



Behavioral Medicine for Sedentary Behavior, Daily Physical Activity, and Exercise to Prevent Cardiovascular Disease: A Review

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Accepted: 30 March 2021 / Published online: 6 July 2021

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Abstract

Purpose of Review Behavioral medicine is a multidisciplinary field that has a key role in reducing risk factors for cardiovascular disease (CVD). The purpose of this review is to describe the role of behavioral medicine for CVD prevention, using physical activity behaviors (e.g., sedentary behavior, daily physical activity, or exercise) as an exemplar. Application of behavioral medicine to improve dietary behaviors is also briefly discussed.

Recent Findings Behavioral medicine interventions that address physical activity behaviors are associated with improved cardiovascular risk factors. Interventions framed in behavior change theory that integrate behavior change techniques to reduce sedentary behavior and promote daily physical activity and exercise have similarly been applied to improve certain dietary behaviors and show promise for reducing CVD risk factors.

Summary Behavioral medicine has an important role in improving various physical activity behaviors for all populations, which is essential for preventing or managing CVD. Further investigation into behavioral medicine interventions that address personal, environmental, and social factors that influence participation in physical activity behaviors, as well as the adoption of a more optimal dietary pattern, is warranted.

Keywords Behavioral medicine · Cardiovascular disease · Prevention · Physical activity · Exercise · Sedentary behavior

Introduction

Atherosclerotic cardiovascular diseases (CVD), which include coronary heart disease, stroke, and peripheral artery disease, are leading causes of death in the USA and globally [1–4]. Despite

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This article is part of the Topical Collection on *Nutrition*

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a steady decline in CVD mortality over the past decade, cardiovascular health has not improved [5]. This stagnated progress foreshadows increasing incidence and prevalence of CVD expected across most racial and ethnic groups in the coming years [6]. Nearly a quarter of CVD-related deaths are preventable by addressing modifiable cardiovascular health behaviors such as insufficient physical activity and diet [7]. Behavioral medicine interventions therefore play a key role in addressing cardiovascular risk behaviors. The purpose of this review is to define the role of behavioral medicine, using *physical activity behaviors* as an exemplar, for cardiovascular disease prevention. In this brief review, we will define physical activity behaviors (sedentary behavior, daily physical activity, and exercise) and describe the role of behavioral medicine in optimizing physical activity behaviors. We will also briefly describe the current evidence for behavioral medicine interventions that address physical activity and diet to improve cardiovascular health.

What Are Physical Activity Behaviors?

Broadly, the term *physical activity behavior* encompasses bodily movement that can be classified by purpose or intent,

intensity (or lack thereof), posture, or energy expenditure [8]. *Sedentary behavior* is characterized by a seated or reclined posture and very low levels of energy expenditure [9]. *Daily physical activity* is accumulated through engaging in the activities that make up daily life. This type of activity is referred to by several names in the physical activity literature, including but not limited to non-exercise physical activity, habitual physical activity, leisure-time physical activity, occupational physical activity, and daily physical activity [8]. Examples of daily accumulated physical activity include the total time spent preparing a meal, taking the dog for a walk, biking to commute to work, and playing basketball with friends. These activities encompass physical activity at all intensities (light to vigorous) that can benefit cardiovascular health. *Exercise* is planned, structured, repetitive activity that is completed for the explicit purpose of fitness [10]. Sedentary behavior, daily physical activity, and exercise each play an independent role in health and risk factors for CVD.

What Is the Relationship Between Physical Activity Behaviors and CVD?

Mounting evidence suggests increased sedentary behavior is associated with greater risk for CVD, diabetes, certain cancers, obesity, and premature mortality [11, 12]. High levels of sedentary behavior are also associated with elevated risk for CVD events and CVD mortality, even after controlling for time spent in moderate to vigorous physical activity [13, 14, 15•]. Consequently, several studies have shown that displacing sedentary behavior with moderate to vigorous physical activity [16–19] or even light physical activity [18] may confer significant and clinically important improvements on the cardiometabolic profile, through its effect on body mass index (BMI), waist circumference, high density lipoprotein (HDL) cholesterol, fasting glucose, and fasting insulin. Further, among people with high levels of sedentary behavior (more than 6 h per day), displacing sedentary time with standing [16] or light intensity physical activity [17] was associated with reduced CVD mortality risk. Individuals with chronic health conditions or disabilities may experience significant barriers to physical activity and exercise [20–22]. These individuals may derive health benefits from displacing sedentary time with standing or light or moderate physical activities as an achievable first step toward improving cardiovascular health [23–25]. This evidence that sedentary behavior is a risk factor for CVD, independent of physical activity, supports the need to focus on sedentary behavior as a novel and independent behavioral target for interventions.

