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Human Kinetics
ORIGINAL RESEARCH

The Scientific Foundation for the *Physical Activity Guidelines for Americans*, 2nd Edition

Kenneth E. Powell, Abby C. King, David M. Buchner, Wayne W. Campbell, Loretta DiPietro, Kirk I. Erickson, Charles H. Hillman, John M. Jakicic, Kathleen F. Janz, Peter T. Katzmarzyk, William E. Kraus, Richard F. Macko, David X. Marquez, Anne McTiernan, Russell R. Pate, Linda S. Pescatello, and Melicia C. Whitt-Glover

Background: The 2018 Physical Activity Guidelines Advisory Committee Scientific Report provides the evidence base for the *Physical Activity Guidelines for Americans*, 2nd Edition. **Methods**: The 2018 Physical Activity Guidelines Advisory Committee addressed 38 questions and 104 subquestions selected for their public health relevance, potential to inform public policies and programs, maturity of the relevant science, and applicability to the general US population. Rigorous systematic literature searches and literature reviews were performed using standardized methods. **Results**: Newly described benefits of physical activity include reduced risk of excessive weight gain in children and adults, incidence of 6 types of cancer, and fall-related injuries in older people. Physical activity is associated with enhanced cognitive function and mental health across the life span, plus improved mental health and physical function. There is no threshold that must be exceeded before benefits begin to accrue; the accrual is most rapid for the least active individuals. Sedentary time is directly associated with elevated risk of all-cause and cardiovascular mortality, incident cardiovascular disease and type 2 diabetes, and selected cancer sites. A wide range of intervention strategies have demonstrated success in increasing physical activity. **Conclusion**: The 2018 Physical Activity Guidelines Advisory Committee Scientific Report provides compelling new evidence to inform physical activity recommendations, practice, and policy.

Keywords: public health, exercise, disease prevention, health promotion

Regular physical activity is associated with a wide range of health benefits.[1] Unfortunately, only about 20% of adults and high school aged youth meet the current federal guidelines for both aerobic and muscle-strengthening physical activity.[2] In 2016, the US Department of Health and Human Services convened the 2018 Physical Activity Guidelines Advisory Committee (PAGAC) to review and summarize the current scientific evidence regarding the relationship between physical activity and health. The committee's report serves as the basis for the *Physical Activity Guidelines for Americans*, 2nd Edition,[3] which updates the 2008 Physical Activity Guidelines for Americans.[4] The 2008 PAGAC Scientific Report[5] provided a fundamental starting point for allowing the 2018 Committee to examine more broadly the wide-ranging benefits of physical activity to health, as well as the types, volumes, and intensities of physical activity that are associated with those benefits.

New findings since the 2008 PAGAC Scientific Report[5] substantially expand the list of health benefits that are attributable to physical activity. Moreover, the 2018 Scientific Report provides more specific knowledge about how to achieve those health benefits and demonstrates that physical activity promotion at the population level can be accomplished using a variety of strategies. This article summarizes the process and major findings of the 2018 PAGAG Scientific Report,[1] with emphasis on topics not previously addressed in 2008. The full report is available at https://health.gov/paguidelines/second-edition/report.aspx.

Methods

Scope of Review

The committee established 9 subcommittees based on current public health priorities and areas with new information since the 2008 PAGAC Scientific Report: (1) aging, (2) brain health, (3) cancer primary prevention, (4) cardiometabolic health and prevention of weight gain, (5) exposure, (6) individuals with

