bed rest [13]. In regards to the musculoskeletal structure, inactivity produces loss of strength and endurance, contractures, changes in soft tissues, disuse osteoporosis, sarcopenia, and degenerative joint disease [8]. At the cardiovascular level, the consequences can be postural hypotension, cardiac dysfunction, and thrombotic events [13]. Additionally, bed rest can lead to impaired respiratory, renal, gastrointestinal, and nervous system levels [9]. Outside hospitalization or illness, free-living healthy adults rarely spend these amounts of bed rest. Nevertheless, technological and social factors have made prolonged sitting time a common practice in all life domains (work, domestic life, and leisure time).

2.3 Quantifying sedentary behavior

Measuring physical activity and sitting time is complex. Research has been aimed at improving the quality of the data through the objective measurement of sedentary behavior using accelerometry, observing that the self-report measurement underestimates the daily time of sedentary behavior concerning the objective measurement.

Researchers have focused on developing devices to be able to objectively quantify physical activity. In the past decades, many studies using accelerometers have been carried out. A multi-country study (USA, Brazil, UK, Denmark, the Czech Republic, and Hong Kong) using accelerometry found that the average sedentary time per day was 513 min/day, or 8.55 h/day [14]. Sedentary time was estimated to be responsible for 3.8% of all-cause mortality in adults according to a meta-analysis pooling data across 54 countries [15]. The United States Physical Activity Guidelines Advisory Committee (PAGAC) [16] recently comprehensively reviewed the scientific evidence, linking sedentary behavior with specific physical health indicators in adults and older adults, including mortality, cardiovascular disease, type 2 diabetes, cancer, and obesity. Moreover, high levels of sedentary behavior are also negative associated with cognitive function, depression, function and disability, physical activity levels, and health-related quality of life [17]. In contrast, little evidence has demonstrated the relationship between sedentary behavior and musculoskeletal pain, accidents or injuries, fatigue, sleep, or work productivity [18]. Ku et al. [19] published in 2018 a meta-regression analysis involving more than 1 million participants in which the cut-off points of daily sedentary time that were related

to all-cause mortality in adults were established for data measured objectively and self-reported [19]. According to the results of the study, the method of measuring sitting time significantly moderated the association between daily sitting time and mortality risk. The cut-off of daily sitting time in studies with self-report data was 7 h/day in comparison with 9 h/day for those with data measured by devices.

2.4 Sedentary behavior VS physical activity

It is accepted that exercise is an effective strategy for reducing key cardiovascular risks [20]. Nevertheless, it is unclear if the benefits can be modified by a sedentary lifestyle. Therefore, it is important to clearly define different concepts such as physical activity/inactivity or sedentary behavior, as their physiological consequences on health are different. While physical activity/inactivity is referred to whether or not a person reaches the physical activity recommendations, a person is considered as sedentary if he/she spends long periods of the day in sedentary behavior. While for the first one (cut-off points for being physically active) there is enough evidence to determine the recommendations (150 minutes of moderate physical activity or 75 minutes of vigorous physical activity or an equivalent metabolic combination between both, plus 2–3 days/week of resistance training) [21], for the second one (cut-off points for being sedentary) there are still no recommendations, since studies have found inconclusive results.

That means that a person can meet the physical activity guidelines and still be considered sedentary. Sedentary behavior might produce harmful effects on health independently of physical activity level, but when both are combined, the results seem to change (combined joint association). In other words, high levels of sedentary behavior combined with low levels of physical activity increase the risk of death by 46% [18]. On the contrary, some studies have shown that high levels of physical activity can counteract or reduce the risk of death caused by prolonged sedentary behavior [22]. Similar results were obtained in cancer patients, where in the most active patients no relationship was observed between sedentary behavior and cancer mortality, while for those less active the risk of death increased [23].

Using the concepts of sedentary and/or physically active person, we can describe four possible combinations:

A. **The sedentary inactive:** Those who do not meet the physical activity recommendations and also spend long periods of the day sitting.

B. **The non-sedentary inactive:** Those who do not meet the physical activity recommendations but do not spend long periods of the day sitting.

C. **The sedentary active:** Those who reach the physical activity recommendation but spend long periods of the day sitting.

D. **The non-sedentary active:** Those who reach the physical activity recommendations and also do not spend long periods of the day sitting.

Figure 1 represents graphically these possibilities.

The health implication for possibilities A and D are clear. Classification A has a negative influence on health and is negatively associated with all-cause mortality and D is positively associated with better health markers. What is not fully clear yet, are the implications of classifications B and C. Can one the variables counteract the negative effect of too much of the other one? Or, are the positive effects of one variable suppressed by the other one?

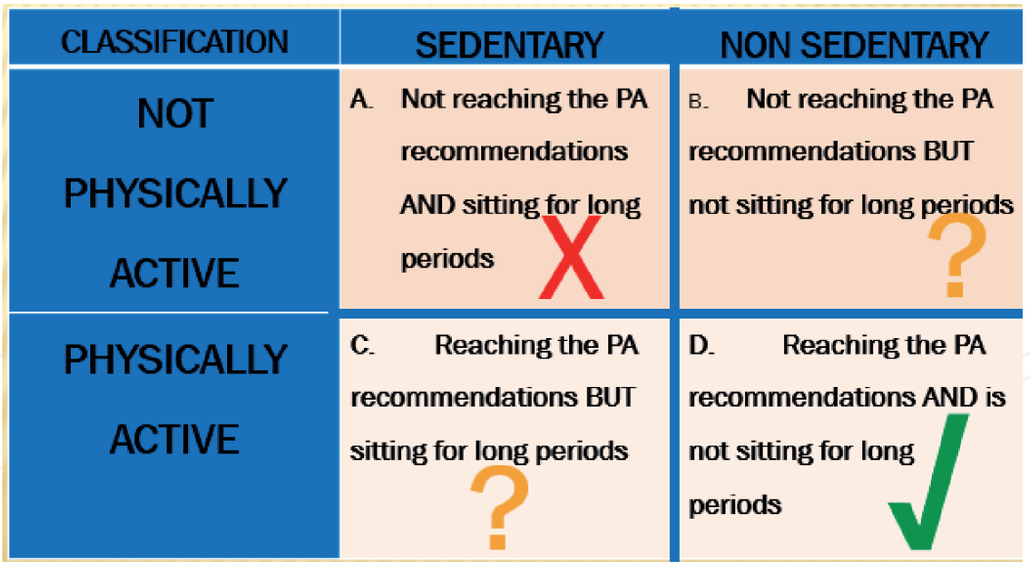

Figure 1.
Person's classification according to sedentary behavior and physical activity practice. (A) Sedentary inactive, (B) non-sedentay inactive, (C) sedentary active, (D) non-sedentary active.