There is strong evidence supporting the cardiovascular health benefits associated with daily physical activity and exercise. Population-based studies have demonstrated that high levels of *daily physical activity* are associated with optimal

waist circumference, HDL cholesterol, triglycerides, and a lower risk of experiencing a cardiovascular event and CVD mortality [26–29]. *Exercise* in itself has positive physiologic effects on cardiovascular health, including but not limited to its impact on coagulation, fibrinolysis, vascular remodeling, blood pressure, and lipids [30]. Given the overwhelming evidence supporting effectiveness of physical activity or exercise for the primary prevention of CVD, national and global public health guidelines speak to each type of physical activity behavior (Table 1). Furthermore, physical activity is a common component of secondary prevention programs for adults with CVD risk factors and diagnosed CVD. Physical activity recommendations that provide specific guidelines within these populations are available [41, 42]. In general, there is a consensus that achieving 150 min per week of moderate to vigorous physical activity is associated with significant cardiometabolic and overall health benefits (Table 1). However, among populations with chronic disease and those who are inactive, lower volumes of physical activity and exercise and small increases in activity may importantly improve cardiovascular health and reduce mortality risk [43].

Adherence to Physical Activity Guidelines

Despite consistent and compelling evidence of the health benefits of physical activity, adherence to physical activity guidelines is poor. Though insufficient physical activity trends persist [44, 45], the greater concern, perhaps, may be the high prevalence of sedentary behaviors observed among all ages [46]. Recent analyses of the National Health and Nutrition Examination Survey (NHANES) revealed no change in adherence to physical activity guidelines between 2007 to 2008 (63%) and 2015 to 2016 (65%), and a significant increase in sedentary behavior between 2007 and 2014 (5.7 to 6.4 h/day) [45]. Of particular concern, adults with CVD diagnoses are more likely to demonstrate persistent low levels of physical activity and high levels of sedentary behavior [47–49]. Mounting evidence for the detrimental impacts of prolonged sedentary time has been the impetus for the World Health Organization (WHO) to recommend minimizing sedentary behavior as part of the 2020 Global Physical Activity Guidelines [40•]. Coincidentally, recommendations by the WHO for physical activity and sedentary behaviors echo the messaging, “*sit less and move more*” that has been emphasized in several national and public health guidelines [31, 32, 38, 39]. Behavioral medicine plays a distinct role in promoting physical activity behaviors and supporting long-term adherence to physical activity guidelines through tailored person-centered interventions that account for diverse personal, environmental, and social factors.

