Chapter

Sedentary Behavior, Cardiovascular Risk and Importance of Physical Activity and Breaking-Up Sedentary Behavior

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Abstract

Sedentary behavior (SB) is one of the common leading modifiable risk factor for cardiovascular (CV) morbidity and all-cause mortality. However, not much is known concerning the relationship between SB and CV risk factors. This chapter aimed to explore the scientific knowledge that examines the association between SB and CV risk factors and its association with the development of CVD. Besides, the focus on preventing the SB by avoiding prolonged sitting and breaking-up the extended periods of sitting, and participating in physical activity (PA) are usually highlighted in this chapter, explaining how these intervention protocols can reduce the burden of CVD due to SB. Regardless of the known benefits of both PA and taking frequent breaks when engaging in sedentary tasks, the adaptation of a physically active lifestyle has remained very low because of various reasons; habitual behavior, insufficient or lack of time, misconceptions of CVD related health benefits from PA. Thus, it is very important to break these barriers associated with PA and encourage the physically inactive population, especially those who practice prolonged sitting to actively participate in PA and break the prolonged sitting time with regular interval breaks. Therefore, promotion of PA and limiting the sedentary tasks which would lead to improved levels of cardiorespiratory fitness (CRF) and better quality of living is necessary among all age groups, gender and ethnicities to prevent many chronic illnesses, specifically CVD and its associated risks related to SB.

Keywords: sedentary behavior, cardiovascular disease risk, prolonged sedentary time, moderate-to-vigorous physical activity, cardiorespiratory fitness

1. Introduction

The advancement of sedentary behavior (SB) research in health science has increased rapidly which has led to numerous terminologies and definitions about SB. With this fast development, a standardized, clear, and common definition is to be formulated to address these issues. The "Sedentary Behaviour Study network" (SBSN) carried out a project to overcome this issue and developed a comprehensive conceptual model based on movement, structured around 24 hour period (**Figure 1**), and defines SB as "any waking behaviour in which the energy expenditure is low, generally ≤1.5 metabolic equivalents (MET's) while in sitting, reclining or lying position" [1]. The SBRN definition of SB includes two parts; posture and energy expenditure. The postural element is very easily operationalized and broadly utilized to determine SB by use of inclinometers, questionnaires, and direct observation, but dismisses the energetic part. Nevertheless, it requires to be mentioned that accelerometers usually measure movement rather than energy expenditure and represents an indirect approach to assess energy expenditure. Some of the common examples of SB include television (TV) viewing, sitting in the classroom, computer use, desk-based occupations, and passive commuting.

It is very important to emphasize that SB differs from physical inactivity (PI), in which an individual usually does not perform any of the recommended moderate-to-vigorous physical activity (MVPA). Although SB and PA are on the opposite ends of energy expenditure continuum, the inclusion of a postural element is a requirement for this to be considered sedentary, suggesting that this is a distinctive and unique behavior that can be intervened on. A person could be is actually physically active for the recommended 75–150 minutes of moderate PA each week or 150–300 minutes of vigorous PA every week [2], yet he or she may sit for several hours a day in a sedentary occupation or during their leisure time. The

