Circulation

AHA SCIENTIFIC STATEMENT

Sedentary Behaviors in Today's Youth: Approaches to the Prevention and Management of Childhood Obesity

A Scientific Statement From the American Heart Association

ABSTRACT: This scientific statement is about sedentary behavior and its relationship to obesity and other cardiometabolic outcomes in youth. A deleterious effect of sedentary behavior on cardiometabolic health is most notable for screen-based behaviors and adiposity; however, this relation is less apparent for other cardiometabolic outcomes or when sedentary time is measured with objective movement counters or position monitors. Increasing trends of screen time are concerning; the portability of screen-based devices and abundant access to unlimited programming and online content may be leading to new patterns of consumption that are exposing youth to multiple pathways harmful to cardiometabolic health. This American Heart Association scientific statement provides an updated perspective on sedentary behaviors specific to modern youth and their impact on cardiometabolic health and obesity. As we reflect on implications for practice, research, and policy, what emerges is the importance of understanding the context in which sedentary behaviors occur. There is also a need to capture the nature of sedentary behavior more accurately, both quantitatively and qualitatively, especially with respect to recreational screen-based devices. Further evidence is required to better inform public health interventions and to establish detailed quantitative guidelines on specific sedentary behaviors in youth. In the meantime, we suggest that televisions and other recreational screen-based devices be removed from bedrooms and absent during meal times. Daily device-free social interactions and outdoor play should be encouraged. In addition, parents/guardians should be supported to devise and enforce appropriate screen time regulations and to model healthy screen-based behaviors.

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Key Words: AHA Scientific Statements ■ pediatric obesity ■ prevention and control ■ sedentary lifestyle

https://www.ahajournals.org/journal/circ

It was Owen and colleagues[1] who first proposed that sedentary behavior was distinct from physical inactivity. The latter describes low involvement in light, moderate, or vigorous physical activity. In contrast, sedentary behaviors are "a unique set of behaviors, with unique environmental determinants and a range of potentially unique health consequences."[1] From the Latin *seder* (to sit), sedentary behaviors typically occur while seated but more generally refer to any low-energy expenditure pursuit such as television viewing, reading, and motorized transport. Physical inactivity has been described as the fourth highest risk factor for mortality worldwide[2] and is associated with excess morbidity and mortality in adults.[3] No such claims have been attributed to sedentary behavior, but longitudinal studies among adults show that increases in key indicators of sedentary behavior, including screen time and sitting time, are associated with an increased risk of fatal and nonfatal cardiovascular disease.[3] In its statement focusing on sedentary behavior and disease outcomes in adults, the American Heart Association further concludes, "sedentary behavior contributes to CVD [cardiovascular disease] and diabetes mellitus risk"[4] and recommends that adults "sit less, move more." Although it seems reasonable to generalize this advice to children, the deleterious effects of sitting on cardiometabolic risk factors observed in adults are generally not supported in pediatric studies.[5,6] On the other hand, screen time, generally operationalized as television viewing time, has consistently been associated with a range of adverse outcomes, including adiposity,[7,8] in children. However, it is fair to question whether these findings are still relevant because much of the evidence is based on technology that precedes the modern screen-based media landscape.[9] Until recently, recreational screen time included mostly television viewing time, with video games, DVDs, and computer use occasionally referenced. Today, the image of the stationary television set in a centralized location where family members gather to watch live programming falls short of most children's experience. According to Common Sense Media, the average daily time spent using recreational screen-based media among 13- to 18-year-olds was 6 hours, 40 minutes, of which only 2.5 hours were spent watching television content.[10] Although access differs by income, 7 in 10 adolescents own a smartphone and use it an average of 4.5 hours daily, excluding talking and texting.[10] Confronted with this virtual ubiquity of screens, researchers are grappling with key questions: What are the appropriate indicators of sedentary behavior? What are the implications for children's health? What opportunities can we seize to mitigate their potential impact? This American Heart Association scientific statement provides an updated perspective on sedentary behaviors and contexts specific to modern youth. We focus primarily on the possible impact of sedentary behaviors on pediatric obesity and secondarily on other possible cardiometabolic consequences in children and adolescents. In the next sections, we summarize the state of knowledge with respect to sedentary behavior and youth, identify potential opportunities for research, and offer general considerations for reducing sedentary behaviors.

SEDENTARY BEHAVIOR MEASUREMENT

Throughout this statement, total sedentary time refers to the accumulated time throughout the day spent in any activity that yields energy expenditure values no greater than when at rest, excluding sleep. In adults, this has been operationally defined as activities producing a metabolic equivalent of task of ≤1.5.[11] This threshold may not be entirely appropriate for children; classification accuracy has been reported to improve when a threshold value of 2.0 is used to identify children's sedentary time.[12] Total sedentary time can be captured objectively through the use of movement sensors (accelerometers) or position monitoring devices (inclinometers), whereas screen time relies on subjective self-reports or proxy reports, most commonly through recalls or diaries.[13] Throughout this statement, recreational screen time is used to describe the total reported time engaged in recreational screen-based pursuits; this combines time watching television and time spent using the computer or other screen-based device such as tablets and smartphones to view television content, watch movies and videos, browse the Internet, spend time on social media, and play video games.