Powell is retired from the Centers for Disease Control, Georgia Department of Public Health, Atlanta, GA. King is with the Departments of Health Research & Policy (Epidemiology), and Medicine, School of Medicine, Stanford Prevention Research Center, Stanford University, Stanford, CA. Buchner is with the Department of Kinesiology and Community Health, University of Illinois at Urbana–Champaign, Champaign, IL. Campbell is with the Department of Nutrition Science, Purdue University, West Lafayette, IN. DiPietro is with the Department of Exercise and Nutrition Sciences, Milken Institute School of Public Health, The George Washington University. Washington, DC. Erickson is with the Departments of Psychology and Geriatric Medicine, University of Pittsburgh, Pittsburgh, PA. Hillman is with the Departments of Psychology and Physical Therapy, Movement, and Rehabilitation Sciences, Northeastern University, Boston, MA. Jakicic is with the Department of Health and Physical Activity, Physical Activity and Weight Management Research Center, University of Pittsburgh, Pittsburgh, PA. Janz is with the Departments of Health and Human Physiology and Epidemiology, University of Iowa, Iowa City, IA. Katzmarzyk is with Pennington Biomedical Research Center, Baton Rouge, LA. Kraus is with the Department of Medicine, School of Medicine, Duke University, Durham, NC. Macko is with the Departments of Neurology and Medicine and Geriatrics, School of Medicine, University of Maryland, Baltimore, MD. Marquez is with the Department of Kinesiology and Nutrition, University of Illinois at Chicago, Chicago, IL. McTiernan is with Fred Hutchinson Cancer Research Center, School of Medicine, School of Public Health, University of Washington, Seattle, WA. Pate is with the Department of Exercise Science, Arnold School of Public Health, University of South Carolina, Columbia, SC. Pescatello is with the Department of Kinesiology, College of Agriculture, Health and Natural Resources, University of Connecticut, Storrs, CT. Whitt-Glover is with Gramercy Research Group, Winston-Salem State University, Winston-Salem, NC. Powell (nekllewop@hotmail.com) is corresponding author. Kenneth E. Powell and Abby C. King are co-first authors.

chronic conditions, (7) promoting regular physical activity, (8) sedentary behavior, and (9) youth, as well as a pregnancy working group. Through a series of discussions and ranking procedures, the committee identified 38 questions and 104 subquestions to be addressed by the subcommittees (Supplementary Table S1 [available online]). Questions were selected for their public health relevance, potential to inform public policies and programs, maturity of the relevant science, and applicability to the general US population. Methodological details regarding question development, analytical frameworks, inclusion and exclusion criteria, and search strategies are available in the 2018 Scientific Report,[6] the supplementary material to the report,[7] and a peer-reviewed article.[8]

Data Sources and Searches

The review of the literature was assisted by a consulting services company through a contract with US Department of Health and Human Services. Three bibliographic databases (PubMed®, CINAHL, and Cochrane Library) were used for all searches, which included only studies of human subjects published in English in peer-reviewed journals or high-quality reports. The inclusion dates varied among questions (Supplementary Table S1 [available online]), most often depending on whether a similar question had been addressed by the 2008 PAGAC Report.[5] All searches began with a search for systematic reviews, meta-analyses, pooled analyses, and high-quality reports such as the 2008 PAGAC Report. For a few questions, the committee expanded the search to include original research articles because the search for systematic reviews: (1) was insufficient to address the question at hand (excessive weight gain, children <6 y, progression of osteoarthritis, relation of step counts and bout duration to health outcomes), (2) had captured experimental studies but not observational studies (fall-related injuries among older people), or (3) had not captured recently published original research known to be important (sedentary behavior). If the committee became aware of a relevant article that was not captured by the search, the search methods were examined to determine why the article had been missed, and if appropriate, the search was revised and repeated.

Study Selection, Evidence Extraction, and Synthesis

All titles and abstracts were reviewed by 2 subcommittee members. Discrepancies were resolved by discussion or by a third reviewer. Potentially relevant articles based on title and abstract underwent full-text review by 2 subcommittee members. Articles that remained after title, abstract, and full-text review were examined in detail by 2 or more subcommittee members. Although procedures varied among subcommittees, subcommittee members generally extracted the most pertinent information into "working tables" (see, eg, https://health.gov/paguidelines/second-edition/report/supplementary_material/pdf/Supplementary_Table_S-F2-1.pdf). Using standard procedures, the consulting service staff prepared extractions, which included the citation, search dates for systematic reviews, the abstract, and information about the exposure and the outcome. Information from these tables and from the ad hoc tables prepared by subcommittee members provided the foundation for committee discussions and conclusions.