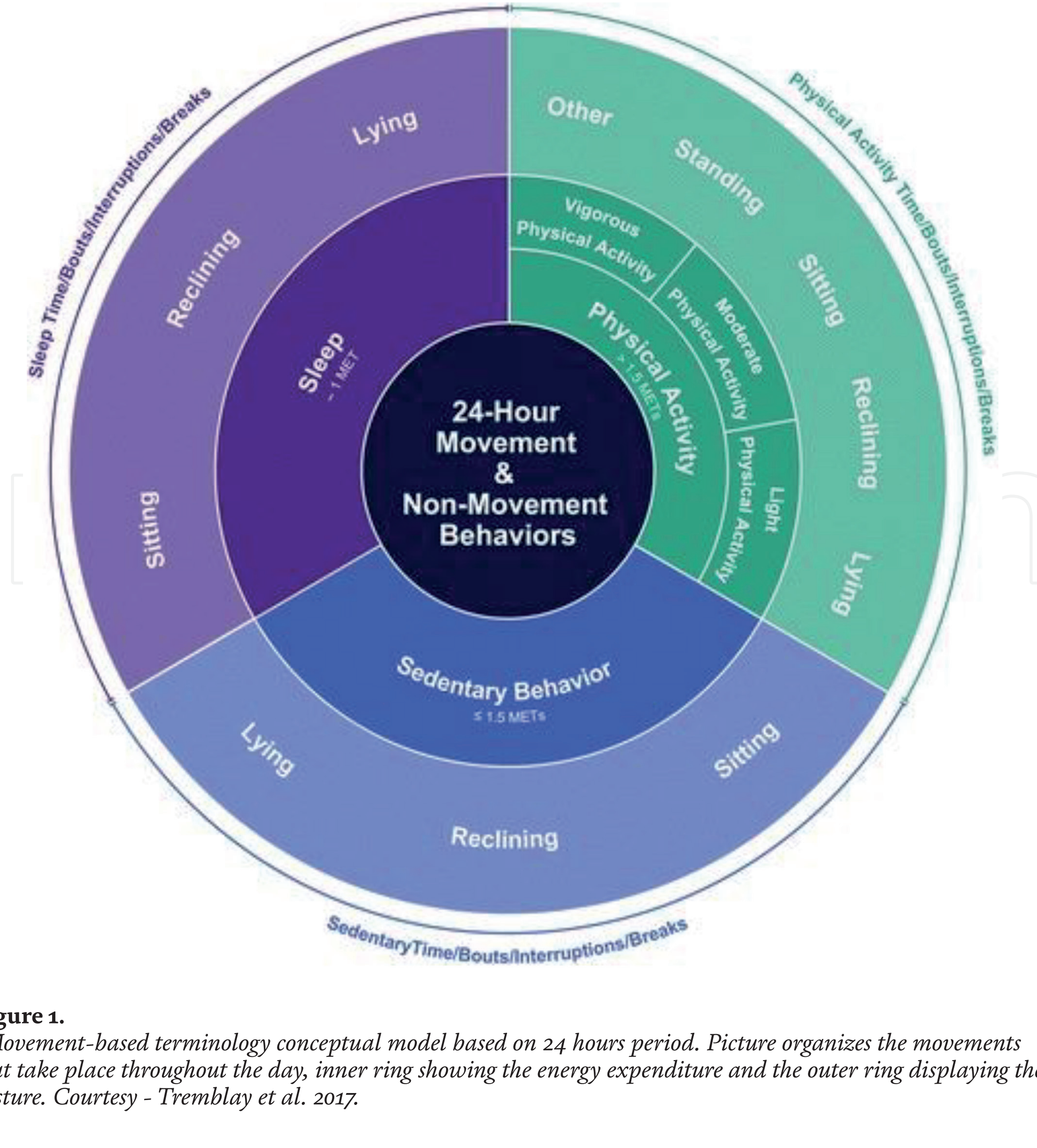

Figure 1.
"Movement-based terminology conceptual model based on 24 hours period. Picture organizes the movements that take place throughout the day, inner ring showing the energy expenditure and the outer ring displaying the posture. Courtesy - Tremblay et al. 2017.

adult population in the United States and the United Kingdom spend 60%–70% of the waking hours at sedentary activates, 25%–35% in light-intensity exercise, and the reminder little proportion of time on MVPA.

Time spent in SB is essential because it displaces the time spent in MVPA causing a decrease in overall PA energy expenditure. Displacement of 2 hours each day of light activity (2.5–3.0 MET's) by sedentary tasks (1.5 MET's) is predicted to decrease the PA energy expenditure by about 2 METs per hour each day or around the amount of energy expenditure while walking for 30 minutes per day. Research on PA and wellness has focused mostly on calculating the amount of time spent in PA carried out at 3 MET's or more, characterizing people that have no involvement in activates at such level as sedentary. Nevertheless, this explanation overlooks the considerable effect light-intensity PA can have daily on the overall expenditure energy [3] as well as the positive health-related outcome benefits by taking part in the light-intensity PA instead of simply sitting and doing nothing. Furthermore, although people could be both physically inactive and sedentary, additionally there is a higher chance of more time spent in sedentary tasks and PA to coexist. A good example could be an employee who jogs or bicycles to his or her workplace, but subsequently sits all day long at the workplace and spends many hours viewing TV at night after returning from work. Therefore, SB is not simply the absence of MVPA, but instead is a unique behavior with specific environment determinants and a variety of potentially distinctive wellness consequences.

Compared to previous generations, people are spending much more time in an environment which not merely restricts the PA, but also spent prolonged periods sitting at workplace, at home, in communities, and driving. Workplaces, schools, homes and common public areas are re-engineered in a manner that reduces body movements and muscle activity leading to dual influence on individuals behavior; move little and sit longer. Humans were made to locomote and take part in every form of manual labour on day to day basis. The recent change from a challenging and active life to one with only a few physical demands and challenges has been fast. The increased development of SB and its associated decrease in energy expenditure in the previous few years have become surprising. In the 1970s, 2 in 10 working people in America had been in occupations needing just light activity (primarily in sitting position), whereas 3 in 10 had been in occupations needing high energy expenditure like farming, manufacturing production, and construction [4]. By 2000, it was found more than 4 in 10 adults were in jobs that required light-to-moderate activity, whereas 2 in 10 had been at jobs that needed high energy expenditure. Furthermore, in the past 2 decades, the amount of screen time using computers and smartphones, playing video games and TV viewing has increased significantly. In 2003, about 6 in 10 working people used a computer at the job and 9 out of 10 children used a computer in schools and colleges. By 2016, more than 89% of households had a computer including a smartphone rendering it a common feature for everyday activity [5, 6].

Watching TV is associated with more than some other sedentary behaviors with higher CVD risk factors. It is hypothesized that watching TV results in lower energy expenditure than other sedentary activities like reading quietly in sitting, as a result of a slower resting metabolic rate. It is possible that watching TV requires less muscle contraction and activation than pursuits like driving, and this muscular inactivity is thought to be associated with a decrease in lipoprotein lipase [7], a protein that play an important role in managing lipid metabolism [8]. Therefore, more passive behavior of TV watching could have a strong association with higher CVD risk factors than various other sedentary activities because of reduced lipoprotein lipase. Another possible reason is that watching TV is connected with unhealthy nutritional habits, like decreased usage of fruits and vegetables and more intake of energy-dense food including fast food and sugar-sweetened beverages [9]. This may lead to increased snacking behavior while watching TV or expose people particularly young children to beverage and food advertising that attract them to make a harmful and unhealthy dietary choice [10]. Finally, a third feasible explanation is that people could be able to recall the period spent watching TV in comparison to the time allocated to other sedentary activities [11].

This chapter aimed to synthesize the scientific knowledge about the relationship between SB and CV risk factors and its association with the development of CVD. From the above findings it is very clear how people nowadays are spenting more time in SB, particularly extended period of time spent in watching TV, using computer and other electronic gadgets, administrative work, and passive commuting. All these sedentary tasks decrease the energy expenditure drastically and can negatively impact the health related outcome measures, and impose a higher risk of developing CVD and cardiometabolic disease. Furthermore, this chapter will explore the strategies that would help to prevent or minimize the SB by avoiding the prolonged sitting and breaking-up the extended periods of sitting, and engagement in physical activities, describing how these intervention protocols can reduce the burden of CVD due to SB.