Accurate measurement of sedentary behavior is essential. The Table summarizes instruments and methods that are commonly used in sedentary behavior research in youth, along with their strengths and limitations. Broad categories of assessment include objective approaches, self-report (or proxy report), and direct observation. Self-report tools provide the opportunity to describe the behavioral context and type of sedentary behavior; they are generally cost-effective, and they exert a relatively low burden on participants.[30] However, self-reported sedentary behavior is susceptible to various forms of bias[31,32] such as social desirability or poor recall of duration. Nevertheless, reliability coefficients of self-reported sedentary behavior for pediatric populations are generally high, and validity coefficients are wide-ranging, with lower validity coefficients reported for younger children.[33–35] Self-reported hours of television viewing is the most commonly referenced indicator, likely because television viewing time has traditionally been the sedentary behavior that is most

Table. Traditional and Emerging Methods for Assessing Sedentary Behavior in Children and Adolescents: Strengths and Limitations*

	Typical Approaches in Children	Methods	Strengths	Limitations
Self-report	Questionnaires Examples: International Physical Activity Questionnaire, Sedentary Behavior Questionnaire, Child Sedentary Activity Questionnaire	Recall of activity (eg, type, social contexts) within a specific recall time frame Specific sedentary activities in recall may include sitting time, television watching, computer use, reading, transportation Reference: 14	Provides information on type, context of activity (location and social network with whom activity is done), and duration of activity Low cost Ability to measure large samples	Requires validation against objective measures Recall bias is common Intensity of activity may not be well documented Low reliability and validity in some cases Does not provide a reliable measure of intensity of activity Not suitable for younger children Social desirability biases
Objective	Accelerometry Examples: ActiGraph GT3X, ActivPAL, Sensewear Pro Armband	Sensor that measures physical acceleration (ie, change in velocity over time), from which minutes spent in sedentary, light, moderate, and vigorous activity can be derived Considered to be one of the current standards in assessing free-living physical activity levels Usually placed at waist/hip, wrist, or ankle References: 15–21	Able to assess intensity of activity Can assess and calculate patterns of physical activity Can obtain data for vertical and nonvertical motions	Lack of a standard cut point† Disparities in data processing procedures among researchers Missing data are common; data entry may be required Range of cut points varies among researchers No data for 0- to 2-year-olds Does not provide contextual information Sleep must be discounted from wear time (for 24-h protocols) Cost associated with the purchase of accelerometers Technical expertise required to transform the raw data into usable data Additional costs associated with retrieving the monitors from study participants Compliance with wearing the device
Others	EMA	Use of cell phone prompts (either randomly or at specific predetermined times) to attempt to capture more detail about activity and location attributes Reference: 22	Real-time self-reported data EMA strategy to measure sedentary behavior appeared to be feasible and acceptable in children as young as 9 y of age	Relies on participants responding to a prompt Relies on accurate data entry by the participant Does not indicate the intensity or duration of activities Additional cost of mobile phone
	Inclinometers Example: ActivPAL	Instrument that measures posture and can distinguish between sitting, standing, and lying Device is usually worn around the thigh Reference: 23	Provides information on body posture (ie, sitting/lying, upright) and stepping speed (from which energy expenditure can be inferred indirectly)	No consensus on minimum wear days and minimum wear time Very few studies have validated the use of inclinometers in youth populations Studies have used a variety of attachment methods (ie, to fix inclinometer to thigh), and it is not clear whether the type of attachment (eg, PAL stickies vs a piece of Hypafix) may influence wear compliance Provides no information on the type of behavior being undertaken or the social or environmental context in which it occurs Poor compliance with wearing the device
	Wearable cameras, OpenBeacons, GPS, RFID, RTLS, etc	New technology to contextualize activity Wearable cameras take photos from a first-person point of view GPS relies on satellites to calculate longitude and latitude coordinates to provide objective quantification of outdoor location RFID and RTLS measure indoor location Complementary source of information to accelerometer data	Can provide an objective measure of locational context and complement accelerometer data Wearable cameras and OpenBeacons able to record whether the participant is alone or socially engaged	Very few studies use new technology to complement accelerometer-based behavior assessment Signal loss in some indoor or underground locations for GPS Compliance with wearing the device (especially if participant is required to wear >1 device) Image coding and associating to accelerometer data are time consuming and labor intensive Short battery life (wearable cameras)

(*Continued*)

Table. Continued

	Typical Approaches in Children	Methods	Strengths	Limitations
	Direct observation Example: SOFIT	Physical activity and inactivity are observed by trained staff, mostly during PE in schools Observations on student engagement (eg, sedentary behaviors such as lying, sitting, standing), lesson context, and teacher behaviors are recorded References: 24, 25	Potential for providing contextual information Less potential for bias than self-report or proxy report measures Good method for young children because their ability to recall physical activity is more limited Demonstrated as highly reliable in estimating activities during PE Provides lesson context (eg, game, fitness, general management), student engagement, and teacher interactions that are not captured in other measures	Highly labor intensive and expensive Difficulty observing children and adolescents in large classes Risk of behavioral changes in subjects who are being observed (reactivity) Cannot assess total sedentary time, only sedentary behavior in specific predefined settings (eg, home, classroom, playground, parks)

EMA indicates ecological momentary assessment; GPS, global positioning system; PE, physical education; RFID, radiofrequency identification; RTLS, real-time locating systems; and SOFIT, System of Observing Fitness Instruction Time.

*Heart rate monitors and pedometers have the potential to measure physical inactivity but have not been used to assess sedentary behavior in youth.[26–29]

†Although there is no agreed-on standard for data processing, the following thresholds have often been used in youth sedentary behavior studies: epoch, 15 seconds for children 2 to 18 years of age; axis, vertical or vector magnitude; monitoring, 7 days of wear; minimum wear time for analysis, total of ≥4 weekdays or 3 weekdays, 1 weekend, and 6 hours/day (360 minutes); and sedentary cut point, 0 to 204.[15–21]

consistently associated with adverse health outcomes in adults[36] and children[37] alike.