As mentioned before, some studies found that high levels of physical activity might attenuate the increased risk of some illness or death associated with high sitting times [22]. Notwithstanding, there is still some uncertainty in the characteristics of the specific dose–response curves, which makes it difficult to determine specific quantitative public health recommendations [24]. As sedentary lifestyle in western societies does not tend to reduce, new strategies might be the solution. Some degree of sedentary lifestyle might be beneficial for health so that it helps to rest and recover. On the contrary, excessive sitting time may become a risk factor. Scientific evidence has not found an increase in the risk of death from any cause in people with a total sitting time between 4–8 hours/day when compared to those who remain seated for less than 4 hours. Nevertheless, the risk increases by 15% when sitting time rises to 8–11 hours/day, and by 40% with sitting times higher than 11 hours/day [25]. Contrary, some other studies found a dose–response relationship for every 1-hour increase in sitting time in intervals between 0–3, >3–7, and > 7 h/day total sitting and all-cause mortality. This model estimated a 34% higher mortality risk for adults sitting 10 h/day, after taking physical activity into account, although the risk increased staggered [26], similar to other studies that observed statistically significantly higher risk of death with sedentary times of 9.5 h/day or more [23].

This situation has put the focus on the double challenge of increasing levels of physical activity and reducing sedentary behavior. Many countries have developed strategies to promote changes in the population. As an example, the Canadian government created the Canadian 24-Hour Movement Guidelines for Adults (https://csepguidelines.ca/). It recommends that adults between 18–64 years must limit sedentary time to 8 hours/day or less, including no more than 3 hours/day of recreation screen time and breaking long periods of sitting as often as possible.

2.5 Sedentary breaks: effectivity of the different types according to scientific evidence

As it has been mentioned before, modern lifestyles predispose a high percentage of the population to spend long periods in sedentary behaviors. As too much sitting

time is related to different chronic diseases such as type 2 diabetes, obesity, hypertension, and cardiovascular diseases, or some types of cancer, it seems crucial to clearly understand the mechanism and strategies to reduce the negative effects of a sedentary lifestyle. Generalizing, we get up, use the elevator to go to the car, drive to work, take the escalator to go work, spend 8 hours at least working with minimum movement, drive back home, eat, have some hours of recreational time, watch TV and go to bed. Fortunately, different lifestyles and personal situations (occupational situation and leisure-time preferences) as well as inherent individual differences, result in different accumulations of sedentary time. Due to the strong available evidence on the deleterious effects of a sedentary lifestyle on health, it is necessary to better understand the metabolic mechanisms and how it is accumulated. Researchers have observed that reducing or breaking up sedentary time may result in beneficial changes in body composition and acute improvements in markers of cardiometabolic risk.

Sedentary behavior might be considered as a multifactorial concept, where four different aspects influencing it should be taken into account:

a. **Type of activity performed seated:** intellectual or occupational sitting seems to be less harmful than TV time or less intellectual activities.

b. **Level of PA:** adequate levels of physical activity may attenuate the negative effect of prolonged sitting.

c. **Age:** as an accumulative factor, so that, normally, if a person has a sedentary lifestyle, it has been adopted for more years when the person is older and the deleterious effects have been applying longer.

d. **Interruptions in sedentary bouts**: interrupting sitting time regularly may attenuate its negative effects when comparing to the same average uninterrupted sitting time.

It has been proposed that breaks in sedentary time could help counteract the negative effect of prolonged periods of whole-body inactivity. A break in sedentary time can be defined as a period of non-sedentary activity, such as standing or walking in between two sedentary bouts [7]. Experimental studies have demonstrated that interrupting sedentary time with short frequent breaks reduces daily glucose, postprandial glucose, and insulin resistance [3, 26, 27]. In a study carried out by Healy et al. [28] in 2008, the authors found, that interruptions of sedentary behavior were negatively associated with obesity and cardiometabolic health. These results highlighted, already at that time, the fact that not only total sitting matters but also how it is distributed in a period of time. The characteristic of the sedentary breaks in the study from Healy et al. showed that the breaks reported by the participants were shorter than 5 min on average, and they were performed at a light intensity. Results from this study also found lower waist circumference, BMI, triglycerides, and 2-h plasma glucose in the participants with higher sedentary break bouts, independent of total sedentary time or moderate-to-vigorous intensity activity time. Since this pioneering study was published, the scientific community have had an increased interest in analyzing the effects of sedentary breaks, to be able to deeply understand the effects of prolonged sitting on metabolism, as well as to establish clear and specific guidelines of intervention. Different types of sedentary breaks have been studied trying to analyze if shorter bouts of sitting time, are less metabolic disrupting even when the total amount of daily or weekly sitting times are similar.

Brief bouts of light-intensity-activity sedentary breaks could reduce the negative effects of long periods sitting on lower limb vascular function in healthy and overweight/obese adults [29]. Experimental studies [30–32] have seen that combining exercise with breaks in sitting resulted in additional reductions in postprandial insulin-glucose dynamics and triglycerides when comparing exercise and uninterrupted sitting. This effect, although useful in any case, seems to be more effective in those with high basal insulin resistance.

As many studies focused on analyzing the effects of sedentary breaks to counteract the metabolic problems associated with prolonged sitting time have found positive interactions, the question that remains unanswered is not if we should break sitting regularly, what already has a positive answer. The unanswered question is, which is the best structure for a sedentary break?

As it has been mentioned before, the lack of enough specific interventional studies complicates for experts to concrete the most optimal structure for sedentary breaks. A recent study by Wheeler et al. [30] investigated the effects of 3 different sitting strategies in overweight and obese: i) uninterrupted sitting for 8 h, ii) sitting for 1 h, moderate-intensity walking for 30-min and uninterrupted sitting for 6.5 h and iii) sitting for 1 h, moderate-intensity walking for 30 min and sitting for 6.5 h interrupting sitting every 30 min with 3 min of light-intensity walking. They found reductions in postprandial insulin-glucose dynamics and triglycerides by combining exercise with breaks in sitting. This study not only proposes a way to help reach the physical activity recommendation by breaking sedentary time for 30 min/day but also demonstrates that regular sedentary breaks help control the metabolic deleterious effect of prolonged sitting.

A well-controlled meta-analysis conducted by Loh et al. in 2020 [33] found that the use of sitting breaks moderately attenuated post-prandial glucose, insulin, and triacylglycerol. The authors also found that the glycemic attenuation was greater in people with a higher body mass index. An interesting result was that for attenuating glucose levels, a statistically significant small advantage for sitting breaks was found over continuous exercise when exercise matched energy. That could mean that for glucose regulation, it might be more interesting short regular breaks along the day, than one continuous bout of exercise.