2. Objective measurement of sedentary behavior

The uncertainty encircling the necessity for posture in the definition of SB poses challenges for measuring and evaluating measures of SB, as well as the difficulty in quantifying individual behavior. Most commonly used assessment options for SB consist of questionnaires, recalls, and behavioral logs, all of which possess methodological limitation of measurement errors. These assessment methods have fair to good reliability but reduced validity in comparison with criterion measures. However, objective assessment on SB can decrease measurement error and offer information regarding patterns of activities like time spent in sedentary tasks, breaks and MVPA. However, the drawbacks of objective based measurement include the cost of these objective tools, participant burden, converting data into the functional summary, devices failing to register position and intensity of some specific kind of activities (e.g. riding on a stationary bike), and insufficient information with regards to specific behavioral domains. Accelerometers (count the number of steps), heart-rate monitors, inclinometers along with other devices are used to offer an objective measurement of various variables such as intensity, volume, and frequency of a task that could be downloaded and converted into a purposeful activity interpretation. National Health and Nutrition Survey (NHANS) have been collecting accelerometer data from a large population of adults in the United States. The NHANS demonstrated that the degree of participation in MVPA's are lower and around 60% or even higher percentage of the adult population spent waking hours in sedentary activities [12, 13]. In a recently available validity study which was carried among 40 university employees aged 18–70 years, SB was evaluated by an accelerometer (<100 counts per minute [cpm]) that captured coded images by a very small wearable digital camera. The study demonstrated that some particular behaviors (watching TV, using computer and administrative routines) were properly classified utilizing the standard 100-cpm threshold by simpler accelerometry. Nevertheless, when tested for standing still position, it captured only 9% of the total time and generated <100-cpm 72% of that time, indicating that most of the time spent in standing will be categorized not as sedentary. However, scientists debate on what usually is the best-suited activity cut-off points to recognize time spent in sedentary tasks and time spent on the light-intensity activity. Besides, various cut-off points could be befitting populations of various ages, ethnic background, and adiposity status. **Figure 2** depicts a cluster heat map, displaying accelerometer information for a single individual during 1 week. The accelerometer value counts are recorded each minute, are usually represented by various colors. The darkish blue color represents accelerometer data information which is significantly less than the currently utilized, cut-off of 100-cpm for the sedentary tasks, and is mostly indicative of sitting behavior. Light blue through yellow color indicates some kind of light-to-moderate intensity activities, dark blue color indicates a very low level of expenditure of energy, and red color showing a high energy expenditure levels such as MVPA. What strikes the most is the degree to which this individual spends the time either in very light-intensity tasks as shown in pale-blue to white-color or mostly being sedentary as indicated by dark blue color.

Both self-reported and objective assessment methods could be essential to progress forward when quantifying the SB. Healy et al. [14] demonstrated that objective and self-reported sedentary behaviors are usually complementary and each provides distinct information. For instance, the TV viewing period was comparable for Mexican American citizens and non-Hispanic blacks (self-report), whereas overall time engaged in SB was shown to be increased in non-Hispanic blacks in comparison to Mexican Americans when assessed objectively. Therefore, understanding and possibly enhancing the reliability and validity of both self-report and objective assessment methods is a priory. Furthermore, due to the different information provided by each evaluation method, a better knowledge of the efficiency characteristics across both measurement approaches is needed.

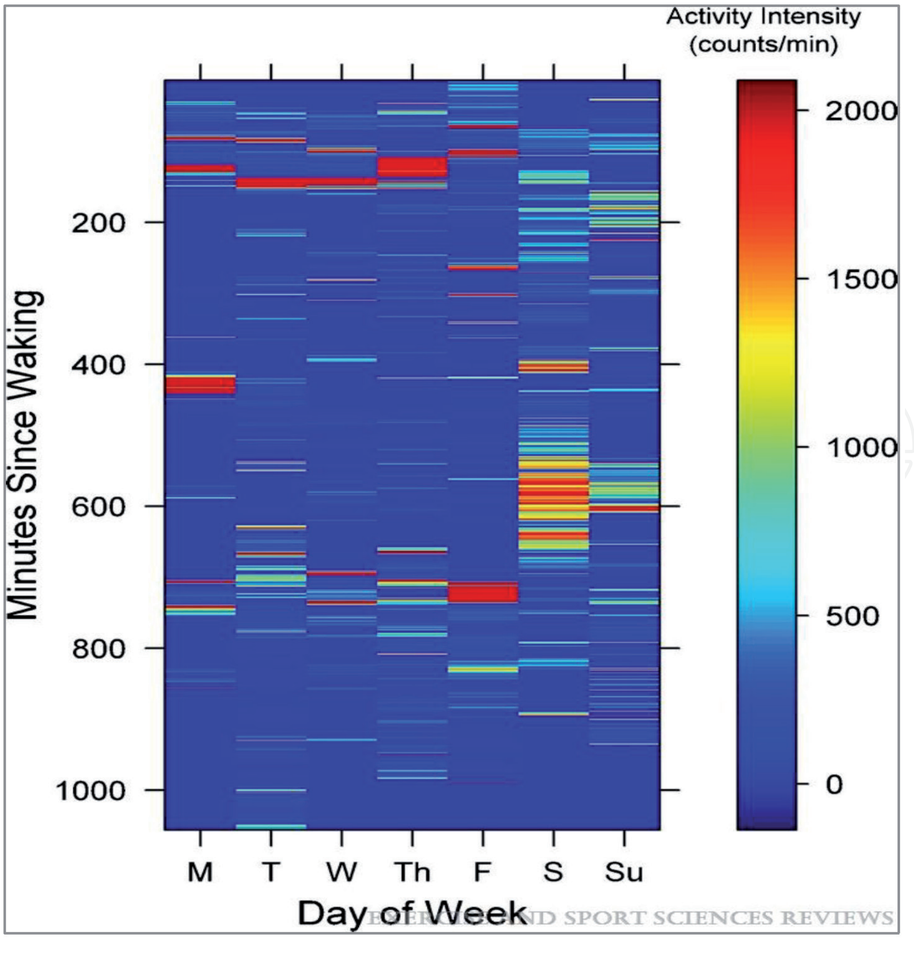

Figure 2.
1 week of accelerometer data - 31 minutes MVPA (> 1951 counts each minute), 71% waking hours being sedentary (> 100 counts every minute). Courtesy - Owen et al. 2010.