Accelerometers are devices that measure and record acceleration and can be used to gauge the frequency, intensity, and duration of physical movement. Accelerometers are often preferred because they clearly overcome the inherent biases of subjective reports. Different cutoff points[38–42] and epoch length[41–43] and decisions dealing with nonwear time[44,45] have led to substantial variation in estimates of prevalence and of reported associations between sedentary behavior and health-related outcomes.[46] The lack of standardized methods for processing raw data and computing the volume of sedentary behavior remains a major limitation. Furthermore, estimated volumes of activity can differ across brands of accelerometers.[47] Typically, study protocols targeting physical activity require children to wear accelerometers for 7 consecutive days and to exclude participants with <4 valid days (ie, with a minimum of 10 hours of wear time). However, >7 days appears to be necessary to accurately assess sedentary behavior in children.[48,49] Classification accuracy is particularly low for preschool children,[50,51] with variations attributed to differences in brand-specific programming, cut points to define sedentary time, and number of days of assessment.[52]

Epoch length, the time sampling interval in which the accelerometer consecutively measures counts, is thought to play a particularly important role in the potential (mis)estimation of time spent at various intensities of activity[53,54] in younger children. Wide variation in epoch length may further limit comparisons across studies; shorter epochs (eg, 5 seconds) are more sensitive to detecting physical activity than longer ones (eg, 1 minute) and therefore less likely to misclassify sedentary time. This is of particular importance in children for whom sitting may be more frequently interspersed with fidgeting, standing, or even brief bouts of light physical activity.

Research protocols typically call for accelerometers to be placed at the hip or on the wrist. In direct comparisons, hip placement provides greater specificity and sensitivity than wrist placement for categorizing adults as sedentary,[55,56] possibly because of its greater proximity to the center of the body's mass and because wrist movements are recorded regardless of large body mass movement (eg, while seated). Although both methods appear to perform similarly in children,[57] accelerometer wear compliance among children and adolescents is superior for wrist placement rather than for hip placement.[58,59]

Traditional "waking hours" accelerometer protocols require participants to remove the device at bedtime and resume wearing it on waking[60] or to discount data collected between self-reported usual bedtime and wake time in instances when accelerometers are worn continuously for 24 hours.[61] Increasingly, 24-hour protocols are being promoted to assess energy expenditure and activity patterns continuously when accelerometers are used.[62] A resulting challenge is the need to differentiate sleep from wake time in the process of analyzing these data[15,63] because different criteria may lead to different estimated volumes of sedentary time.[64]

Inclinometers (eg, the ActivPAL) can document standing, sitting, or lying down positions; these devices are typically worn on the thigh and detect limb position and postural changes. Although the measurement properties of inclinometers have been reported for preschool[23] and adult populations,[65] they have not

been established in school-aged populations. School children's irregular sitting styles (eg, sitting on the edge of the chair or with elevated knees) may hamper our ability to accurately classify sitting.[66]

Several alternative approaches for assessing sedentary behavior are noteworthy. In particular, ecological momentary assessment, in which a person is queried randomly throughout the day to report on variables of interest, including behavior, location, mood, and presence of others, has been used to describe patterns of sedentary behavior in youth.[67–69] Although feasible for use in older children, ecological momentary assessment can be time consuming and intrusive and can place an unreasonable burden on respondents. Direct observation, wherein a trained observer classifies children's free-living activity by categorizing their behavior in predetermined areas for given time segments,[30] has been used more often to assess physical activity, but it may also be useful for documenting sedentary behavior in limited contexts.

Sedentary Behavior Measurement: Summary of Key Findings

- Self-reported time spent watching television remains the most common measure of sedentary behavior in children.
- Accelerometers are useful to describe patterns and volumes of sedentary behavior but lack contextual information.

SEDENTARY BEHAVIOR PREVALENCE

Sedentary Time Assessed From Accelerometers

In the 2003 to 2004 NHANES (National Health and Nutrition Examination Survey), it was estimated that children and adolescents were sedentary for ≈7 hours daily; in the 2009 Canadian Health Measures Survey, the average sedentary time was 8.6 hours daily, or 62% of participants' time awake.[70,71] NHANES included participants with 1 to 7 days of wear time, whereas the more recent Canadian Health Measures Survey applied a more rigorous minimum of 4-day wear time to its measurement protocol.[70,71] Measured sedentary time increases substantially with age and is marginally higher in girls than in boys.[70–72] In the Gateshead Millennium cohort, median daily sedentary time increased from approximately half of waking hours at age 7 years to three quarters of waking hours at age 15 years, with the steepest increase occurring between the ages of 9 and 12 years.[73] Modest differences by race or ethnicity are apparent, but they may vary by age and sex; mean sedentary time was greater in 16- to 19-year-old black boys compared with their white or Mexican American counterparts[74] and lower in 6- to 11-year-old black girls compared with same-aged white or Mexican American girls.[70]

Children of preschool age (2–5 years) are sedentary between 7 and 7.5 hours daily on average,[75] reaching an excess of 90% of their day according to some reports.[76] However, estimates vary widely, partly as a result of lower accuracy when accelerometers are used in very young children.[50,51]

Sedentary Behavior Assessed From Self-Report or Parent Report

In a recent systematic review of mostly US-based studies, the average daily television time among children <2 years of age ranged from ≈35 minutes to >3 hours.[77] The proportion of children meeting recommendations of zero television viewing ranged from 3% to 83%. Given the substantial variability across studies, the true prevalence is not known, but a majority of toddlers are engaging in screen time, contrary to national recommendations.[78]

In an Australian study, preschool children had an average of 113 min/d of screen time, well above their recommended maximum 60-minute threshold.[79] According to the 2009 to 2010 NHANES, 46% of all elementary school children exceeded the recommendation of ≤2 hours of screen time per day, with children 9 to 11 years of age least likely to fall below the 2-hour threshold.[80] According to more recent pooled data, two thirds of youth consistently exceed 2 h/d of screen time.[81] In the 2011 National Youth Risk Behavior Survey, 31% of students in grades 9 through 11 spent ≥3 h/d on a computer unrelated to school work, and 32% watched ≥3 hours of television per day; 4 years later, 42% of students in grades 9 through 12 were spending ≥3 h/d on a computer during their leisure time.[82]

As with measured sedentary behavior, age is generally positively associated with screen time.[83] Boys tend to report more television viewing and video game playing, whereas girls report more computer use.[84] There are modest differences by ethnicity/race,[85–87] with blacks reporting the highest prevalence, followed by Hispanics, with non-Hispanic whites reporting the lowest.[87] However, Fulton et al[88] found that Mexican American youth were almost twice as likely as their non-Hispanic counterparts to report no computer use in the previous day compared with non-Hispanic whites.