The skeletal muscle might also play a key role in glycaemia control, which is even more important in overweight. Bergouignan et al. [34] performed an analysis from randomized clinical trials comparing one or three days uninterrupted sitting with sitting interrupted with light-intensity or moderate-intensity walking every 20-min in the modulation of contraction- and insulin-stimulated glucose uptake pathways in muscle. They found that both sitting break interventions reduced postprandial glucose concentration as well as a transition to modulation of the insulin-signaling pathway and increased capacity for glucose transport. The moderate-intensity intervention resulted in a greater capacity for glycogen synthesis and ATP production. These results might through some light in preventive strategy for metabolic diseases.

Published literature [35] might tend to propose that the best option to reduce the negative effects of sedentary behavior on metabolic functions could be to combine regular activity breaks of several minutes every 30 min of sitting with 30 min of continuous walking whether at the beginning or the end of the long sitting period.

Therefore, breaking sedentary time should be a good way to reduce the negative effects of long periods of sitting, for both metabolic and muscle function. These breaks are even more interesting for patients with initial high blood sugar, insulin resistance, or overweight-obesity. The general recommendation would be to make an active 2–3 min-break every 30 min of sitting time. If the activity made during these breaks is of moderate-high intensity, such as climbing stairs, the metabolic benefits might be greater.

2.6 Sedentary behavior in the workplace. Strategies

The workplace is considered an important environment for the promotion and protection of health [36]. According to a report from the World Health Organization (WHO) together with the World Economic Forum, 65% of the world's adult population is part of the workforce [37]. In 2007, about 3.1 billion people were part of the economically active population and it was estimated that by 2021 this number would exceed 3.6 billion [38]. Taking into account that this working adult population spends around a third of the day at work, workers´ health must be seen as a priority action.

Encouraging the reduction of sedentary behavior and promoting the practice of physical activity in the workplace is a strategy that helps maintain the health of the working population and affects their close environment. In 2018, the WHO presented the Global Action Plan for Physical Activity [39], with two mean challenges: reducing sedentary behavior by 2030 as well as the percentage of inactive population by 15% to the reported values of 2016. This plan encourages the population to take advantage of the many opportunities that arise in daily living to integrate physical activity, including the workplace (as a fundamental environment to practice physical activity programs as well as its promotion).

The activities where sedentary behavior predominates have increased lately and the workplace is a clear example. The machines have replaced human physical work at the same time that there has been a notable increase in office jobs, where the employee spends most of the working day in front of a computer. Although the negative consequences for cardiometabolic and musculoskeletal health of sedentary behavior have been widely demonstrated and office work represents for many workers a third of their day sitting, few have been made to improve this situation and reduce sitting time at workplaces, with the associated health risk.

The Healthy Work Environment model, proposed by the WHO [38] proposes intervention programs to reduce and break sedentary behavior in the workplace as a health promotion model and protection strategy. This model proposes four scenarios of action or "avenues of influence", which are not isolated, but rather overlap each other:

1. The physical environment of the work, which refers to the structure, air, machinery, furniture.

2. The psychosocial work environment, which includes the organization of work and institutional culture, attitudes, values, beliefs that can affect the mental and physical well-being of workers.

3. Personal health resources in the workplace, that consist in an environment that promotes health, health services, information, resources, opportunities, and the flexibility that the companies offer to workers to support the efforts to improve or maintain healthy lifestyles, as well as to monitor and support your physical and mental health.

4. The physical participation of the institution in the community, which includes the activities that the company carries out to improve the safety, well-being, and quality of life of workers and their families.

To successfully establish health promotion programs in the workplace, certain conditions must be considered:

1. Raising awareness among managers and chiefs of the importance of these interventions, facilitating employees to carry them out. Companies' leaders must understand that these strategies are not only not time wasted but will also result in increased productivity.

2. A previous evaluation of the workplace and the type of tasks that are developed, that help design an optimal plan.

3. Execution of the plan with the support of all interested parts (managers, middle managers, bosses, CEO, etc.) and commitment by workers.

4. Re-evaluation and adaptation of the proposal.

With different adaptations, similar models can be recommended with more or less the same stages.

Experts have suggested different strategies to reduce or interrupt sedentary behavior in the workplace, which could be grouped into the following categories [40].

a. Physical/environmental changes in workplace design

   - Desks with adjustable height that allow lifting them to work standing up.
   - Raised desks with a treadmill.
   - Rooms with high tables for standing meetings.
   - Modify the layout of the workplace, for example, by placing printers, trashcans, or water dispensers away from desks, which will force employees to stand up and walk a few steps when they need to use these items.
   - Provide bicycle racks, lockers, and services to wash up to encourage active transportation to work.
   - Eliminate architectural barriers to allow employees to move around the workplace, creating unobstructed corridors and spaces that invite walking.

b. Changes in workplace policy to incentivize and encourage reduction and disruption of sitting time

   - Promote the holding of standing or walking meetings.
   - Propose active breaks during working hours (short breaks in which you can do joint mobility exercises, put on a musical theme and dance, or any activity that allows interrupting the sedentary behavior through light physical activity)
   - Offer group physical activity practice.
   - Encourage the use of breaks for short walks.
   - Encourage employees to communicate with their colleagues by approaching their desks rather than by phone or messages.

- Propose to take advantage of telephone communications to do them standing or walking (obviously, spaces that do not interfere with the work of others should be considered).

- Encourage the use of the stairs instead of the elevator or escalator.

c. Information and advice to raise employee awareness and commitment by offering

- Workshops, training courses and outreach programs on the importance of reducing sedentary behavior. Reporting on the health risks of sedentary behavior and the benefits of practicing physical activity could allow people to evaluate their behavioral choices.

- Campaigns through various means, such as posters, signage, emails, WhatsApp messages, telephone calls or internal messages to motivate a change in behavior or.

- Install reminder software every 30 minutes on employees' mobile phones or personal computers, for example, to interrupt the sedentary behavior by standing up, dancing or doing some movements.

2.7 Sedentary behavior in the leisure time. Strategies

As mentioned so far, human bodies are adapted to maintain a physically active lifestyle. Proof of this is the health consequences of an insufficient level of physical activity. However, it is also true that neurobiologically we are adapted to "optimize" our energy expenditure, avoiding additional efforts when possible; In other words, sedentary behaviors are attractive for human beings, and willing power is required to counteract this attraction and opt for a behavior with higher associated energy expenditure [41]. It has been studied how the energy cost associated with a task affects, not only our decision to choose another more "economic" one, but directly to our perception of the initial task [42] and, therefore, to our future intention to undertake it.

A process as complex as human behavior cannot be reduced to just one component. Emotional/affective factors, as well as built habits, are also related to sedentary behavior and physical activity [43]. However, it is an interesting starting point if we seek an alternative approach to the one traditionally used. The assumption that human behaviors are decided by rational evaluations of the available information are underlying concepts in many current intervention strategies and, therefore, knowing the benefits of regular physical activity and the damages of prolonged sedentary behavior should be enough to solve the problem [44]. Nevertheless, in light of the sustained global pandemic of physical inactivity, it may be necessary to complement and enrich this approach with other perspectives.