Strength of Evidence Assessment

For every question and subquestion, each subcommittee presented a draft of its conclusions based on the available evidence to the full committee. This draft included information on the strength of the evidence supporting that conclusion and a summary of the underlying evidence. Evidence was graded as strong, moderate, limited, or not assignable based on a modification of the Assessment of Multiple Systematic Reviews ($AMSTAR_{ExBP}$) for systematic reviews, meta-analyses, and pooled analyses[6,9,10]; the US Department of Agriculture Nutrition Evidence Library Bias Assessment Tool for original research[11,12]; a tool created for the 2018 PAGAC for reports[6]; and committee-developed procedures for grading the evidence based on 5 criteria: applicability, generalizability, risk of bias/study limitations, quantity and consistency, and magnitude and precision of effect (Supplementary Table S2 [available online]). The committee discussed, modified if appropriate, and gave final approval for all conclusions and strength of evidence assessments in public meetings.

Results

A total of 20,838 titles, 4,913 abstracts, and 2,139 full-text articles were evaluated; 837 unique articles met the criteria for inclusion. The number of included articles per question ranged from 2 to 96, with a median of 15 articles (Supplementary Table S1 [available online]). Operational definitions and methods for measuring physical activity varied considerably among the included articles. For the general adult population, self-reported leisure-time aerobic activity of moderate to vigorous intensity was the most prevalent domain reported in the available literature. Other domains (eg, occupational, transportation, household activity) were inconsistently available. Studies of device-measured physical activity (eg, accelerometer, pedometer) were uncommon, except for studies that examined the role of step counts, bout duration, and high-intensity interval training on health outcomes. For children <6 years of age, most studies utilized device-measured physical activity and included light-, moderate-, and vigorous-intensity activity. For older adults, most intervention studies used combinations of different types of activity (eg, aerobic, muscle strengthening, balance training), which tended to be of light to moderate intensity. Sedentary behavior was operationalized as time spent sitting, time spent watching television, or counts below a specified value on an accelerometer.

The Health Benefits of Physical Activity

The scientific evidence accumulated since the 2008 Scientific Report markedly expands the list of documented health benefits accruing to more physically active individuals. The most recent literature now includes evidence of (1) reduced risk of cancer of the bladder, endometrium, esophagus, kidney, lung, and stomach; (2) reduced risk of dementia; (3) reduced risk of excessive weight gain in children, adults, and pregnant women; (4) reduced risk of gestational diabetes and postpartum depression; and (5) reduced risk of fall-related injuries in older people. In addition, there is evidence that physical activity is associated with (1) improved quality of life, (2) improved sleep; (3) reduced feelings of anxiety and depression in healthy people and in people with existing clinical syndromes, and (4) improved cognitive function across the life span. Regular physical activity improves bone health and weight status in children 3 to <6 years and physical function among older people regardless of frailty or existing chronic disease (Table 1).[1] For individuals with 1 of 15 prevalent and diverse chronic conditions examined (eg, breast cancer, osteoarthritis, Parkinson's disease) 1 or more preventive health benefits were reported for those who were more physically active (Table 2).[13–15] In the paragraphs below, we summarize

Table 1 Physical Activity–Related Health Benefits for the General Population Documented by the 2008 and 2018 Physical Activity Guidelines Advisory Committees

Children and youth	
3 to <6 y of age[a]	**Improved bone health and weight status**
6–17 y of age	**Improved cognitive function** Improved cardiorespiratory and muscular fitness Improved bone health Improved cardiovascular risk factor status Improved weight status or adiposity Fewer symptoms of depression
Adults, all ages	
All-cause mortality	Lower risk
Cardiometabolic conditions	Lower risk of cardiovascular disease and cardiovascular disease mortality (including heart disease and stroke) Lower risk of hypertension Lower risk of type 2 diabetes
Cancer	Lower risk of **bladder**, breast, colon, **endometrium, esophagus, kidney, stomach, and lung cancers**
Brain health	**Reduced risk of dementia** Improved cognitive function **Improved cognitive function following acute bouts of aerobic activity** **Improved quality of lifeImproved sleep** **Reduced feelings of anxiety and depression in healthy people and in people with existing clinical syndromes** **Reduced risk of depression**
Weight status	**Reduced risk of excessive weight gain** An additive effect on weight loss when combined with moderate dietary restriction Weight loss and the prevention of weight regain when a sufficient dose of moderate-to-vigorous physical activity is attained
Older adults	
Falls	Reduced risk of falls **Reduced risk of fall-related injuries**
Physical function	**Improved physical function in older adults with and without frailty**
Women who are pregnant or postpartum	
During pregnancy	**Reduced risk of excessive weight gain** **Reduced risk of gestational diabetes** **No risk to fetus from moderate-intensity physical activity**
During postpartum	**Reduced risk of postpartum depression**