Several studies have noted a decrease in television viewing among US students and a concurrent increase both in computer use and in video game playing over the past 2 decades.[82,84] However, total recreational screen time is far greater when other screen-based devices are taken into account. The 2013 Kaiser Family Foundation report provides one of the most detailed

descriptions of media use by US youth.[89] In 2009, youth 8 to 18 years of age logged a daily average of 4.5 hours of television content, 1.5 hours of (recreational) computer use, and 1.2 hours of video games when all mobile devices and web-based sources were included, representing a far more substantial increase in overall screen time compared with 1999 values. Indeed, in 2009, only 60% of television content was through regular programming viewed on a television set, and 40% was recorded, on demand, or streamed on an alternative platform such as a laptop, tablet, or smartphone. According to a recent Common Sense Media report,[10] 13- to 18-year-olds are spending 6 hours, 40 minutes daily on all screen media combined, including 2.5 hours watching television content, whereas preadolescents are spending just over 4.5 hours daily on average on all screen-based recreational media, including 2.5 hours watching television content. With the continued proliferation of viewing platforms and seemingly unlimited content available at any time, television viewing is not likely to see meaningful decreases, and overall screen time is likely to increase.[90–92]

Sedentary Behavior Prevalence: Summary of Key Findings

- School-aged children are sedentary for ≈8 of their daily waking hours on average; most are engaging in excessive screen time.
- Screen time increases substantially with age, most notably during preadolescence.
- Traditional television viewing has declined in the past 10 years, whereas use of other screen-based devices for viewing television and other recreational content is on the rise, leading to overall net increases in screen time.
- Adolescents are the most sedentary of pediatric populations and are engaging in the most total recreational screen-based media.

CORRELATES OF SEDENTARY BEHAVIOR

There are few consistently reported correlates of sedentary behavior.[85,93–95] Moreover, objectively measured sedentary behavior and screen time have few common correlates,[94,96] often differing by type of screen-based activity[97,98] and by sex.[99] Sedentary behavior varies by socioeconomic status according to some reports,[77,85,100] but this relationship is not consistent across all behaviors: Lower socioeconomic status is associated with more hours of television viewing time[85] but not with computer- or video game–based screen time[101] or with leisure-time computer use.[97] However, the inverse has been reported with the use of accelerometer-measured sedentary time, with children from families with higher socioeconomic status being more sedentary during after-school hours and on weekends.[99]

A number of correlates from family, home, and neighborhood environments have been identified, especially for screen time. These are based largely on cross-sectional studies and vary considerably between study populations. More outdoor play is associated with lower total sedentary time among school-aged children,[102,103] whereas parental restrictions on outdoor play are associated with greater sedentary time in girls.[99] Maternal television viewing is positively associated with sedentary time in girls[99] and with screen media use in children <3 years of age.[104] Maternal distress or depression and less cognitive stimulation in the home environment are also associated with greater screen media use in younger children.[104] Not surprisingly, the number of televisions and computers or game consoles in the household is positively associated with screen time.[85,86,105] Having a television set in the bedroom is also associated with more screen time,[105–111] particularly in boys,[112] and with more accelerometer-measured sedentary time.[113] Similarly, the presence of a computer in the bedroom is positively associated with screen time,[113] and the presence of a video game system in the bedroom is positively associated with time spent playing video games.[109] Access to televisions, computers, and mobile devices in the bedroom can disrupt sleep, leading to later sleep onset and shorter sleep duration.[114–116] This is of concern given the link between poor sleep quality and obesity.[117] Having family television viewing rules is associated with lower television viewing time.[85,105,109,110,118] Lower frequency of family meals[110,119] and eating meals in front of the television[120] are associated with greater screen time. Distance to green spaces in the neighborhood is associated with more weekly television time in children,[121] whereas those living in neighborhoods with more services, more walking infrastructure, and more parks were less likely to exceed 2 hours daily of screen time.[122] An increase in the availability of neighborhood green space is associated with a reduction in weekend television viewing, but in boys only.[123] Neighborhoods with greater access to a diversity of local and youth-related destinations are associated with decreased screen time, but in girls only.[124] Parental perception of lack of neighborhood safety is associated with greater television viewing,[125] and crime rates are positively associated with video game playing in boys and with television viewing in girls.[126]

Correlates of Sedentary Behavior: Summary of Key Findings

- There are few consistent correlates common to both measured and reported sedentary behavior.

Circulation. 2018;138:00–00. DOI: 10.1161/CIR.0000000000000591

- Correlates tend to differ by age, sex, and indicator of sedentary behavior.
- Reported environmental correlates associated with greater screen time include number of accessible screen-based devices, presence of a television in the bedroom, fewer family rules about television viewing, infrequent family meals, less walkable neighborhoods, fewer appealing outdoor areas, and concerns about neighborhood safety.

EFFECTS OF SEDENTARY BEHAVIOR ON ADIPOSITY AND CARDIOMETABOLIC HEALTH

There is little to no association between objectively measured sedentary behavior and adiposity in children and adolescents both in cross-sectional and in longitudinal studies,[127–129] particularly after accounting for moderate to vigorous physical activity.[128,129] However, a positive relationship has been observed with the use of self-reported screen-based measures,[8,37,127,130,131] even after controlling for physical activity[132] and diet.[131,133] In the NHANES, participants who exceeded 2 hours daily of recreational screen time were 1.8 times more likely to be adolescents with overweight or obesity.[132] The association of screen time with adiposity may be confounded to some extent by the effects of sexual maturation.[88]

Sedentary behavior can cluster with other health behaviors such as diet, physical activity, and sleep.[134] How best to account for these covariates to better quantify and classify sedentary behavior is unclear. It is notable that in a 2-year longitudinal study of 9064 children, television watching was positively associated with weight gain, but conversely, elevated weight was associated with an increase in television watching, raising questions about the directionality of the relationship.[135]