Table 1 Summary of the current physical activity guidelines for adults

Country (year)	Daily physical activity and exercise recommendations			Frequency	Sedentary behavior recommendations
	Type	Intensity	Time		
Adults (18–64 years)					
Australia (2012)[31]	Aerobic	Moderate Vigorous	150–300 min/week 75–150 min/week	Most days/week	Minimize the amount of time spent in prolonged sitting
Canada (2020)[32]	Resistance Aerobic Resistance Others (including standing)	- Moderate to vigorous - Light	- 150 min/week - Several hours per day	2 d/week - 2 d/week -	Minimize sedentary behavior
Dutch (2017)[33]	- Resistance Aerobic	Moderate - Moderate	150 min/week - 50 min/week→300 min/week	Several days per week 2 d/week	Avoid long periods sitting down
European Society of Cardiology (ESC) (2021)[34•]	Aerobic	Moderate Vigorous	75 min/week→150 min/week	4–5 d/week → Most days per week	-
Finland (2009)[35]	Aerobic	An equivalent combination of moderate and vigorous intensity	150–300 min/week	Several days per week	-
Ireland (2009)[36]	Resistance/balance Aerobic	- Moderate	75–150 min/week 30 min/d or 150 min/week or a minimal of 10 min/session	2 d/week 5 d/week	-
New Zealand (2020)[37]	Resistance/balance -	Vigorous - Moderate	75 min/week - 150–300 min/week	2 d/week Throughout the week	Sit less, move more; break up long periods of sitting
UK (2019)[38]	Resistance Aerobic	Vigorous - Moderate Vigorous Very vigorous	75–150 min/week - 150 min/week 75 min/week Shorter duration	2 d/week -	Minimize sedentary time
USA (2018)[39]	Resistance Aerobic	An equivalent combination of moderate, vigorous, and very vigorous intensity - Moderate	- - 150–300 min/week	2 d/week Most days per week	Move more and sit less throughout the day
World Health Organization (2020)[40•]	Resistance Aerobic	An equivalent combination of moderate and vigorous intensity Moderate or greater Moderate Vigorous	- - 150–300 min/week 75–150 min/week	2 d/week -	Replacing sedentary time with physical activity of light or higher intensity
	Resistance	An equivalent combination of moderate and vigorous intensity Moderate or greater	-	2 d/week	

Table 1 (continued)

Country (year)	Daily physical activity and exercise recommendations				Frequency	Sedentary behavior recommendations
	Type	Intensity	Time	Frequency		
Adults aged 65 years or older Canada (2020)[32]	Aerobic	Moderate to vigorous	150 min/week	-	Minimize sedentary behavior	
	Resistance	-	-	2 d/week		
	Balance	-	-	-		
	Others (including standing)	Light	Several hours per day	-		
Dutch (2017)[33]	-	Moderate	150 min/week	Several days per week	Avoid long periods sitting down	
European Society of Cardiology (ESC) (2020)*[34]	Resistance/Balance	-	-	2 d/week	-	
	Aerobic	Moderate	150 min/week	5 d/week		
	Resistance/balance	-	-	-		
	Aerobic	Moderate	30 min/d or 150 min/week or a minimal of 10 min/session	-		
New Zealand (2013)[37]	Resistance/balance	Vigorous	75 min/week	2–3 d/week	Limit sedentary behavior	
	Aerobic	Moderate	30 min/d	5 d/week		
	Resistance	Vigorous	15 min/d	-		
	Flexibility/balance	An equivalent combination of moderate and vigorous intensity	-	-		
UK (2019)[38]	Aerobic	Moderate	150 min/week	2 d/week	Minimize sedentary time	
	Resistance	Vigorous	75 min/week	3 d/week		
	Balance	An equivalent combination of moderate and vigorous intensity	-	-		
	Aerobic	Moderate	-	-		
USA (2018)[39]	Resistance	-	-	2 d/week	Move more and sit less throughout the day	
	Balance	-	-	2 d/week		
	Aerobic	Moderate	150–300 min/week	Most days per week		
	Resistance	Vigorous	75–150 min/week	-		
World Health Organization (2020)[40]	Resistance	An equivalent combination of moderate and vigorous intensity	-	2 d/week	Replace sedentary time with physical activity of light or higher intensity	
	Balance	Moderate or greater	-	-		
	Aerobic	Moderate	150–300 min/week	3 d/week		
	Resistance	Vigorous	75–150 min/week	-		
	Resistance	An equivalent combination of moderate and vigorous intensity	-	3 d/week		
	Balance	Moderate or greater	-	3 d/week		

*Recommended a full clinical assessment including a maximal exercise test prior to vigorous-intensity activity

What Is Behavioral Medicine's Role in Physical Activity?