Note: Benefits in bold are those added in 2018; benefits in regular font are those noted in the 2008 Scientific Report.[5] Only outcomes with strong or moderate evidence of effect are included in the table.
[a]Insufficient information available for children 0 to <3 years.

findings from 2 topic areas (brain health and weight gain) not previously addressed in the 2008 Scientific Report.

Brain Health. Brain health, an area of recent and rapid development, is positively affected by single bouts, as well as by regularly performed moderate- to vigorous-intensity physical activity (MVPA). In addition to reducing the risk of dementia, physical activity improves several components of cognition, including executive function (ie, the organization of everyday activities, planning for the future, and self-regulation of impulsive and sensation-seeking behaviors), memory, processing speed, attention, and academic performance. These performance improvements are supported by evidence from neuroimaging techniques demonstrating parallel changes in brain structure and function.[16–20] The beneficial effects are observed across a variety of physical activities, including aerobic and strength training activity, and are reported in both healthy populations and in populations exhibiting cognitive deficits due to conditions such as schizophrenia, stroke, Parkinson’s disease, and Alzheimer’s disease. Improvements in cognitive performance are observed for up to an hour after a single bout of physical activity, with more sustained improvements observed with regular participation.[13] MVPA also improves other aspects of brain health, such as symptoms of depression and anxiety among individuals with and without clinical depression or anxiety and perceived quality of life.[13] In addition, both a single bout and regularly performed MVPA improve sleep quality, reduce sleep onset latency, increase time in deep sleep, improve sleep efficiency (the percentage of time actually sleeping), and reduce daytime sleepiness.[13] Moreover, it does not seem to matter whether the activity is performed more than 8 hours, 3 to 8 hours, or less than 3 hours before bedtime.[21]

Prevention of Weight Gain. Excessive weight gain is less common among children and adults (including pregnant women) who are more physically active,[22–24] with greater amounts of physical activity associated with a lower risk of significant weight gain or development of obesity (Figure 1).[25] For people with overweight or obesity, the relative risk reduction in all-cause mortality, cardiovascular disease

Table 2 Physical Activity–Related Health Benefits for Individuals with a Chronic Condition Documented by the 2008 and 2018 Physical Activity Guidelines Advisory Committees

Individuals with preexisting medical conditions	
Breast cancer[a]	**Reduced risk of all-cause and breast cancer mortality**
Colorectal cancer[a]	**Reduced risk of all-cause and colorectal cancer mortality**
Prostate cancer[a]	**Reduced risk of prostate cancer mortality**
Osteoarthritis[b]	**Decreased pain**
	Improved function and quality of life
Hypertension[b]	**Reduced risk of progression of cardiovascular disease**
	Reduced risk of increased blood pressure over time
Type 2 diabetes[b]	**Reduced risk of cardiovascular mortality**
	Reduced progression of disease indicators: hemoglobin A1c, blood pressure, blood lipids, and body mass index
Recent hip fracture[c]	**Improved walking, balance, and activities of daily living**
Frailty[c]	**Improved walking, balance, and activities of daily living**
Stroke[c,d]	Improved walking, physical fitness, functional independence
	Improved cognition
Spinal cord injury[b]	Improved physical fitness
	Improved walking and wheel chair skills
Dementia[d]	**Improved cognition**
Multiple sclerosis[b,d]	Improved walking
	Improved strength and physical fitness
Parkinson's disease[c,d]	**Improved walking, balance, activities of daily living, and cognition**
Schizophrenia[d]	**Improved quality of life and cognition**
Attention deficit hyperactivity disorder[d]	**Improved cognition**

Note: Benefits in bold are those added in 2018; benefits in normal font are those noted in the 2008 Scientific Report.[5] Only outcomes with strong or moderate evidence of effect are included in the table. Outcomes assessed varied by chronic condition.
[a]Mortality and disease progression outcomes. [b]Mortality, development of new chronic condition, quality of life, physical function, and progression of disease. [c]Physical function only. [d]Cognition.