Sedentary behaviors in free time are usually classified as screen-time (watching television, videos via streaming platform or physical medium, browsing the internet and social networks by both on a computer, tablet or cell phone and the use of video games) or not screen-time (sitting down to eat, participating in social gatherings, playing board games, recreational, attending cultural events such as cinema, theater, show music, sports competition, religious ceremony, doing artistic activities like writing or drawing or hobbies. The extensive list is testimony to the enormous offer of sedentary activities in free time. Recommendations on physical activity and sedentary behavior limit the amount of time in sedentary behaviors, but particularly those carried out in front of the screen [21].

Sedentary activities in front of the screen in free time, in addition to adverse effects on physical health, are related to adverse effects on mental health, mainly in minors [45]. Screen time during childhood is negatively correlated with brain connectivity, compared to time spent reading books, as well as being related to loss of imagery ability [46] or social–emotional functionality [47]. Interestingly, and in contrast to these studies, in the specific case of video games, there is evidence that indicates various cognitive benefits according to the type of game (action, strategy), and even positive socio-emotional impacts [48].

Of the large number of sedentary activities carried out in free time, although the impact on physical health is equivalent, it would be differential over other dimensions of the subject's health. This leads to one of the perspectives mentioned in the literature as a strategy to address sedentary behavior: "harm reduction". Assuming that certain socio-cultural (technological) changes are already part of daily life, priority is given to modifying those behaviors that present a greater health risk: replacing sedentary behaviors in front of the screen with sedentary behaviors without a screen, or by non-sedentary screen activities (for example, walking while using portable devices or replacing sedentary video games with active ones) [49].

Different classifications have been proposed for reducing sedentary behavior in the free time [50]: 1) environmental interventions such as devices that limit the time of television use), and 2) behavioral interventions like education campaigns about the harms of prolonged sedentary behavior; 3) multi-component interventions which include both types mentioned above.

Although studies on this fact do not have homogeneous methodologies, some findings can be pointed out. Studies that focus on the sedentary behavior of children in the home context have found a relationship between the existence of screen devices in the bedroom and greater sedentary behavior (with less reading time). Likewise, both the interventions that use devices that limit the use of television and those on family rules for screen use have been successful in reducing sedentary behavior. Furthermore, it was observed that in those cases in which the parents had more television time, or participated with their children in sedentary activities, the children presented higher levels of sedentary behavior. In some studies, the existence of adequate space or equipment for practicing physical activity at home is related to less sedentary behavior (although it does not present higher levels of physical activity at moderate or vigorous intensities) [51].

In the case of adults and the elderly, studies on free time are scarce and methodological imprecise. The absence of control in the domains makes it difficult to control the changes since the decrease of sedentary time in a domain does not imply its replacement by physical activity since it could simply shift to sedentary behavior in another domain. Those interventions aimed exclusively at reducing sedentary behavior have better results than those that also focused on increasing physical activity [50].

For children and adolescents, as well as for adults and the elderly, there is another alternative intervention strategy, which constitutes itself in an emerging field of research: exergaming, also known as active gaming or effort video game. These video games, unlike the traditional ones, are controlled with body movements (either full body or only certain segments); Thus, instead of being a sedentary activity, at least light-intensity physical activity is achieved (with the potential to become moderate intensity and even vigorous). In the US, it is estimated that 90% of children and adolescents play video games recreationally. In an increasing technophile society, and in which electronic entertainment is already part of our lives, exergaming stands as a strategy to address those to whom other physical activity proposals are not convincing. In addition, the commitment, immersion,

and experience of "flow" that they can generate, make them a great resource for health-related purposes. Sustainability over the years of this type of activity has been investigated, finding greater adherence in women, and similar to that of team sports [52].

Results for studies analyzing experiences in exergaming as part of both school physical education and at-home context show a decrease in sedentary behavior with potential, according to the intensity at which the game is played, increase of moderate-to-vigorous physical activity and good adherence to intervention programs. One of the challenges of exergaming is the "replay value" (once the game becomes monotonous and therefore the motivation to continue playing decreases), which maintain adherence. Multiplayer games (both face-to-face and remotely) show greater adherence. The eventual increase in the number of published games would compensate for this situation, allowing simply to change to a new one [53].

Particularly interesting is the research with older people, which improvements for both institutionalized and community-dwelling subjects, and not only in the physical dimensions but also in the cognitive one [54].

In all these cases, we refer mainly to consoles-home exergaming, but everyday mobile devices with augmented reality technology (Pokémon Go with geo-location system integrated into cell phones) are great opportunities to promote exergaming. Pokémon Go requires active movement of the player around their surroundings to play. This game mechanic has achieved a statistically significant change in the number of steps per day (thus decreasing sedentary behavior), although there is still not enough evidence on long-term adherence.

In the latter case, as in some home exergaming video games, there is no explicit intention in its design to promote health effects or to prescribe a systematic physical activity program. However, they have the potential to have a positive impact on the health and well-being of those who opt for this type of digital entertainment. Sedentary behavior in free time poses a great global challenge that requires, particularly for new generations, imagination and innovative approaches, in tune with contemporary technologies and paradigms.

2.8 Sedentary behavior in special populations: children and adolescents and older people. Strategies

2.8.1 Children and adolescents

It is well accepted that physical activity is beneficial to maintain and improve health and well-being across life [55]. In infants, toddlers, and preschoolers, high levels of physical activity have been seen to be related to better social and motor development improved metabolic health, and decreased adiposity, while a sedentary lifestyle is related to higher adiposity and poorer psychosocial health and cognitive development [54].

Children (preschoolers and scholars) spend more than 2 h/day of screen time, which is the maximal time recommended for this age group [56], plus eating time, school, passive transportation, homework, etc., which results in more than 8 h/day of sitting at this age. Moreover, studies found that screen time was associated with an increased risk of overweight/obese independent of physical activity [54]. Sex differences were also found. Boys are generally more involved in physical activity than girls, which normally spent more time on domestic tasks and homework. Children living in rural areas tend to use more active transportation than those who live in urban areas. Older children also tend to use more active transportation than the younger ones [57]. Taking into account that sedentary behavior in children is directly associated with classical cardiovascular risk factors like elevated blood

glucose levels, insulin resistance, high blood pressure, obesity, and elevated blood lipids [58], strategies that help reduce total daily sitting time in children are crucial.