Behavioral medicine is a multidisciplinary field that leverages interventions focused on behaviors, psychosocial factors, and the biological sciences to improve health conditions across the lifespan [50, 51]. This field has played a central role in linking behavior with health over the past 70 years, including elucidating the profound impact of behaviors such as physical activity on CVD outcomes [52]. A broad range of people can derive benefit from cardiac behavioral medicine interventions, including people with or without CVD and people at risk for CVD [51]. The unique role of behavioral medicine in promoting cardiovascular health is the use of behavior change techniques (such as those described by Michie and colleagues in [53]) to facilitate healthy active lifestyles. Underlying the selection of behavior change techniques are theories of health behavior change. For example, interventions based in Social Cognitive Theory may enhance self-efficacy for participating in exercise classes [54], while an intervention based in the Transtheoretical Model may use decisional balance strategies to facilitate motivation for participating in exercise classes [55, 56]. Person-centered interventions that address personal, environmental, and social barriers are the core of behavioral medicine. Theories of health behavior change allow interventions to be tailored to overcome barriers unique to each individual. The provider's role in behavioral medicine interventions is to screen and, if indicated, deliver brief office-based intervention [57]. The provider may also screen and refer patients to other members of the healthcare team who have training in these interventions (e.g., nurse, occupational therapist, health coach, psychologist).

Behavioral Medicine Interventions for Sedentary Behavior and Physical Activity

Sedentary Behavior

Sedentary time is accumulated during common daily activities: workplace/desk jobs, television watching or screen time, transportation, and leisure activities [58]. These activities are context-specific and habitual in nature, and large amounts of sedentary time can be accumulated without conscious awareness [59, 60]. Thus, reducing sedentary behavior may require distinct behavioral intervention approaches that specifically target sedentary activities. In fact, a systematic review identified that interventions designed to specifically address sedentary behavior are more effective than interventions designed to address both sedentary behavior and physical activity simultaneously [61]. Behavioral interventions that address sedentary behavior may seek to reduce the total duration of sedentary time or to disrupt prolonged periods of sedentary time

with brief periods of light, moderate, or vigorous intensity physical activity [62]. A recent Cochrane review reported on an array of behavior change techniques that are associated with reduction in non-workplace sedentary behavior among older adults [63]. Among the techniques examined, self-monitoring [64] and app-based interventions that use multiple behavior change techniques [65] were promising for reducing sedentary behavior. However, the short-term nature and quality of these studies offer uncertain evidence of behavior change and weak evidence for changes in CVD risk factors and CVD outcomes. Counseling and education-based interventions that focus on reducing screen-time sedentary behavior also show promise for reducing body mass index [66]. The most abundant literature in sedentary behavior interventions addresses occupational sedentary time. These interventions leverage a combination of environmental modification and behavior change. A meta-analysis that examined the effects of movement-permissive workstations (e.g., standing desks and cycle ergometers) identified a reduction in sedentary time of 77 min per 8-h workday [67]. Among the six studies that reported on waist circumference as a secondary outcome, five reported an improvement in waist circumference. Furthermore, workers who are overweight or obese may derive greater cardiovascular benefits from sit-to-stand workstations than workers who are not overweight or obese [68]. Further research is needed that examines the impact of sedentary behavior interventions across contexts (occupational and non-occupational) on CVD risk factors.

Daily Physical Activity

Daily physical activity can be used to displace or break up prolonged sedentary time. Daily physical activity is accumulated through engagement in numerous activities that encompass the full range of intensity: light, moderate, and vigorous physical activity. Physical activity guidelines speak to this full range (Table 1), and as such, daily physical activity is viewed as a critically important target for cardiovascular health. Findings from epidemiological studies have further demonstrated that more steps per day are associated reduced CVD risk, CVD incidence, and CVD mortality [69]. Although physical activity guidelines do not prescribe minimum step count recommendations, the ease of monitoring step count-related goals has supported the development of walking interventions [70]. Other behavioral medicine approaches emphasize lifestyle-based behavior change to increase the amount of light or moderate physical activity that is accumulated through the basic and instrumental activities of daily living [71]. Behavioral medicine interventions that use counseling approaches to address daily physical activity have shown to be effective at improving CVD risk factors as part of primary [57, 72] and secondary prevention [73] of CVD. Behavior change techniques applied through counseling generally apply

frameworks grounded in behavior change theories. A meta-analysis of physical activity interventions reported that the Transtheoretical Model, Social Cognitive Theory, and the Theory of Planned Behavior were the most frequently used to promote physical activity, and no theory was superior to the others [74]. Multi-component interventions that included goal setting and at least one additional behavior change technique (such as feedback or planning) were associated with moderate effects on daily physical activity levels assessed by pedometer and self-report measures [75]. A separate meta-analysis identified that physical activity interventions that aimed to enhance knowledge, attitudes, and skills may lead to improvements in body weight, blood pressure, total cholesterol, triglycerides, and CVD risk profile [76]. Optimal delivery modes (i.e., face-to-face, remote) and intervention intensity (i.e., brief counseling versus multiple face-to-face visits) continue to be explored [77, 78]. Long-term adherence to optimal daily physical activity levels may be achievable with patient-centered referrals [79], but further research on strategies for long-term adherence is needed [80, 81].