3. Sedentary behavior and risk of cardiovascular disease

Scientific research has been mostly centered on finding the association between SB and cardiometabolic morbidity and all-cause mortality. Little is known about the association between SB and higher cardiovascular (CV) risk and its advancement to CVD. The question that comes to mind is what are the possible mechanisms that contribute to the independent relation of SB with higher CVD morbidity and mortality? Probably the most likely and apparent explanation pertains to the influence of SB on risks associated with conventional CVD. Studies have established that in healthy adults, there is an association found between SB and higher conventional CV risk factors. Stamatakis et al. [15] reported the relationship of SB with conventional CV risks (Blood pressure [BP], high density lipoprotein cholesterol [HDL-C], WC, body mass index [BMI]) among 5948 healthy middle-age population. In another study, carried among 2328 young adult participants, prolonged sitting was observed to be independently and positively correlated with adiposity and heart rate and had a negative association with physical fitness as indicated by cardiorespiratory fitness (CRF) [16]. In a healthy population, very little scientific evidence is available on the relationship between SB and total cholesterol or low-density lipoprotein cholesterol (LDL-C) levels [17]. Nevertheless, evidence exists on the positive relationship between SB and triglycerides and HDL-C among the asymptomatic population which is mostly independent of PA [17, 18].

In addition to increased CV risks, SB is highly related to other adverse health-related outcomes, which include CV disease mortality, all-cause mortality, diabetes, increased insulin resistance, high BP, and obesity [15, 19, 20]. Researchers have noticed associations between SB and markers of CVD risk factors (high BP, decreased HDL-C, high triglyceride, and increased WC), which are usually independent of PA levels [15, 17]. Whitaker et al. [21] investigated the relationship between SB and higher CDV risks, authors discovered that the time spent in SB had deleterious associations with risks of CVD. The main factor of the association between SB and increased risk of CVD was time spent watching TV and other electronic gadgets. It was discovered that replacing time spent watching TV with any other kind of sedentary activities (use of the computer, sitting and reading, use of telephone, paperwork), led to a comparatively lower CDV risk. Besides, further findings revealed that the relationship of sedentary tasks with WC, glucose, insulin, and levels of triglyceride was consistent with results from the total CDV risk score, but a strong influence was found on triglyceride levels. Furthermore, the authors noticed that when computer time was replaced by using telephone or reading, this resulted in a high levels of BP. Another research study reported that watching TV had a positive association with numerous risks of CVD, such as BMI, waist to hip ratio, BP, total cholesterol, triglycerides and LDL-C [22]. This association was noticed in either gender and adjusted for age, alcohol consumption, cigarette smoking and dietary practices. There was no association found between PA and BP, LDL-C and total cholesterol. In fact, BP, LDL-C and total cholesterol had a strong association with PI, represented by TV viewing. A systematic review reported the risk of CVD disease in children and adolescents. A positive relationship was observed between screen-time (personal computer, video gaming, TV) and higher BP, reduced degrees of HDL-C, and higher degrees of LDL-C and triglycerides in children and adolescents. Even though not all of the studies support this association in the systematic review, there is growing evidence which indicates that SB is related with detrimental effects of health outcomes and there is a higher risk of developing CVD in children and adolescents. Additionally, not taking frequent breaks during the sedentary tasks and extended periods of sedentary bouts specifically watching TV and using other electronic gadgets actually compromise the cardiometabolic profile [23].

People with CV risk or disease seem to have an apparent relationship between SB and CV risk factors. In hypertensive patients, prolonged periods spent in SB were observed to be associated with higher BP readings [24]. Similarly, in the overweight and obese population, extended periods of sitting was found to have a positive and independent relationship with BP, a 14% increase in risk of developing hypertension with every additional one hour of sitting [25]. Beunza et al. [26] carried out a prospective cohort study among 6742 healthy university students over 40 months to assess the incidence of hypertension. Authors discovered that compared to non-sedentary adults, sedentary participants had a 48% increased risk of developing hypertension which was independent of PA.

A study among 945 participants in a cross-sectional examination found that after adjusting the BMI and BP, every 30 minutes of sedentary tasks were associated with a minimal ankle-brachial index [27]. In another research study among healthy participants, it was noticed that after adjusting for the vigorous PA, resting heart rate, metabolic syndrome, and adiposity, weekend breaks were positively connected with arterial stiffness [16]. These data sets provide proof that SB is positively associated with altered vascular functionality and structure. Further research is needed to explore and fully understand the connection between these complex relationships and examine if these detrimental effects on arterial health are independent of risk factors of CVD.

In short, it is evident from the growing scientific findings that there is a higher risk of CVD (high BP, arterial stiffness, increased BMI, higher levels of blood lipids, and deseased physical fitness) associated with SB as indictaed in **Figure 3**.

3.1 Effect of short periods of sitting on cardiovascular health

Recently studies have examined the effect on CV outcome measures related to short duration (3–6 hours) of continuous sitting. Padilla et al. [28] observed