Studies focused on cardiometabolic risk factors other than adiposity have generally failed to observe any deleterious effect of objectively measured sedentary behavior,[136] in particular after adjustment for moderate to vigorous physical activity.[129,137] In a systematic review that included only cross-sectional studies, greater time spent in sedentary behavior (as measured by either screen time or accelerometer) was associated with lower insulin sensitivity and clustering of metabolic risk factors in youth; however, longitudinal studies to support these observations are lacking.[138] In pediatric studies, no association has been reported between either objectively measured sedentary behavior or screen time and any of the following: glucose and lipids,[139] blood pressure and cholesterol,[140] impaired lipid profiles and blood pressure,[138] and a general cardiometabolic risk score.[141] However, television viewing and total recreational screen time in adolescence, along with increases in these behaviors, were associated with unfavorable levels of several cardiovascular risk factors in young adulthood, including adiposity, triglycerides, and metabolic syndrome.[142] Cross-sectional associations between screen time and metabolic syndrome have also been reported. Specifically, the odds of having metabolic syndrome were greater in those engaging in >2 h/d of screen time on weekends only[143] and in a Korean study of youth engaging in >35 h/wk of screen time compared with youth who engaged in <16 h/wk.[144] In a cross-sectional study, screen time was associated with an increased likelihood of metabolic syndrome in a dose-dependent manner, independent of physical activity.[145]

Effects of Sedentary Behavior on Adiposity and Cardiometabolic Health: Summary of Key Findings

- Screen time is associated with adiposity and often persists after adjustment for diet and physical activity.
- Associations between screen time and adiposity are more consistently observed in cross-sectional than in longitudinal studies; associations between screen time and other cardiovascular risks have been observed infrequently.
- Objectively measured sedentary behavior generally is not associated with adiposity or with other cardiovascular risks.

EVIDENCE FROM EXPERIMENTAL STUDIES: SEDENTARY BEHAVIOR INTERVENTIONS

Interventions to reduce sedentary behavior in youth are usually delivered in home, school, or daycare settings but may also occur in the community and in the context of primary care.[146] By far, most interventions that target reductions in sedentary behavior do so as part of a more comprehensive program; consequently, disentangling the specific effects of the various intervention components is rarely feasible. In general, interventions specifically designed to reduce sedentary behavior report small but significant reductions in sedentary time, with stratified analyses revealing greater decreases in younger participants (<6 years of age) and when interventions are >6 months in duration.[146,147]

Family-based interventions designed to reduce sedentary behavior in youth relied mostly on screen time as the measure of sedentary behavior, with the exception of a few studies that used accelerometers.[148–150]

Parents are frequently targeted as key agents of behavior change, in daycare settings and elsewhere, and are provided with behavioral counseling and strategies for reducing screen time and for increasing opportunities for active play. Although decreases in accelerometer-based sedentary behavior have not been reported,[148,151–153] this is based on a limited number of studies that include pilot and short-duration interventions.[148,152,153]

Several interventions in preschool children, however, led to decreases in screen time[154,155] and in accelerometer-based sedentary behavior, with effects ranging from 13 to 23 fewer minutes per day spent being sedentary.[149,150] One study[156] found that the intervention resulted in decreased mean hours of television viewing in younger children (<2 years of age) but not in children 3 to 5 years of age. A systematic review of 31 high-quality studies in children up to 5 years of age also concluded that interventions to reduce screen time and overall sedentary behavior in early childhood have a significant overall effect of 17 and 19 min/d, respectively, with subgroup analysis for age revealing a larger overall reduction in screen time for studies that targeted younger (<3 years of age) compared with older (3–5 years of age) children.[157] The authors also noted that interventions conducted in a home, community-based, or preschool/daycare setting were more effective at reducing children's screen time than those conducted in a healthcare center/pediatric office setting; however, heterogeneity in methods and in intervention details provided limits our ability to draw conclusions about the specific types of intervention components or strategies that were most effective in early childhood.[157]

In another systematic review of family-based interventions that included 17 studies of youth of all ages, the authors concluded that evidence of favorable impacts on sedentary behavior was inconsistent at best.[158] The most successful interventions incorporated greater parental involvement and structural changes in the home environment; moreover, the degree of parental involvement was a key determinant of intervention success regardless of the intervention setting (home, community, school, or primary care based). Indeed, including intervention components targeting reductions of sedentary behavior in parents was consistently associated with marked favorable impacts on their children's sedentary behaviors,[158] notably in younger children.[159]

Structural changes to the home environment may be as simple as modifying access to video games. For example, in an intervention comparing the impact on sedentary behavior of removing home access to traditional electronic games or replacing them with active video games, both removal and replacement of electronic games resulted in similarly modest decreases in after-school accelerometer-measured sedentary behavior (≈5 minutes for removal and 6 minutes for replacement) and a decrease in after-school self-reported screen time (a decrease of 12 minutes for removal and 14 minutes for replacement).[160] Use of electronic television monitoring devices also appears to be an effective strategy for reducing sedentary behavior,[127,158,159] with decreases in screen time ranging from 1.5 to 3 h/d[159]; however, sustainability once the devices are removed is unknown.[146,159]

Finally, family-based interventions may be more successful in youth with normal weight than in youth with overweight or obesity. For example, a 20-week family-based intervention in a sample of children with overweight and obesity found no effect on the children's self-reported screen time.[161] However, a subsequent report concluded that poor uptake and the low efficacy of the intervention itself may have had a role in the null findings.[162]

Interventions delivered in school-based settings that target school-aged children or adolescents generally combine educational components, goal-setting, and self-monitoring[127,146,163] and involve some kind of in-class instruction about nutrition, physical activity, and media use.[164] In a systematic review of school-based screen time reduction interventions in youth, a little more than half of the school-based interventions targeting children 6 to 12 years of age led to reductions in screen time.[159] Although a 20-month intervention in 7- to 12-year-olds reported no effect on children's screen time, analyses stratified by weight status revealed a reduction in weekday television viewing among children without overweight.[165] Two successful interventions used interactive multimedia, including one delivered with a smartphone application[166] and another delivered over the Internet.[167]