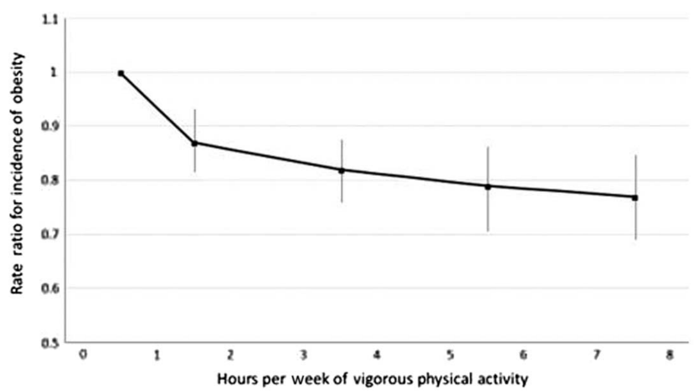

Figure 1 — Inverse dose–response relationship between risk of developing obesity and volume of vigorous physical activity. Adapted from data found in Rosenberg et al.[25]

incidence and mortality, and incidence of type 2 diabetes is similar to that experienced by people with normal body weight.[1]

Characteristics of Physical Activity Associated With Benefits

The Dose–Response Relationship Between Physical Activity and Health. All reviews reported an inverse relationship between self-reported MVPA and all-cause mortality, cardiovascular disease mortality and incidence, and incidence of type 2 diabetes; analyses comparing 3 or more physical activity exposure categories consistently reported an inverse, curvilinear dose–response relationship (Figure 2).[1,22,26–29] The response curves demonstrate that when the least active individuals add even small amounts of activity to their daily routine, (1) there is no threshold that must be exceeded before benefits begin to accrue (ie, the reduction in risk begins with the addition of any amount of MVPA), (2) the slope of risk decline is steepest for the least active individuals, and (3) the reduction in risk continues across the full range of commonly achieved volumes, although the slope diminishes with increasing levels of MVPA.

Sedentary Behavior. There is a direct relationship between sedentary behavior and all-cause and cardiovascular disease mortality, incidence of cardiovascular disease, and type 2 diabetes, as well as the incidence of endometrial, colon, and lung cancers.[30] The dose–response curves illustrate a direct relationship between both total sitting time and television viewing time and all-cause mortality (Figure 3).

Interaction Between Sitting Time and MVPA. Mortality risk is higher for longer versus shorter sitting times; however, this risk difference diminishes as the amount of MVPA increases—especially among those reporting the greatest volume of MVPA (Figure 4).[31] Compared with the referent group (most MVPA [top quartile] and lowest sitting time [<4 h/d]), individuals with the least MVPA (bottom quartile) and most sitting time (>8 h/d) have the