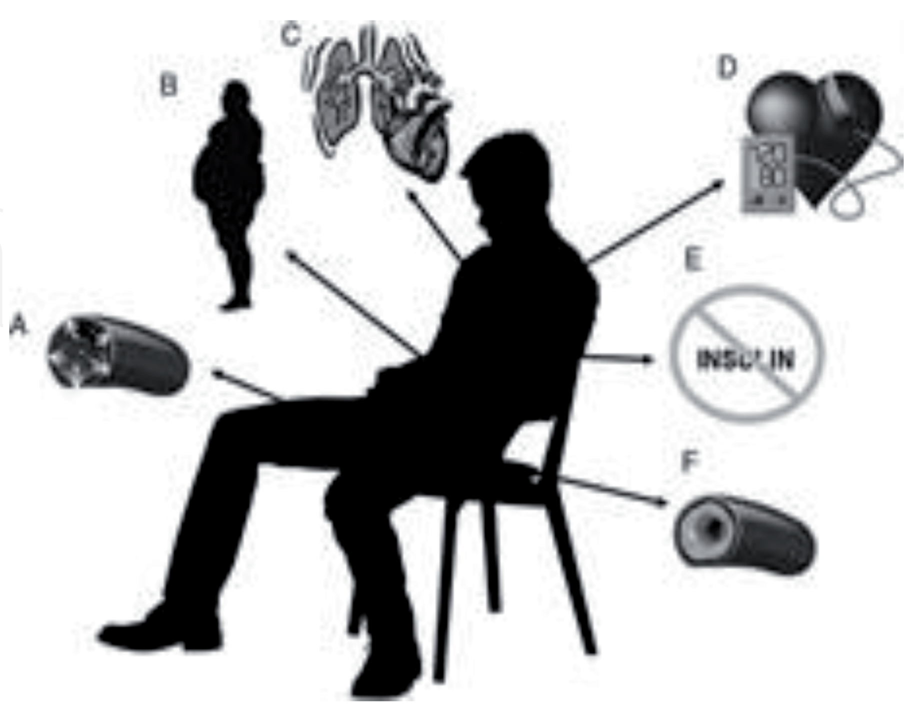

Figure 3.
Impact of sedentary behavior on risks associated with cardiovascular system: A. vasculature – Thickness and stiffness of intima-media increases. B. Anthropometric – Increased body mass index. C. Decrease in physical fitness (CRF). D. Increase in the blood pressure. E. Increase in insulin resistance. F. Increase in the blood lipids. Courtesy - Carter et al. 2017.

that continuous 3 hours of sitting resulted in an upsurge in the BP, together with a reduction in shear rate and blood flow in the popliteal artery. Similarly in another study, after 3 hours of continuous uninterrupted sitting, a reduction in the endothelial function of the superficial femoral artery (SFA) was observed, along with the simultaneous decrease in shear rate and antegrade [29]. These findings suggest that endothelial function in the lower limbs deteriorates with the practice of prolonged uninterrupted sitting. Compared to the lower limbs, uninterrupted sitting for 3 hours does not seem to have any effect on the endothelial function of upper limbs as no effect was reported in the brachial artery shear rate and endothelial function. Recently studies have explored the hypothesis that even little body movements, particularly the lower limb movements that are practiced during prolonged sitting prevent the impairment in the CV health outcomes. Larsen et al. [30] reported that during 7 hours of sitting, with a break given every 20 minutes to carry out light-to-moderate PA for 2 minutes, a significant reduction in both systolic and diastolic BP was seen. These findings point out that intervening on the SB may be appropriate and relevant, especially in a population with a high risk of CVD. Scientists have also examined the effect of regular breaks during prolonged sitting (5 hours to 3 days) on parameters such as lipids and triglycerides but did report any significant changes in any of these outcome measures [31, 32]. Perhaps longer duration break time coupled with some light-to-moderate PA is required to see the effect on these parameters. Because of the very limited information available on the impact of break time on uninterrupted prolonged sitting, further scientific research needs to be carried out to have a better understanding of the effects of break time and PA during prolonged sitting on CV risk factors.

The effect of break time and PA on uninterrupted prolonged sitting has also been investigated to find out its association with endothelial function. In normal healthy non-obese adults, after 3 hours of interrupted sitting, 5 minutes of light PA (walking on a treadmill at a speed of 2 miles per hour) every 60 minutes helped to prevent the reduction in the shear rate and dilation in SFA [29]. Another study also reported similar findings in a cohort of healthy young girls, in which the benefits of regular breaks and mild PA on SFA flow-mediated dilation were seen [33]. These findings suggest that sitting induced endothelial impairment can be offset when appropriate interventional strategies are implemented, particularly the use of low-intensity PA at regular intervals.

3.2 Effect of long periods of sitting on cardiovascular health

Currently, there is very little published literature available to support the claim that effects of long duration, acute exposure (usually more than 1 day) of SB on risk factors associated with higher CVD devlopment. Lyden et al. [34] evaluated effects on lipids and markers of insulin resistance in 10 healthy adults by imposing 7 days of prolonged sitting with little breaks in between. In comparison to the baseline, there was no change seen in fasting plasma lipids, BMI, and WC after 7 days of SB. But, when measured for 2 hours plasma insulin using oral glucose tolerance test and region under the curve were significantly increased after 7 days of prolonged sitting, indicating a detrimental capability of SB to lead to insulin resistance within 1 week [34]. In another study, the authors examined the effect of 3 days of intervention, using either 7 hours of sitting per day with 2 minutes light-intensity walks every 20 minutes or 7 hours per day of uninterrupted sitting without any breaks [31]. As measured by a mixed meal tolerance test, a significant decrease in glucose and insulin area under the curve was found after 3 days of uninterrupted sitting when compared with the group that was given breaks. As described above in this chapter, triglyceride levels did not differ between the 2 groups. Therefore, literature findings on short-term effects, usually between 3 to 7 days or immediate effects, between 3 to 6 hours of SB suggest the presence of quite significantly impaired insulin resistance, even in absence of such changes in the lipid levels. Research work carried out by Graves et al. [35] documented that using standing workstations in comparison to sitting workstations showed an average reduction of 90 minutes in sitting time every day over a period of 8 weeks. Further findings of a significant reduction in total cholesterol support the idea that extended periods of PI is required to cause an alteration in the lipid levels. To conclude, both short term and long term SB can alter vascular health such as endothelial function, peripheral blood flow, and BP.

Mechanisms underlying the SB induced vascular changes are thought to a result of haemodynamic stimuli, most probably the shear stress that causes structural and functional changes in vascular health [36]. Likewise, extended periods of uninterrupted sitting are found to be related to variations in the shear stress which could also induce vascular dysfunction. **Figure 4** summarizes the possible mechanisms associated with sitting induced risks of CVD. Hydrostatic pressure in the lower limbs is found to increase with prolonged sitting, specifically in the popliteal artery. When sitting for more than 3 hours without a break, a decrease in minimum, maximum and mean shear rate is observed in the popliteal artery [28]. Some studies have examined how alterations in shear can cause a decrease in the endothelial function related to extended periods of uninterrupted sitting. Investigations among young healthy adults revealed popliteal artery endothelial impairments caused by 3 hours of an extended period of sitting was effectively reduced by manipulating the popliteal artery perfusion via small fidgeting leg movements or by application of local heat [37, 38]. Both of these interventional strategies effectively prevented any decrease in mean shear which is associated with extended periods of uninterrupted sitting and appropriately prevented any decrease in endothelial function of the