Nevertheless, although childhood should be a life stage where children should freely play, run and jump as part of their natural development, social rules, obligations, parent's overprotection, new technologies, and urban environments, hinder the practice of physical activity for children with dramatic consequences. A qualitative study performed by Hidding et al. [59] aimed in determining the reasons for children to be sitting from the children or parents perspective, found that children most repeated reason was that they sit because is the norm and they have to and because they can play better that way. Other common answers were: I sit because seated activities are fun, I sit because I'm tired, I want to relax, I want to rest, I sit because of my health, I sit because there is nobody to play with, I sit because there is nothing to do, I sit because I'm not in the mood to do anything, I sit because of the weather. In regards to the answer "I sit because there is nobody to play with", in families with more than one child, seems to be easy for children to perform physical activity [59].

All this information brings the experts 'awareness of the necessity of reconsider children's environments. The CSEP Canadian 24-Hour Movement Guidelines [56] propose an Integration of physical activity (both light and moderate-to-vigorous), sedentary behavior, and sleep as the three principal parts of the day. All three must be right balanced to promote overall health, well-being, and quality of life. These guidelines use "the four S rule":

1. SWEAT: Moderate to Vigorous Physical Activity: An accumulation of at least 60 min/day.

2. STEP: Light physical activity: Several hours of a variety of structured and unstructured light physical activities (playing, walking)

3. SLEEP: Uninterrupted 9 to 11 h/night for those aged 5–13 years and 8 to 10 h/night for those aged 14–17 years, with consistent bed and wake-up times.

4. SIT: Sedentary behavior: No more than 2 h/day of recreational screen time and limited sitting for extended periods.

Figure 2 ilustrates de cited guidelines.

In addition, parents might consider changing indoor activities for outdoor ones, when possible, and including moderate to vigorous physical activity in exchange for light physical activity at some point of the day.

Findings from a recent meta-analysis [60] on the physical activity a sedentary behavior suggest that physical activity interventions can improve adolescents' mental health.

2.8.2 Older adults

Worldwide, the population is aging, which results in higher economic and social costs, as well as increased numbers of people living with more health problems, as aging increases the risk of suffering from chronic diseases. Therefore, the concept of successful aging has become a priority to guarantee, not only that life expectancy is high, but also that the years lived are of the best quality possible, free or with minimum chronic diseases. Physical activity has been proven to help increase or maintain health throughout life. Due to physical activity tends to reduce with age, older adults must become a risk population. Disability, frailty, dysfunction,

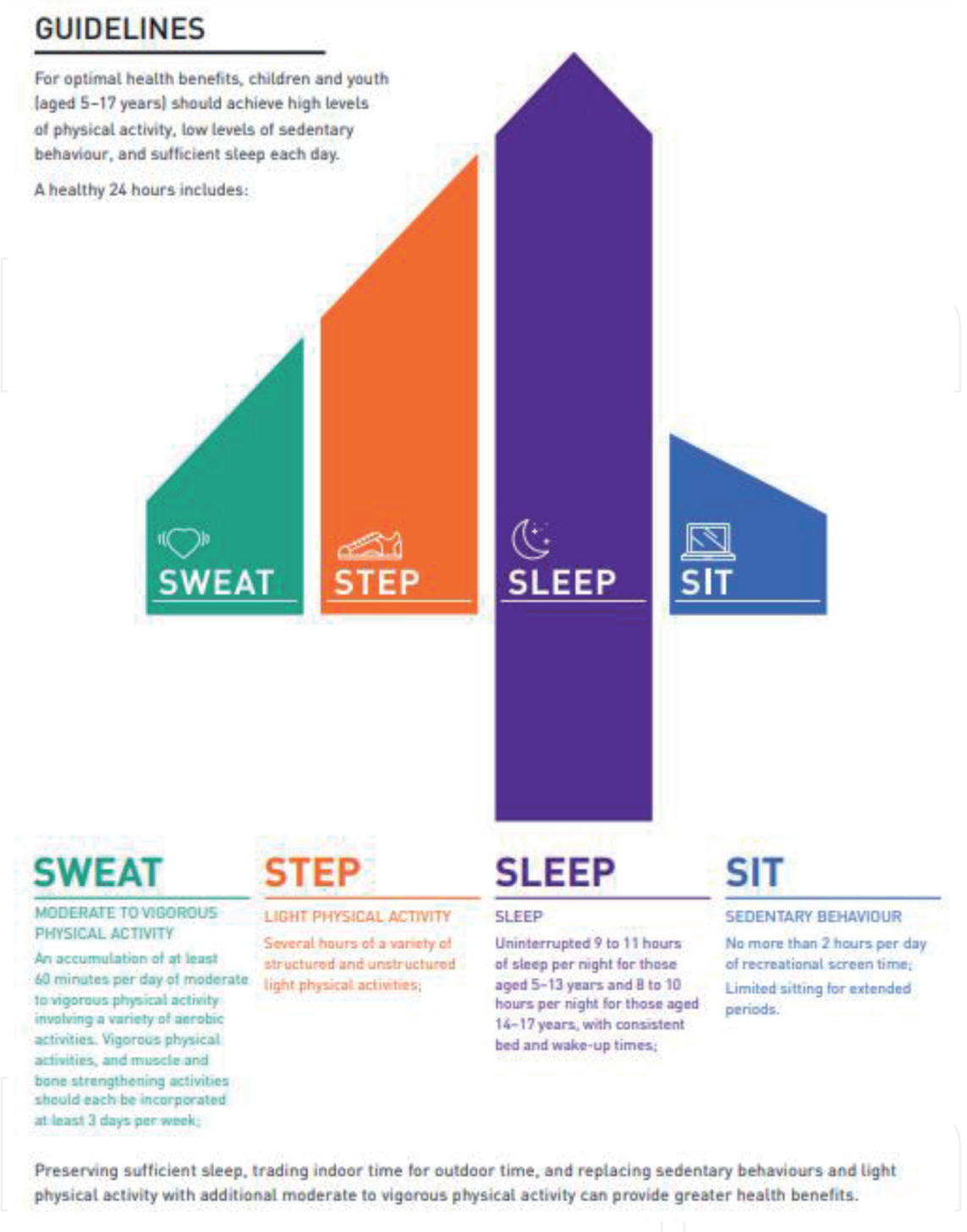

Figure 2.
Canadian 24-hour movement guidelines for children and youth (5-17 years): an integration of physical activity, sedentary behavior, and sleep. Taken from CSEP website (https://csepguidelines.ca/).

or sarcopenia are some of the problems that can affect older adults, which can compromise the independence level [61]. As physical activity decreases in this group, sedentary behavior increases, with fatal consequences. Maintaining physical activity levels and reducing sedentary time, should be a priority for the administrations. In this regard, there is evidence about the negative associations of sedentary behavior with frailty and how this relationship can differ by sitting bout length. Some studies [62] have found that prolonged sedentary bouts and total sedentary time were associated with higher mortality risk in frail individuals but not in robust. These results, including moderate-to-vigorous physical activity, reducing sedentary time in those frail older adults, as well as including sedentary breaks seem like a

suitable strategy to prevent dependency and maintain health. As the total hours of a day are always 24, that means that when a person increases the time spent in moderate-to-vigorous physical activity, this person is reducing the time spent in another activity, that could be sitting or light physical activity. If sleeping time remains stable and a person substitutes 30 min/day of light physical activity for moderate-to-vigorous physical activity that includes resistance training, and at the same time changes 1 hour of sitting for light physical activity such as walking, the frailty status could be significantly reduced. Moreover, if this person would include a short sedentary break every 30 min - 1 hour of the total time this person is seated, the benefits would be even higher with only small changes.