Exercise

In addition to daily physical activity, national and global physical activity guidelines recommend that adults participate in exercise, including aerobic exercise and resistance training, for overall health and the prevention of CVD (Table 1) [82, 83]. Behavioral interventions that promote exercise participation for the prevention of CVD are guided by behavior change techniques, including but not limited to overcoming barriers, enhancing self-efficacy, action planning, developing coping skills, and evaluating intention [84–86]. Studies that employ exercise-based behavioral interventions conventionally focus on optimizing exercise dose. An appropriately dosed exercise prescription is based on four factors: frequency, intensity, duration, and type of exercise [82, 87]. Exercise, particularly when performed at the “appropriate dose,” has been shown to positively influence certain CVD risk factors [88].

Supervised exercise interventions are often prescribed to increase levels of physical activity and improve cardiovascular health for individuals with or at risk for CVD [87, 89–91]. Among the most empirically supported and evidence-based programs is cardiovascular rehabilitation, which is sometimes referred to as cardiac rehabilitation. Cardiovascular rehabilitation programs are recommended for individuals with CVD (including heart failure) [92, 93] and are associated with improved clinical outcomes [94, 95]. Cardiovascular rehabilitation is a comprehensive program that includes tailored, individualized exercise prescriptions guided by assessment and individualized goals [87]. A critical component of cardiovascular rehabilitation programs is behavioral counseling, which is used to explore key behavioral factors to promote engagement in physical activity, including motivational interviewing,

goal setting, coping strategies, understanding facilitators and addressing barriers, and problem-solving strategies to integrate physical activity into daily life [87]. In the context of these behavioral factors, an exercise program is dosed in a personalized, tailored manner [87].

Despite clear guidelines delineating recommended levels of exercise (Table 1) and the success of supervised exercise programs, like cardiovascular rehabilitation, in improving CVD risk factors, individuals often do not meet the physical activity guidelines [45]. This may be due to difficulty with initiation, adoption, and adherence to exercise programs for individuals with or at risk for CVD. The ideal method of referral to supervised and structured exercise programs to promote adoption and adherence is not known [57, 96–99]. Exercise referrals by primary care providers have been associated with trends toward increased levels of physical activity, but these findings, while important, were not statistically significant [99]. Despite well-established clinical benefits, support by national health agencies, and clear referral mechanisms, participation in cardiovascular rehabilitation programs remains extremely low [100], which has prompted research on identifying barriers to enrollment and strategies to enhance participation [101, 102].

Behavioral medicine has an important role in the development and evaluation of interventions to promote long-term participation in supervised exercise programs [103]. Self-efficacy and, particularly, autonomous motivation have been identified as factors that may influence long-term participation in exercise programs for individuals with established CVD [104]. Self-regulatory efficacy and its relationship to adherence have also been proposed as areas to address to promote continued participation in cardiovascular rehabilitation [105]. Perceived barriers influence intention and participation, so these factors may also need to be addressed to encourage continued participation in cardiovascular rehabilitation programs [84]. It was recently reported that women had significantly lower adherence rates than men in cardiovascular rehabilitation, which highlights an important area where further investigation and tailored interventions are needed [106]. Future research on interventions to promote long-term participation in supervised exercise programs is vitally needed, particularly focusing on the role of theory-guided behavior change techniques that address personal, social, and environmental factors [85, 103].