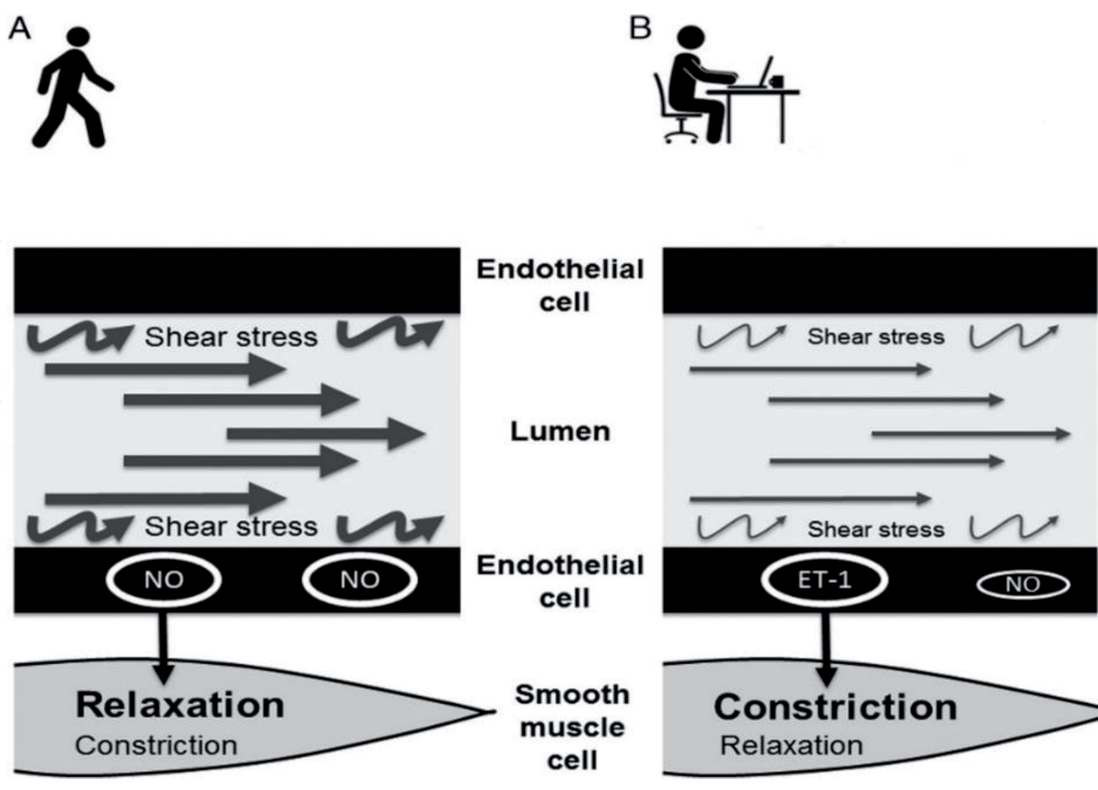

Figure 4.
Overview of mechanisms that mediate risk of cardiovascular disease in association with sedentary behavior: A. arterial structure and function while walking, increased shear stress and normal blood flow. B. Arterial structure and function after a period of SB, shear stress and blood flow is decreased, subsequently causing an increase in nitric oxide production leading to vascular dysfunction. Courtesy - Carter et al. 2017.

popliteal artery. It is believed that patterns of the shear may be equally important in addition of reduction in shear rate; it seems that shear patterns play an important role in maintaining the vascular function by increasing the endothelial function by activating the nitric oxide production or by preserving the antegrade shear stress; even though oscillatory and low shear stress can induce inflammation, increased oxidative stress and atherosclerosis [36].

The hypothesis related to changes in the shear rate and patterns is currently not well known. One of the possible reasons is that exposure to the prolonged periods of gravitational forces can elevate the hydrostatic pressure in the lower extremities, resulting in the pooling of venous blood followed by a reduction in the shear force and blood flow [39]. It has been observed that prolonged sitting causes an increase in calf circumference, reduced blood flow, and calf pooling [39]. Furthermore, an increase in the activity of the sympathetic nervous system and variations in the blood viscosity may also attribute to the alterations in the shear rate and patterns which can lead to further endothelial dysfunction [39]. All these factors may individually or in whole play a role in contributing to this relationship between prolonged sitting and dysfunction of vascular health.

4. Sedentary behavior and mortality

A nationwide cohort study in the United States revealed how sedentary time is strongly associated with all-cause mortality [40]. Over four years in a sample of 7985 middle-aged and elderly population, there had been 340 deaths reported overall. Further analysis demonstrated that longer SB with a sedentary time of more than 12 hours per day and sedentary bouts of more than 10 minutes per bout had the highest mortality risk [40]. However, the findings from a Canada fitness survey mortality follow up to underscore the adverse cardiometabolic health consequences associated with prolonged sitting. Those participants who spent most of the day sitting were seen to have a significantly poor long-term mortality outcome in comparison to those who reported spending less time sitting [41]. Further analysis showed these associations with mortality were consistent with overall sitting time measured across all levels of self-reported data of participants. Surprisingly, the relationship between sitting time and mortality was found to be stronger among those participants who were overweight and obese [41]. In another study during 6.5 years of follow-up, it was found that watching TV for a long time had a significant association with all-cause mortality rate and higher CVD mortality rate [42]. Every 1 hour increase of watching TV was seen to be associated with 11% higher risk of all-cause mortality and 18% greater risk of CVD mortality rates. Besides, compared to those who watched TV less (< 2 hours every day), there was a 80% higher risk of CVD mortality and a 46% high risk of all-cause mortality among those who watched TV 4 hours or more every day. Both these risks were found to be independent of conventional risk factors like BP, cholesterol, smoking, WC, and diet indicating a strong relationship between SB and its detrimental effects on CV and overall health. In another study in the United States, the authors examined the relationship of SB with CVD mortality outcomes based on 21 years of follow up among 7744 participants aged 20–89 years. A total of 377 deaths were reported in this study. It was observed that TV time and time spent in commuting and combined time spent in these 2 sedentary activates had a strong positive association with increased CVD deaths even after age-adjustment. Compared with those who reported spending less than 4 hours every week sitting in automobiles, an 82% greater risk of CVD mortality was seen in those who reported spending more than 10 hours every week in passive commuting. Similarly, those who spent more than 23 hours per week of combined automobile time and TV time had a 64% higher risk of dying from CVD compared to those who spent less than 11 hours every week [20].