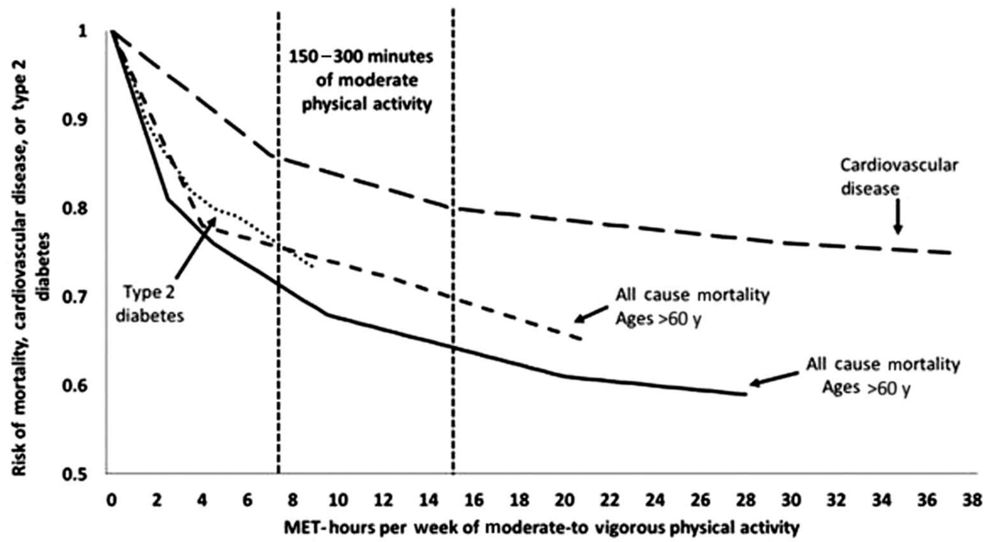

Figure 2 — Inverse dose–response relationships between self-reported aerobic moderate-to-vigorous physical activity and risk of all-cause mortality, risk of cardiovascular disease, and risk of type 2 diabetes. Source: risk of all-cause mortality adapted from Moore et al,[26] risk of all-cause mortality among participants >60 years of age adapted from Hupin et al,[27] risk of cardiovascular disease adapted from Sattelmair et al,[28] and risk of type 2 diabetes adapted from 2018 PAGAC.[22]

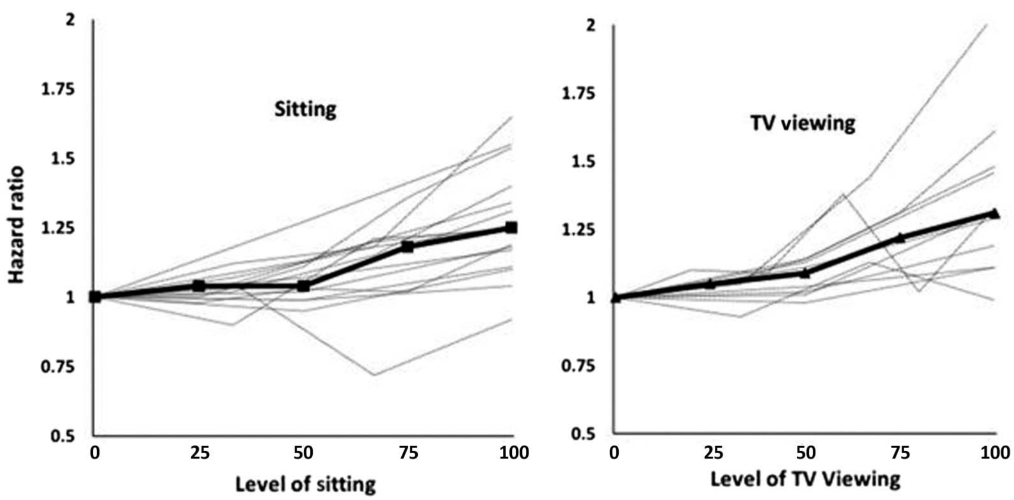

Figure 3 — Direct dose–response associations between sitting time and TV viewing time with all-cause mortality. The hazard ratio for studies with mortality rates for at least 3 levels of sitting or TV viewing time. The original categories of sitting (tertiles, quartiles, quintiles, etc) have been rescaled from 0 to 100 using an ordinal scale. For example, for a study with tertiles, the points are plotted at 0, 50, and 100. Thick lines are median estimates of risk of all-cause mortality for sitting and TV time. Source: Panels A and B adapted from 2018 PAGAC.[30] TV indicates television.

highest risk of all-cause mortality (1.59, 95% confidence interval 1.52–1.66). By contrast, individuals who are in the bottom quartile of MVPA but who report the least sitting time (<4 h/d) are at elevated risk (1.27, 95% confidence interval 1.22–1.30), but only about half that of those who sit the most. For individuals reporting the greatest volume of MVPA (an estimated 35–38 metabolic equivalent-h/wk), the excess risk of mortality for different strata of sitting essentially disappears.