Due to older adults are mostly retired, which releases them of office sitting time and have a lot of leisure time, political strategies must center on providing older adults with a safe environment where they can perform light physical activity, such as walking [63]. Pavements and sidewalks in good conditions, green areas, and safe cross-roads might help improve that older adults go more often outside to take a walk. At the same time, organized affordable exercise activities, specifically designed by experts for this population, could make that older adult reach the recommendation for moderate-to-vigorous physical activity and resistance training. Moreover, these activities also promote social interaction, which improve wellbeing and might help reduce depression and anxiety, improving health-related quality of life, as well. These two actions would help to achieve physical activity recommendations at the same time that sedentary time would be reduced. To completely promote health in this group, clinicians, governments, and media should establish campaigns to make older adults understand the importance of breaking sedentary time. Things such as get up in the commercials when they watch TV, walking or standing while they are phoning, or get up to drink some water once each hour might be enough to break sitting time.

3. Conclusions

Lifestyle has dramatically changed in the last century. Industrialization and technology have reduced the physical requirements of many jobs, urbanization has changed population habits, force them to use passive transport instead of active ones, children play with digital devices since they are very young and older adult do not have to go outside because cities, family and environment easily provide all their needs. However, this sedentary lifestyle has disastrous consequences for health. Physical activity is necessary to maintain an optimal physiological function and prolonged sitting time interferes with the proper metabolic regulation. The combination of both, low physical activity levels and prolonged sitting time, maybe even more deleterious. That suggests a double challenge for developed countries; reducing and stopping prolonged sedentary behavior as well as increasing levels of physical activity. Although each of them separately has concrete effects on health, their interaction must be also taken into account. Sedentary behavior appears to be negative for health "per se", as well as low physical activity levels, but how both are combined is what can make the difference. Scientific evidence says that high physical activity levels might help counteract the negative effects of sitting time and that this effect is progressive. That means, that the higher the physical activity intensity, the less negative effects of sitting time. At the same time, it seems that long continuous sitting bouts are more harmful than the same total sitting time but with breaks in between. Eight hours seated without any break might be a lot worse for metabolic regulation than the same 8 h of sitting but with breaks of 2–3 min every 30 min-1 h. With all these ideas in mind, the strategy to reduce sedentary behavior

seems clear: practice enough physical activity, reduce free-time sitting and screen time, promote active transportation, and include sedentary breaks at sedentary jobs. The reason why these strategies are not working is complex and implies a compromise at different levels. First, governments must provide opportunities for affordable exercise practice and physical activity-friendly environments. Secondly, at workplaces, managers, CEOs, and bosses must be aware of the importance of promoting working places where employees have the opportunity of breaking sedentary time, and that it is seen as normal. Third, citizens should make efforts to include active activities in the free time as well as substitute classic videogames for exergaming, where at least, sitting time is exchanged for light physical activity. Last but not least, special populations (children and older adults) should not be forgotten. Parents and schools should reconsider the rules and norms and adapt them, when possible, to others more active versions, not forcing children to spend long periods seated promoting at the same time at least one hour of physical activity per day. Controlling screen time and giving good examples must be another priority for parents. In regards to older adults, societies should allow them to perform easy tasks that increase physical activity, encouraging them to used active transportations to carry them out, at the same time that exercise programs, specifical design for this population, are easily available in every neighborhood.

Author details

Olga López Torres[1*], Pablo Lobo[2], Valeria Baigún[2] and Gabriela F. De Roia[2]

1 ImFINE Research Group, Health and Human Performance Department, Faculty of Physical Activity and Port Science-INEF, Universidad Politécnica de Madrid, Madrid, Spain

2 Laboratorio de Estudios en Actividad Física, Universidad de Flores, Ciudad Autónoma de Buenos Aires, Argentina

*Address all correspondence to: olga.lopez@upm.es

IntechOpen

References

[1] Guthold R, Stevens GA, Riley LM, Bull FC. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. Lancet Glob Heal [Internet]. 2018;6(10):e1077-86. Available from: http://dx.doi.org/10.1016/S2214-109X(18)30357-7

[2] Chau JY, Grunseit AC, Chey T, Stamatakis E, Brown WJ, Matthews CE, et al. Daily sitting time and all-cause mortality: A meta-analysis. PLoS One. 2013;8(11):1-14.

[3] Chastin SFM, Egerton T, Leask C, Stamatakis E. Meta-analysis of the relationship between breaks in sedentary behavior and cardiometabolic health. Obesity. 2015;23(9):1800-10.

[4] Larsen RN, Kingwell BA, Sethi P, Cerin E, Owen N, Dunstan DW. Breaking up prolonged sitting reduces resting blood pressure in overweight/obese adults. Nutr Metab Cardiovasc Dis [Internet]. 2014;24(9):976-82. Available from: http://dx.doi.org/10.1016/j.numecd.2014.04.011

[5] Kohl HW, Craig CL, Lambert EV, Inoue S, Alkandari JR, Leetongin G, et al. The pandemic of physical inactivity: Global action for public health. Lancet. 2012;380(9838):294-305.

[6] Morris JN. Yoga Para Gestantes - Aula. Coron Hear Phys Act Work. 1953;1111-20.

[7] Tremblay MS, Aubert S, Barnes JD, Saunders TJ, Carson V, Latimer-Cheung AE, et al. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. Int J Behav Nutr Phys Act. 2017;14(1):1-17.

[8] Douglas K D, Robert T. Complications of Immobilization and Part 1 : Musculoskeletal and cardiovascular complications. Can Fam Physician. 1993;39(1):1428-37.

[9] Teasell R, Dittmer DK. Complications of immobilization and bed rest. Part 2: Other complications. Can Fam Physician. 1993;39(June):1440-2, 1445.

[10] Dirks ML, Wall BT, Van De Valk B, Holloway TM, Holloway GP, Chabowski A, et al. One week of bed rest leads to substantial muscle atrophy and induces whole-body insulin resistance in the absence of skeletal muscle lipid accumulation. Diabetes. 2016;65(10):2862-75.

[11] Brower RG. Consequences of bed rest. Crit Care Med. 2009;37(SUPPL. 10).