To combat all these adverse health-related outcome risks associated with SB, recently a major focus has been directed at making health promotion a priority, including the promotion to reduce the sitting time and to take frequent breaks, in addition to participate in PA to improve the levels of CRF.

5. Breaking-up long periods of sedentary behavior and engaging in physical activity

It is believed that most often serious efforts are required from the people to make even smaller changes in the health behavior to become a part of their lifestyle. With regards to this, interventional protocols that promote healthy behaviors should be easy to follow, simple, recognizable, and not require much energy from a cognitive perspective. Because prolonged sitting is regarded to be highly habitual, the interventional approaches used should be able to instantly elicit a response of breaking and getting up and thus decreasing the prolonged sitting time. Since prolonged sitting is considered to extremely habitual, with little if any conscious planning and processing compared to PA, which requires higher degrees of planning and mental processing. Thus it is easy to express that SB is different from PA based on the above explanation.

Scientific data has provided evidence that SB is highly associated with health risks (e.g. high BP, increased levels of triglycerides, lower DHL-C, arterial stiffness, and increased BMI and WC) regardless of the PA levels [15–17]. This shows that prolonged periods of sitting cannot be compensated by just 30 minutes of MVPA and a shift in the scientific focus has been suggested to include the physiology of sedentary inactivity together with exercise when considering to address the health issues related to SB [8, 31]. If a day is divided into periods of SB, light PA, and MVPA, it can be seen that very little time is spent on light PA and MVPA and a large period is spent on sedentary activates like TV viewing, use of computer and other electronic gadgets and passive commuting. Besides, if a person tries to reduce the SB, that time is mostly spent on doing light PA rather than MVPA. Thus, it makes a lot of sense to focus and target the SB as important health behavior.

Interventional approaches should promote a healthy lifestyle in addition of including the MVPA and simultaneously a major focus should be on reducing and breaking the prolonged sedentary time [43]. The reason for limiting the sitting time is that all sedentary activities evoke a catabolic response which suppresses the skeletal muscle lipoprotein activity [7]. Even though little evidence is available with regards to the thresholds for the prolonged sitting time or when exactly sitting should be interrupted before it can evoke the detrimental health consequences, it is suggested that when short breaks are taken frequently during prolonged sitting, it can help to prevent these detrimental health outcomes [29, 30, 32]. Recently in a systematic review, authors examined the experimental and epidemiological studies and concluded that breaking up prolonged sitting can generate positive effects on metabolic-related health outcomes, even though the type, intensity and frequency of PA were different for participants based on their characteristics, particularly with regards to their habitual PA levels in each study included in the review [44]. By looking at the healthy physiological responses that the body can generate by simply standing up and breaking the prolonged sitting, people with morbidity which are related to lifestyle (SB), may be able to benefit more by taking regular breaks and decreasing the prolonged sitting time [45].

5.1 American College of Sports Medicine guidelines on reducing sedentary behavior

In our current contemporary time, we cannot completely eliminate the time spent in sedentary behaviors, but breaking-up the prolonged sitting using simple activities such as standing or walking can be very helpful at preventing the deleterious health-related outcomes, especially minimizing the higher CVD risk associated with SB. In line with this, the American College of Sports Medicine recommends to adopt an active action plan both at workplace and home to break-up or reduce prolonged periods of sitting, which is summarized in **Table 1** [46].

5.2 World Health Organization (WHO 2020) guidelines on sedentary behavior and physical activity

World Health Organization (WHO 2020) has revised the guidelines on PA and SB for all age groups including people that live with chronic morbidity or disability. It is stated that for all age groups doing some PA is always better than doing no PA at all [2]. If people are physically inactive and living a sedentary life, they should begin with PA that is small in amount and of light intensity, then slowly increasing the intensity, frequency, and time duration over time. The following

Active action plan ideas for work	Active action plan ideas for daily life
1. Take a walk break every time you take a coffee or tea break. 2. Do some leisurely walking with colleagues after you eat lunch together. 3. Stand up and move whenever you have a drink of water. 4. Whenever possible stand up as opposed to sitting down. 5. Stand up and talk on phone conversations. 6. Stop at the park on your way home from work and take a walk. 7. Walk to a co-workers desk instead of emailing or calling him/her 8. Walk briskly when headed To meetings. 9. Take the stairs whenever you can. 10. Take the long route to the restroom. 11. Schedule walking meetings with colleagues. 12. Schedule short breaks into your electronic calendar as reminders to above. 13. Every 45 minutes to one hour, do some squats, lunges, upper body stretches, shoulder rolls.	1. Take a family walk after dinner. 2. Get a pedometer and start tracking your steps. Progress to 10,000 steps or more a day. 3. Walk your dog daily. 4. Replace those Sunday drives with Sunday walks. 5. Wen watching TV, stand up and move with every commercial break. 6. Walk up and down escalators instead of just riding them 7. Walk fast when doing errands. 8. Pace the sidelines at your kids' athletic games. 9. Walk up and down the shopping aisles at the store before you shop. 10. Pick up a new active hobby, such as cycling or hiking. 11. After reading six pages of a book, get up and move a little. 12. Try standing and moving whenever you are talking on a cell phone. 13. Play with your kids 15–30 minutes a day. 14. Dance to your favorite inspiring music selections. 15. Walk briskly in the mall.c

Sit less and move more: Len Kravitz, and Chantal a. Vella (ACSM).

Table 1.
American College of Sports Medicine Information on reducing sedentary behavior.

sub-heading will cover the recommendations on PA and SB for children and adolescents, adults, and elderly including those who live with chronic conditions/disabilities in detail.