Behavioral Interventions that Address Physical Activity and Diet

A recent meta-analysis identified that adherence to multiple healthy lifestyle behaviors, such as physical activity and healthy diet patterns, is associated with a 66% greater reduction in CVD risk factors than adherence to one or no healthy

lifestyle behaviors [107]. Healthy dietary patterns include the Mediterranean-style diet or, similarly, those that emphasize higher intakes of plant-based foods, whole-grains, lean meats, seafood, and foods with healthy fat sources (e.g., nuts, unsaturated vegetable oils) and lower intakes of processed meats, sugar-sweetened foods and beverages, and refined grains [108]. Adoption of favorable dietary patterns, in addition to physical activity or exercise, is recognized as a critical strategy to improve cardiovascular health and reduce risk of CVD and related comorbidities [7]. As such, the US Preventive Task Force has identified that behavioral medicine interventions that promote physical activity and healthful diet patterns are likely to be effective at improving CVD risk factors (e.g., blood pressure, cholesterol, glucose, and adiposity) among adults with and without elevated CVD risk factors [7, 72, 73]. Given the strong evidence base, it is clear why well-established supervised exercise intervention programs (i.e., cardiovascular rehabilitation) integrate diet and nutrition counseling as a core component to promote cardiovascular health [87]. Accordingly, there is an overlap among specific behavior change techniques that influence physical activity behaviors and diet patterns. Specifically, motivational interviewing, goal setting, problem solving, feedback on behavior, and social support are critical techniques of theory-driven interventions that are considered to effectively modify both behaviors [72, 73, 109–111]. Further, interventions that include the use of adding objects to the environment and social comparison were identified as key behavior change techniques to promote healthy dietary patterns [111]. Further research in this area should focus on optimizing intervention dose and identifying specific behavior change techniques that improve intervention efficacy, which is necessary to promote and maintain meaningful changes in dietary behaviors. Furthermore, it is critical to account for individual social determinants of health that impact adoption, implementation, and translation of interventions targeting diet, across the diverse populations served in clinical practice [112].

Future Directions

Behavioral medicine has made profound contributions to the prevention of CVD with interventions that promote behavior change for physical activity and diet behaviors. In this brief review, we focused on behavioral techniques to improve physical activity behaviors (inclusive of interventions that address both physical activity and diet) that have potentially important implications for CVD risk management. However, further research is needed. Theory-driven behavior change techniques can facilitate “*sitting less and moving more,*” but behavior change takes time and requires active participation and communication between providers and patients. Investigation into behavior change techniques to reduce

sedentary behavior and increase physical activity that occur in community-based environments is vital, particularly in the context of global pandemics, such as the COVID-19 pandemic [113]. Further, there is a great need for exploration into behavioral factors that facilitate promotion of long-term maintenance of reduced sedentary time and increased physical activity. Given the tremendous growth of technology, there is great opportunity to integrate behavior change techniques into electronic and mobile health supported interventions to reduce sedentary behavior and promote physical activity for CVD risk reduction in various high-risk populations [114]. Finally, there is a critical need to advance the science on the most appropriate behavior change techniques that can be applied to vulnerable, diverse, and under-resourced populations; such research may consider unique patient-specific environmental and social factors to promote health equity for the prevention of CVD [112, 115].

Conclusion

CVD is a common and pervasive disease that can be prevented by reducing risk factors with behavior modification. Behavioral medicine has a critical role in CVD risk factor reduction. Interventions grounded in behavior change theory have demonstrated success at reducing sedentary behavior and promoting physical activity. Similar approaches have been used in physical activity interventions that also address diet. However, low adherence to physical activity guidelines persists. There is a substantial opportunity for adoption and integration of patient-centered personalized behavioral interventions that effectively promote behavior change related to sedentary behavior and physical activity, as well as diet, for the prevention and management of CVD.

Funding Research reported in this publication was supported by the National Heart, Lung, and Blood Institute (M. Hannan and E. Kringle, Award Number T32HL134634; D. Laddu, Award Number K01HL148503), and by the by the National Institute on Alcohol Abuse and Alcoholism (C.L. Hwang, Award Number K99AA028537). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. M. Hannan is also supported by the Robert Wood Johnson Foundation as a Future of Nursing Scholar Postdoctoral Fellow. The views expressed here do not necessarily reflect the views of the Foundation.

Declarations

Conflict of Interest The authors declare no competing interests.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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