Of 2 school-based intervention studies in which sedentary behavior was measured with accelerometry, 1 study reported no significant effect on sedentary behavior,[168] whereas the other led to substantial reductions at 8 months after intervention, but among boys only.[169] It is noteworthy that interventions in which both self-reported screen time and accelerometer-based assessments of sedentary behavior were used, reductions were observed for self-reported recreational computer use and for total screen time, but not for accelerometer-based sedentary behavior.[168,170]

Successful interventions involving structural changes in the school environment include the use of standing desks in classrooms. For example, in a recent systematic review, time spent standing reportedly increased in all studies (effect sizes, 0.38–0.71), and the decrease in time spent sitting ranged from 59 to 64 minutes (effect sizes, 0.27–0.49).[171] However, only 8 studies were included in the review, and half of the studies had nonrandomized designs, most were pilot

or feasibility studies, and none had a follow-up period >1 year.

Interventions to Reduce Sedentary Behavior: Summary of Key Findings

- The effectiveness of interventions designed to reduce sedentary behavior appears to vary by weight status.
- Interventions appear to be more effective in younger school-aged children, possibly because of their reduced autonomy and control over their environment.
- School-based interventions that use screen-based technology can reduce overall screen time.
- Features of effective strategies to reduce sedentary behavior include structural changes to the environment, the involvement of family, and the use of electronic television monitoring devices.

DISCUSSION

Many children are sedentary most of their waking hours, with much of this time spent diverted by screens and disengaged from human interaction. Although concerns have been raised about the possible adverse impacts of this phenomenon, the appropriate public health response is unclear because a strong evidentiary basis is lacking. Although we did not explore potential mechanisms in depth in the present statement, there is compelling evidence ranging from animal studies to social experiments indicating that screen-based recreational media places children at increased risk, possibly by creating a kind of "screen addiction."[172] Some concern has been expressed with respect to subsequent levels of distraction and disengagement, opening several pathways through which screen-based recreational media could adversely affect cardiometabolic health. An in-depth exploration is beyond the scope of this statement. Readers are encouraged to consult guidelines and tips prepared by the American Academy of Pediatrics, Canadian Paediatric Society, and Family Media Plan. On the basis of our collective appreciation of the state of the evidence, we discuss herein a number of salient issues and challenges. Two key illustrations are provided, including a detailed list of opportunities for research (Figure 1) and general considerations for reducing sedentary behaviors (Figure 2). We consider these to be moving targets, subject to revising and updating as concepts evolve.

Sitting

Screen time, most markedly television viewing, is implicated in a number of cardiometabolic outcomes, notably with obesity, independent of moderate to vigorous physical activity. To the extent that online and mobile viewing platforms are used as substitutes for television, the risks associated with viewing television content (on myriad devices) are most likely similar to those associated with traditional television viewing, but this has not been established definitively. Of note, the physiological damage evident in adults resulting from prolonged sitting[5,137] has not yet been observed in pediatric populations. This may be attributable to the previously mentioned challenges related to assessing posture in children or to other methodological limitations. Although sitting is largely implicit in screen-based recreational media, the nature of portable screen-based devices means that screen time should not be presumed to be engaged in by an individual in a predominantly seated or stationary position. Moreover, there is compelling evidence that viewing screen media may be physiologically different from other forms of sedentary behavior.[172] This could be at the root of discrepancies between self-reports of more easily recalled activities such as television viewing and objective assessments of sedentary behavior, which would include many non–screen-based situations such as motorized travel and eating. Although sitting is likely a necessary cause, it remains unclear whether it is a sufficient cause to increase cardiometabolic risk meaningfully in most children. Because the most health-compromising aspects of sedentary behavior to date are still best described by television viewing, the focus of interventions should remain on television viewing and on those new and emerging substitutes, albeit paired with a responsive program of research that can move this area forward. The available evidence suggests that it is prudent to minimize time spent in recreational screen-based media, but optimal device-specific levels have yet to be established.

Toward Optimal Measurement of Sedentary Behavior

Objective assessments are valuable for surveillance but hinder our ability to understand mechanisms or to identify opportunities for intervention. On the other hand, subjective measures allow for context and nuance but suffer from poor precision. Complementing accelerometry data with self-reported data has been advocated by a number of researchers, but specific protocols have yet to be established.[173–176] Existing self-report instruments could be designed in such a way as to adequately capture a greater range of contexts and modified to more easily accommodate technological innovations and the ways in which these are used. One potential challenge is the need to account for exposure to multiple screens. Given the importance of broader environmental factors, some have proposed combining accelerometers with global positioning systems. Global positioning systems or real-time locating systems can complement ac-