5.2.1 WHO 2020 recommendations for children and adolescents aged 5–17 years

In this population, PA confers benefits when it comes to physical fitness (CRF and muscle strength), cardiometabolic wellness (BP, dyslipidemia, glucose and insulin tolerance), bone health, cognitive functions like academic performance, and executive function, and decreased adiposity. It is suggested that this population should take part in moderate PA of at least 60 minutes every day across the week, with exercises mainly aerobic. Vigorous PA and exercises that target muscles and bones to increase the strength of these tissues should also be included at least 3 days every week. The research evidence suggests that there is a strong association between adverse health-related outcomes and SB, particularly between watching TV or recreational screen time with adverse health consequences in children and adolscents [2]. Therefore, very limited sedentary time should be allowed for this age group.

5.2.2 WHO 2020 recommendations for adults aged 18–64 years including people that have chronic conditions and disability

In grown-ups, PA confers advantages to all-cause mortality, CVD mortality, incident hypertension, incident type 2 diabetes and measures of adiposity. Recommendations for adults include 150–300 minutes of moderate-intensity PA, aerobic in nature 75–150 minutes of vigorous PA or combination of equivalent volumes of MVPA throughout the week. In addition, adults must also do muscle strengthening exercises at MVPA involving major muscle groups at least 2 or more days every week. Furthermore, evidence on effect of SB on health outcomes provide a strong support that prolonged sedentary time should be limited by adults [2].

5.2.3 WHO 2020 recommendations for older adults aged 65 years and above including people that have chronic conditions and disability

In this population, PA is beneficial in preventing falls and falls-related injuries and declines in bone health and functional ability. It is suggested that older people should follow the same guidelines as recommended for adults. In addition, the elderly should also engage in varied multicomponent PA that emphasizing strengthening exercises and functional training at the moderate-to-high intensity on 3 or even more days weekly. The recommendations on SB apply to this group in the same way as adults [2].

5.3 Australian guidelines on sedentary behavior and physical activity

Australian guidelines on SB and PA are supported by strong evidence and considers the relationship between PA (e.g. type of PA, intensity, frequency, and duration) and outcome indicators of health, including the risk of chronic diseases and obesity.

The association between SB and outcome indicators of health, including the risk of chronic disease and obesity [47]. Like WHO 2020 guidelines, Australian guidelines on PA and SB are divided based on different age groups.

5.3.1 Recommendations from birth to 5 years

Most of the waking hours of this group should be playful, engaging them in a variety of activities.

Infants from birth to 1 year: PA encouraged for this age group should be done under supervision, mostly floor-based activities of play conducted in safe environment. For infants that are not yet mobile, 30 minutes of tummy time period, which includes reaching, grasping, puling, pressing and crawling during awaking hours throughout the day [47].

Toddlers aged one to 1-2 years: For this group, it is recommended to carry out 180 minutes of varieties of PA, which include 60 minutes of energetic play like jumping, kicking, throwing and running during awaking hours throughout the day [47].

Small children aged 3-5 years: They should not be restrained in strollers or car seats for more than one hour or allowed to sit for prolonged time. Screen time spent in sedentary tasks (watching TV, playing with electronic gadgets) should not be more than one hour based on twenty four hour time period. When these children are sedentary, parents or caregivers should build a playful relationships with them through routines like singing, reading, storytelling using puzzles etc. [47].

5.3.2 Recommendations of young children and young people aged 5–17 years

This particular population ought to achieve the suggested and recommended low levels of SB and high levels of PA for optimal health benefits [47].

Guidelines on Physical Activity:

- 60 minutes or higher aerobic MVPA each day.
- Variety of several hours of light PA.
- Vigorous PA and strengthening workouts that target major muscle groups and bones ought to be included at least 3 times per week.
- Replacing sedentary time with additional MVPA to accomplish greater benefits of health [47].

Guidelines on Sedentary Behavior:

- Whenever possible breaking up prolonged periods of sedentary behavior.
- Not more than 2 hours to be spent on sedentary screen time.
- Emphasis on encouraging the positive social interactions when using electronic devices that are used for screen time [47].

5.3.3 Recommendations for adults aged 18–64 years

Guidelines on Physical Activity:

- All adults should take part in some type of PA, regardless of their age.
- Those who are beginning to engage in a new PA or those who were previously active but have stopped, shall start at a rate that is easily manageable and slowly build-up to the recommended levels.
- Adults should be active in many ways, participating in a wide range of PA that includes fitness, strength, flexibility and balance.

- They are encouraged to accumulate at least 30 minutes of moderate intensity PA, preferably every day.

- Older adults who had been enjoying vigorous PA of lifetime, shall continue to do so in a manner that is suited for their capacity, provided they abide by the recommended safety procedures and recommendations [47].

Guidelines on Sedentary Behavior:

- Whenever possible breaking-up prolonged sitting.

- Reduce the time spent in prolonged sitting [47].

5.3.4 Recommendations for older adults aged 64 years and above

For this population, being physically active for 30 minutes is achievable. In addition, their health and wellbeing can be improved further if a little increase in the recommended PA is achieved [47].

Guidelines on Physical Activity:

- If currently inactive, start with some light exercises and gradually target the recommended quantity.

- Encouraged to be physically active on most of the day, every week.

- 150–300 minutes of MVPA or 75–150 minutes of vigorous PA, or combined equivalent of MVPA, every week.

- Strengthening exercises, at least 2 times per week targeting major muscles groups of the body [47].

Guidelines on Sedentary Behavior:

The guidelines for SB are the same as recommended for adults, which includes minimizing the prolonged sitting time and taking frequent breaks whenever possible during sedentary tasks [47].

6. Conclusion

SB is a habitual behavior that can be managed effectively when appropriate interventional strategies are employed. If not ponder upon, it can lead to detrimental health consequences. Evidence strongly supports and recommends minimizing the sedentary time and taking regular breaks in between the sedentary tasks, in addition of incorporating the MVPA to decrease the CVD risks and compromising metabolic health. The higher risk of CVD mortality and morbidity and all-cause mortality is independent of PA levels in individuals who engage in longer periods of SB. Therefore, in addition to participating in recommended PA guidelines, equally important is to break-up prolonged sitting and reduce the time spent in sedentary tasks like watching TV, using the computer and other electronic gadgets, and passive commuting, which would lead to improved levels of CRF and better quality of life in all age groups, gender, race, and ethnicities.

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Conflict of interest

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