[12] Parry SM, Puthucheary ZA. The impact of extended bed rest on the musculoskeletal system in the critical care environment. Extrem Physiol Med. 2015;4(1):1-8.

[13] Bringard A, Pogliaghi S, Adami A, De Roia G, Lador F, Lucini D, et al. Cardiovascular determinants of maximal oxygen consumption in upright and supine posture at the end of prolonged bed rest in humans. Respir Physiol Neurobiol. 2010;172(1-2):53-62.

[14] Van Dyck D, Cerin E, De Bourdeaudhuij I, Hinckson E, Reis RS, Davey R, et al. International study of objectively measured physical activity and sedentary time with body mass index and obesity: IPEN adult study. Int J Obes. 2015;39(2):199-207.

[15] Owen N, Sugiyama T, Eakin EE, Gardiner PA, Tremblay MS, Sallis JF. Adults' sedentary behavior: Determinants and interventions. Am J Prev Med [Internet]. 2011;41(2):189-96. Available from: http://dx.doi.org/10.1016/j.amepre.2011.05.013

[16] King AC, Powell KE, Kraus WE. The US Physical Activity Guidelines Advisory Committee Report - Introduction. Med Sci Sports Exerc. 2019;51(6):1203-5.

[17] Olanrewaju O, Stockwell S, Stubbs B, Smith L. Sedentary behaviours, cognitive function, and possible mechanisms in older adults: a systematic review. Aging Clin Exp Res [Internet]. 2020;32(6):969-84. Available from: https://doi.org/10.1007/s40520-019-01457-3

[18] Biswas A, Oh PI, Faulkner GE, Bajaj RR, Silver MA, Mitchell MS, et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults a systematic review and meta-analysis. Ann Intern Med. 2015;162(2):123-32.

[19] Ku PW, Steptoe A, Liao Y, Hsueh MC, Chen LJ. A cut-off of daily sedentary time and all-cause mortality in adults: A meta-regression analysis involving more than 1 million participants. BMC Med. 2018;16(1):1-9.

[20] Hansen D, Niebauer J, Cornelissen V, Barna O, Neunhäuserer D, Stettler C, et al. Exercise Prescription in Patients with Different Combinations of Cardiovascular Disease Risk Factors: A Consensus Statement from the EXPERT Working Group. Sport Med. 2018;48(8):1781-97.

[21] Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med. 2020;54(24):1451-62.

[22] Ekelund U, Steene-johannessen J, Brown WJ, Fagerland MW. Ekelund , U ., Steene-Johannessen , J ., Brown , W . J ., Fagerland , M . W ., Owen , N ., Powell , K . E ., Bauman , A ., Lee , I . (2016). Does physical activity attenuate, or even eliminate , the detrimental association of sitting time with mortalit. Lancet. 2016;6736:972-7.

[23] Ekelund U, Brown WJ, Steene-Johannessen J, Fagerland MW, Owen N, Powell KE, et al. Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. Br J Sports Med. 2019;53(14):886-94.

[24] Dempsey PC, Biddle SJH, Buman MP, Chastin S, Ekelund U, Friedenreich CM, et al. New global guidelines on sedentary behaviour and health for adults: broadening the behavioural targets. Int J Behav Nutr Phys Act. 2020;17(1):1-12.

[25] Chau JY, Grunseit A, Midthjell K, Holmen J, Holmen TL, Bauman AE, et al. Sedentary behaviour and risk of mortality from all-causes and cardiometabolic diseases in adults: Evidence from the HUNT3 population cohort. Br J Sports Med. 2015;49(11):737-42.

[26] Dempsey PC, Larsen RN, Sethi P, Sacre JW, Straznicky NE, Cohen ND, et al. Benefits for Type 2 Diabetes of Interrupting Prolonged Sitting With Brief Bouts of Light Walking or Simple Resistance Activities. Diabetes Care. 2016;39(6):964-72.

[27] Duvivier BMFM, Schaper NC, Hesselink MKC, van Kan L, Stienen N, Winkens B, et al. Breaking sitting with light activities vs structured exercise: a randomised crossover study demonstrating benefits for glycaemic control and insulin sensitivity in type 2 diabetes. Diabetologia. 2017;60(3):490-8.

[28] Healy GN, Dunstan DW, Salmon J, Cerin E, Shaw J, Zimmet P, et al. Beneficial associations with metabolic risk. Diabetes Care. 2008;31(4):661-6.

[29] Thosar SS, Bielko SL, Mather KJ, Johnston JD, Wallace JP. Effect of prolonged sitting and breaks in sitting time on endothelial function. Med Sci Sports Exerc. 2015;47(4):843-9.

[30] Wheeler MJ, Green DJ, Cerin E, Ellis KA, Heinonen I, Lewis J, et al. Combined effects of continuous exercise and intermittent active interruptions to prolonged sitting on postprandial glucose, insulin, and triglycerides in adults with obesity: a randomized crossover trial. Int J Behav Nutr Phys Act. 2020;17(1):1-11.

[31] Climie RE, Wheeler MJ, Grace M, Lambert EA, Cohen N, Owen N, et al. Simple intermittent resistance activity mitigates the detrimental effect of prolonged unbroken sitting on arterial function in overweight and obese adults. J Appl Physiol. 2018;125(6):1787-94.

[32] Saunders TJ, Atkinson HF, Burr J, MacEwen B, Skeaff CM, Peddie MC. The Acute Metabolic and Vascular Impact of Interrupting Prolonged Sitting: A Systematic Review and Meta-Analysis. Sport Med [Internet]. 2018;48(10): 2347-66. Available from: https://doi.org/10.1007/s40279-018-0963-8

[33] Loh R, Stamatakis E, Folkerts D, Allgrove JE, Moir HJ. Effects of Interrupting Prolonged Sitting with Physical Activity Breaks on Blood Glucose, Insulin and Triacylglycerol Measures: A Systematic Review and Meta-analysis [Internet]. Vol. 50, Sports Medicine. Springer International Publishing; 2020. 295-330 p. Available from: https://doi.org/10.1007/s40279-019-01183-w

[34] Bergouignan A, Latouche C, Heywood S, Grace MS, Reddy-Luthmoodoo M, Natoli AK, et al. Frequent interruptions of sedentary time modulates contraction- and insulin-stimulated glucose uptake pathways in muscle: Ancillary analysis from randomized clinical trials. Sci Rep [Internet]. 2016;6(July):1-13. Available from: http://dx.doi.org/10.1038/srep32044

[35] Homer AR, Fenemor SP, Perry TL, Rehrer NJ, Cameron CM, Skeaff CM, et al. Regular activity breaks combined with physical activity improve postprandial plasma triglyceride, nonesterified fatty acid, and insulin responses in healthy, normal weight adults: A randomized crossover trial [Internet]. Vol. 11, Journal of Clinical Lipidology. National Lipid Association; 2017. 1268-1279.e1 p. Available from: http://dx.doi.org/10.1016/j.jacl.2017.06.007