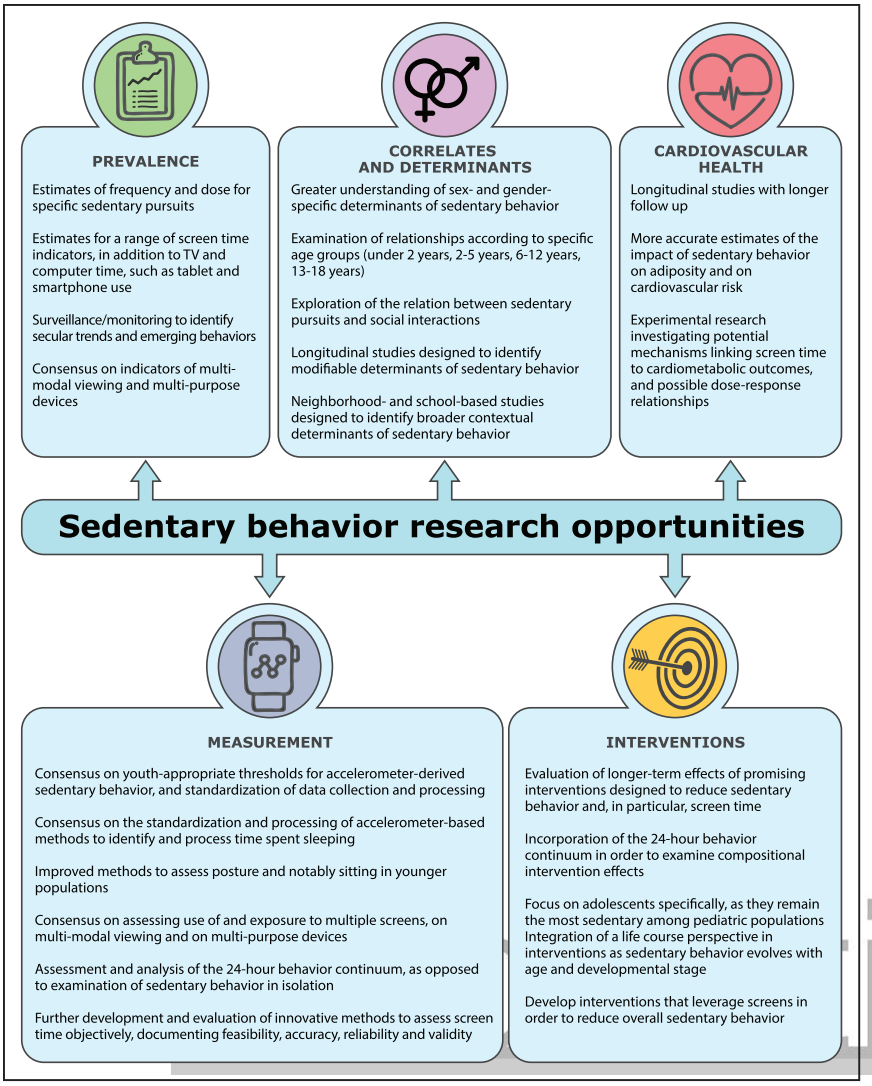

Figure 1. Opportunities for research on sedentary behaviors.
TV indicates television.

celerometers by providing precise coordinates and, by extension, journeys and locations.[177] Although this can provide useful contextual information (mode of travel, destinations),[178–181] the indoor context, where sedentary behaviors are most likely to occur, would be lacking. One solution could be to use wearable cameras that can capture a first-person picture at a given frequency and with sufficient memory capacity to store multiple images.[182] Results from studies in adults using SenseCam suggest that this device may be a useful complement to accelerometers to measure sedentary behavior in free-living conditions.[183,184] Microlocation and automated detection technology using radiofrequency identification and OpenBeacon proximity tags could be used to monitor interaction patterns at specific interior locations (eg, watching television in the bedroom, using a personal computer). Initial pilot data are compelling; methods allowing objective assessments of sedentary behavior with detailed contextual information using automated recognition will no doubt be widely available in the near future.[182]

Relying on a single marker of screen time may be impeding our understanding of mechanisms and opportunities to intervene. More informative indicators of sedentary behavior may help disentangle the various dimensions of screen time and allow us to identify its more harmful components. Although we should aim to assess all forms of screen time and situations that promote sedentary behavior, focusing on passive screen time, as opposed to screen time related to interacting and communicating, may help identify more salient areas in which to intervene.

In an effort to move toward the optimal measurement of sedentary behavior, we list below a number of suggestions for research and provide a list of research opportunities (Figure 1):

- Youth-appropriate thresholds and cut points for sedentary behavior and standardized procedures for data collection and processing are needed. Until they are available, studies should include detailed information on protocols and data processing used to facilitate cross-study synthesis and comparison.

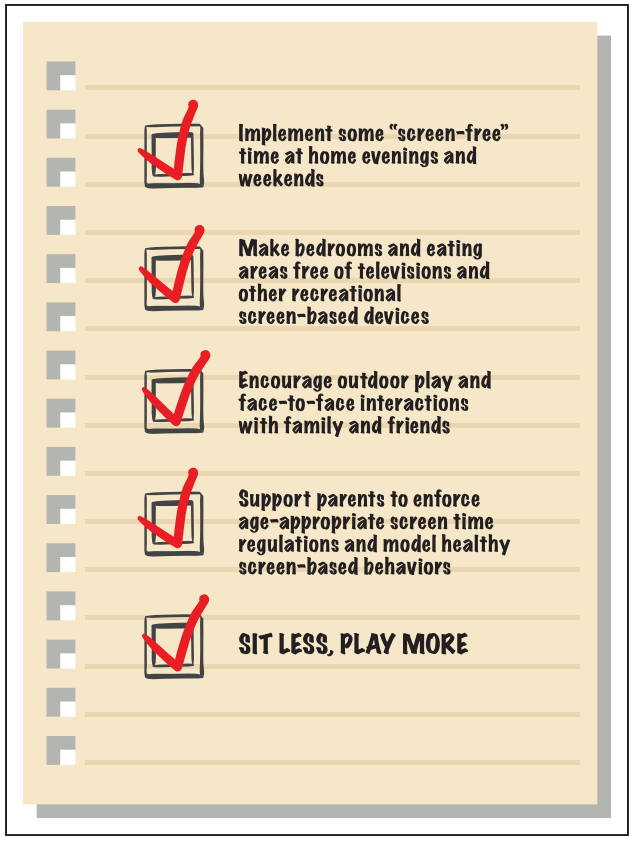

Figure 2. Considerations for reducing sedentary behaviors.