[36] World Health Organization (WHO). No Title. Ottawa Chart Heal Promot [Internet]. 1986; Available from: http://www.who.int/healthpromotion/conferences/previous/ottawa/en/

[37] (WHO) WHO. Preventing noncommunicable diseases in the workplace through diet and physical activity : WHO/World Economic Forum report of a joint. World Heal Organ / World Econ Forum 2008 [Internet]. 2008;Global Str. Available from: https://www.who.int/dietphysicalactivity/workplace/en/

[38] World Health Organization & Burton J. World Health Organization. WHO Heal Work Framew Model Backgr Support Lit Pract [Internet]. 2010; Available from: https://apps.who.int/iris/handle/10665/113144

[39] WHO. More Active People for a Healthier World. J Policy Model. 2018;28(6):615-27.

[40] Shrestha N, Kukkonen-Harjula KT, Verbeek JH, Ijaz S, Hermans V, Pedisic Z. Workplace interventions for reducing sitting at work. Cochrane Database Syst Rev. 2018;2018(6).

[41] Cheval B, Tipura E, Burra N, Frossard J, Chanal J, Orsholits D,

et al. Avoiding sedentary behaviors requires more cortical resources than avoiding physical activity: An EEG study. Neuropsychologia [Internet]. 2018;119(May):68-80. Available from: https://doi.org/10.1016/j.neuropsychologia.2018.07.029

[42] Hagura N, Haggard P, Diedrichsen J. Perceptual decisions are biased by the cost to act. Elife. 2017;6:1-20.

[43] Brand R, Cheval B. Theories to explain exercise motivation and physical inactivity: Ways of expanding our current theoretical perspective. Front Psychol. 2019;10(MAY):1-4.

[44] Hagger MS, Weed M. DEBATE: Do interventions based on behavioral theory work in the real world? Int J Behav Nutr Phys Act. 2019;16(1):1-10.

[45] Zink J, Belcher BR, Imm K, Leventhal AM. The relationship between screen-based sedentary behaviors and symptoms of depression and anxiety in youth: A systematic review of moderating variables. BMC Public Health. 2020;20(1).

[46] Suggate SP, Martzog P. Screen-time influences children's mental imagery performance. Dev Sci. 2020;23(6):1-13.

[47] Wan MW, Fitch-Bunce C, Heron K, Lester E. Infant screen media usage and social-emotional functioning. Infant Behav Dev [Internet]. 2021;62(November 2020):101509. Available from: https://doi.org/10.1016/j.infbeh.2020.101509

[48] Granic I, Lobel A, Engels RCME. The benefits of playing video games. Am Psychol. 2014;69(1):66-78.

[49] Leigh M. Vanderloo PSCPMAMsKTCPJMMCSBMMs. Vanderloo2020. J Dev Behav Pediatr. 2020;41(5):19-20.

[50] Nguyen P, Le LKD, Nguyen D, Gao L, Dunstan DW, Moodie M. The effectiveness of sedentary behaviour interventions on sitting time and screen time in children and adults: An umbrella review of systematic reviews. Int J Behav Nutr Phys Act. 2020;17(1):1-11.

[51] Biddle SJH, Petrolini I, Pearson N. Interventions designed to reduce sedentary behaviours in young people: A review of reviews. Br J Sports Med. 2014;48(3):182-6.

[52] Emara AK, Ng MK, Cruickshank JA, Kampert MW, Piuzzi NS, Schaffer JL, et al. Gamer's Health Guide: Optimizing Performance, Recognizing Hazards, and Promoting Wellness in Esports. Curr Sports Med Rep. 2020;19(12):537-45.

[53] Stojan R, Voelcker-Rehage C. A Systematic Review on the Cognitive Benefits and Neurophysiological Correlates of Exergaming in Healthy Older Adults. J Clin Med. 2019;8(5):734.

[54] Claus GM, Redkva PE, Brisola GMP, Malta ES, de Poli R de AB, Miyagi WE, et al. atric Exercise Science. The article appears here in its accepted, peer-reviewed form, as it was provided by the submitting author. It has not been copyedited, proofread, or formatted by the publisher. 2017;

[55] Warburton DER, Bredin SSD. Health benefits of physical activity: A systematic review of current systematic reviews. Curr Opin Cardiol. 2017;32(5):541-56.

[56] Tremblay MS, Carson V, Chaput JP, Connor Gorber S, Dinh T, Duggan M, et al. Canadian 24-hour movement guidelines for children and youth: An integration of physical activity, sedentary behaviour, and sleep. Appl Physiol Nutr Metab. 2016;41(6):S311-27.

[57] Song C, Gong W, Ding C, Yuan F, Zhang Y, Feng G, et al. Physical activity and sedentary behavior among Chinese children aged 6-17 years: A cross-sectional analysis of 2010-2012 China

National Nutrition and health survey. BMC Public Health. 2019;19(1):1-8.

[58] Königstein K, Klenk C, Appenzeller-Herzog C, Hinrichs T, Schmidt-Trucksäss A. Impact of sedentary behavior on large artery structure and function in children and adolescents: a systematic review. Eur J Pediatr. 2020;179(1):17-27.

[59] Hidding LM, Altenburg TM, van Ekris E, Chinapaw MJM. Why do children engage in sedentary behavior? Child- and parent-perceived determinants. Int J Environ Res Public Health. 2017;14(7).

[60] Rodriguez-Ayllon M, Cadenas-Sánchez C, Estévez-López F, Muñoz NE, Mora-Gonzalez J, Migueles JH, et al. Role of Physical Activity and Sedentary Behavior in the Mental Health of Preschoolers, Children and Adolescents: A Systematic Review and Meta-Analysis. Sport Med [Internet]. 2019;49(9):1383-410. Available from: https://doi.org/10.1007/s40279-019-01099-5

[61] Kehler DS, Theou O. The impact of physical activity and sedentary behaviors on frailty levels. Mech Ageing Dev [Internet]. 2019;180(November 2018):29-41. Available from: https://doi.org/10.1016/j.mad.2019.03.004

[62] Kikuchi H, Inoue S, Amagasa S, Fukushima N, Machida M, Murayama H, et al. Associations of older adults' physical activity and bout-specific sedentary time with frailty status: Compositional analyses from the NEIGE study [Internet]. Vol. 143, Experimental Gerontology. 2021. 111149 p. Available from: https://doi.org/10.1016/j.exger.2020.111149

[63] Brookfield K, Thompson CW, Scott I. The uncommon impact of common environmental details on walking in older adults. Int J Environ Res Public Health. 2017;14(2).