- In instances of continuous accelerometer wear, consensus on the standardization of methods to identify and process time spent sleeping needs to be established to avoid including sleep time in indicators of sedentary time.
- Most studies are still using the 2-hour threshold for screen time, yet in some studies, screen time in excess of even 1 hour appears to be detrimental. Provision of more refined categories of screen time, ideally beyond the basic 2-hour cut point, is warranted.
- There is a need to better establish estimates of frequency and dose for involvement in specific sedentary pursuits and to establish surveillance and monitoring to identify secular trends and emerging behaviors.
- Estimates of a more comprehensive range of screen time indicators, in addition to television and computer time, such as tablet and smartphone use are needed.
- Although youth are perceived to be avid multimodal consumers, research shows adolescents (like others) to be inefficient multitaskers.[185] There is a need to establish consensus on multimodal viewing and multipurpose devices to better monitor their use and to document trends in the screen-based behaviors of modern youth.
- There is a need to develop and validate methods to assess posture, notably sitting, in younger populations.
- Further development and evaluation of innovative methods to assess screen time objectively, documenting feasibility, accuracy, reliability, and validity in youth populations, are needed.

Challenges and Opportunities for Intervention

Few, if any (neighborhood and school), environmental determinants of sedentary behavior have been identified. The potential of these key youth-oriented settings to favorably affect behaviors remains poorly understood, undermining our ability to identify opportunities to intervene early and influence behavioral trajectories. Leveraging situations and contexts in which sedentary behavior would be less likely to occur could result in substantial reductions in sedentary time through simple displacement. For example, maximizing time outdoors, encouraging face-to-face interactions, and placing screens in inconvenient or less hospitable locations could substantially reduce sedentary behavior through increases in (even marginally) light-intensity physical activity or even standing. Below, we expand further on suggestions for research on sedentary behavior, with additional research opportunities included in Figure 1:

- Data from longitudinal studies that provide more accurate estimates of the impact of sedentary behavior on adiposity and cardiovascular risks such as hyperlipidemia, hypertension, and type 2 diabetes mellitus are needed.
- Longitudinal studies with longer follow-up are needed because some effects of sedentary behavior during childhood may become measurable only in the longer term; high-quality evidence from longitudinal studies will help identify modifiable determinants of sedentary behavior.
- Examination of relationships according to specific age groups (toddlers [<2 years], preschool-aged children [2–5 years], school-aged children [6–12 years], adolescents [13–18 years]) is warranted because environments change with greater age and autonomy, with corresponding determinants expected to evolve accordingly.
- Elucidation of the extent to which sedentary pursuits can be inherent to various social interactions in children and adolescents is needed; notably, the role of screens in both promoting and hindering social interactions needs to be explored.
- Research should integrate a life-course perspective in interventions when possible because sedentary behavior evolves with age and developmental stage.

- More investigation of neighborhood and school environments to identify broader contextual determinants of sedentary behavior is needed.
- A greater understanding of sex- and gender-specific determinants of sedentary behaviors is essential to inform the development of more effective interventions.
- Experimental research investigating potential mechanisms linking screen time to cardiometabolic outcomes and the possible dose-response relationships is needed.
- Identification and reporting of key intervention characteristics and components that are most effective in reducing sedentary behavior are needed.
- Evaluation of longer-term effects of promising interventions designed to reduce sedentary behavior and, in particular, screen time is needed.
- Studies should consider sedentary behavior as part of a 24-hour whole pattern continuum rather than as an isolated behavior. Twenty-four–hour continuous monitoring may be useful for behavior change interventions that focus on whole patterns rather than on sedentary behavior in isolation.
- Effective ways of reducing sedentary behavior in adolescents specifically are needed because they remain the most sedentary among pediatric populations.

CONCLUSIONS

Despite significant research gaps and substantial heterogeneity across observational and intervention studies, the preponderance of evidence suggests that screen time adversely affects adiposity in youth. The evidence is not conclusive for other indicators of sedentary behavior or for other aspects of cardiovascular risk. Although trends in overall sedentary behavior are unclear, screens are becoming more and more embedded in all aspects of children's lives, and increased exposure seems inevitable. We still lack sufficient evidence that can provide guidance on the dose-response relationship between sedentary behaviors and various health outcomes. Although we are not yet able to identify the threshold beyond which sedentary time increases cardiovascular risk in children, there is evidence from various types of studies that sedentary activity can and should be reduced. When possible, all screen-based activities should be reduced to mitigate risks. Passive consumption of screens should be avoided (eg, leaving the television on in the background) to avoid normalizing this behavior. Bedrooms and meal times should be free of televisions and other recreational screen-based devices. In addition, parents/guardians should be supported to devise and enforce appropriate screen time regulations and to model healthy screen-based behaviors. Innovative approaches that promote more face-to-face interactions and more outdoor play are encouraged, for example, by leveraging social networks or making appealing structural changes to neighborhoods. In the meantime, we advise all children to "sit less, play more."

ARTICLE INFORMATION

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel. Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

This advisory was approved by the American Heart Association Science Advisory and Coordinating Committee on April 4, 2018, and the American Heart Association Executive Committee on June 26, 2018. A copy of the document is available at http://professional.heart.org/statements by using either "Search for Guidelines & Statements" or the "Browse by Topic" area. To purchase additional reprints, call 843-216-2533 or e-mail kelle.ramsay@wolterskluwer.com.

The American Heart Association requests that this document be cited as follows: Barnett TA, Kelly AS, Young DR, Perry CK, Pratt CA, Edwards NM, Rao G, Vos MB; on behalf of the American Heart Association Obesity Committee of the Council on Lifestyle and Cardiometabolic Health; Council on Cardiovascular Disease in the Young; and Stroke Council. Sedentary behaviors in today's youth: approaches to the prevention and management of childhood obesity: a scientific statement from the American Heart Association. *Circulation*. 2018;138:e•••–e•••. DOI: 10.1161/CIR.0000000000000591.

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Disclosures

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Writing Group Member	Employment	Research Grant	Other Research Support	Speakers' Bureau/ Honoraria	Expert Witness	Ownership Interest	Consultant/ Advisory Board	Other
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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be "significant" if (a) the person receives $10 000 or more during any 12-month period, or 5% or more of the person's gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns $10 000 or more of the fair market value of the entity. A relationship is considered to be "modest" if it is less than "significant" under the preceding definition.

*Modest.

†Significant.

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