Sedentary time, light physical activity, and MVPA interact within a finite, 24-hour day. A heat map developed by the 2018 PAGAC committee depicts the risk of all-cause mortality associated with various combinations of sitting time (in hours) and MVPA (in minutes) (Figure 5). The heat map was derived from regression techniques to interpolate the hazard ratios between 4 levels of sitting time and 4 levels of MVPA based on a harmonized meta-analysis of Ekelund et al.[31] We have assumed that for any given level of MVPA, the time spent sitting and the time spent in light-intensity activity (eg, walking about, light housework) are reciprocal. High sitting time is associated with low light-intensity time and low sitting time is associated with high light-intensity activity. As indicated by the heat map: (1) at low levels of MVPA, replacing sitting time with light-intensity activity reduces risk of premature mortality, (2) MVPA is necessary to achieve the greatest risk reduction, (3) for an equivalent reduction

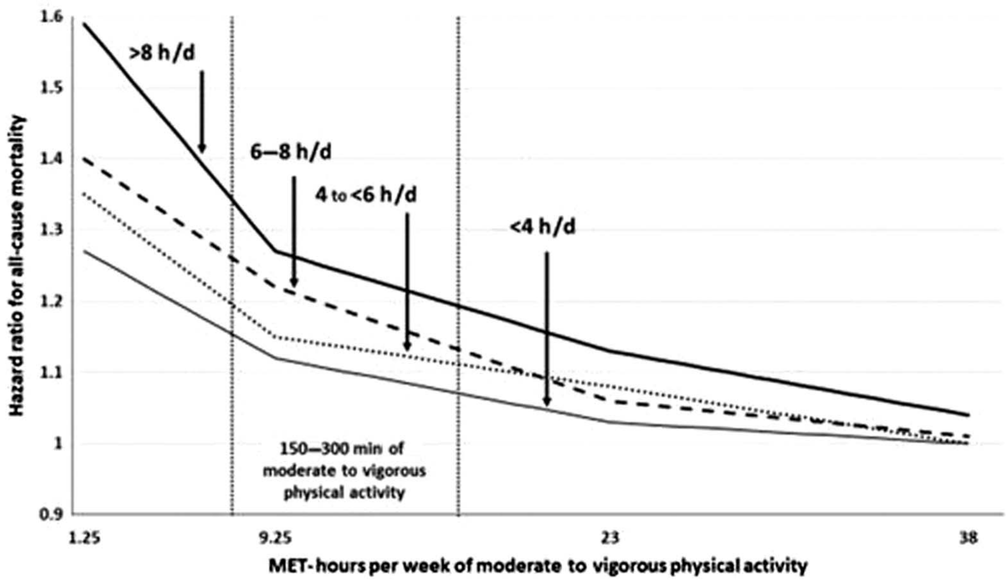

Figure 4 — Interaction between sitting time and volume of moderate-to-vigorous physical activity demonstrated by the reduction in risk associated with sitting time and TV viewing time at increasing volumes of moderate-to-vigorous physical activity. Adapted from 2018 PAGAC.[30] The figure was developed from data presented in Ekelund et al.[31] TV indicates television.

in risk, increasing MVPA requires appreciably less time per day than increasing light-intensity activity, and (4) at the highest levels of MVPA (an estimated 35–38 metabolic equivalent-h/wk), the time spent sitting has a negligible effect on mortality risk.

Bout Length of MVPA. Recent research using device-measured physical activity and assessing a variety of cardiometabolic health indicators indicates that bouts of MVPA of any length (ie, time duration) contribute to the health benefits associated with the accumulated total volume of physical activity.[32–46] Of 40 comparisons within 14 studies, 78% (31 comparisons) indicated that bouts <10 minutes long were as good or better than bouts ≥10 minutes.[1] An additional 10% (4 comparisons) reported that bouts <10 minutes long were associated with risk reduction but did not make a direct comparison with bouts ≥10 minutes.

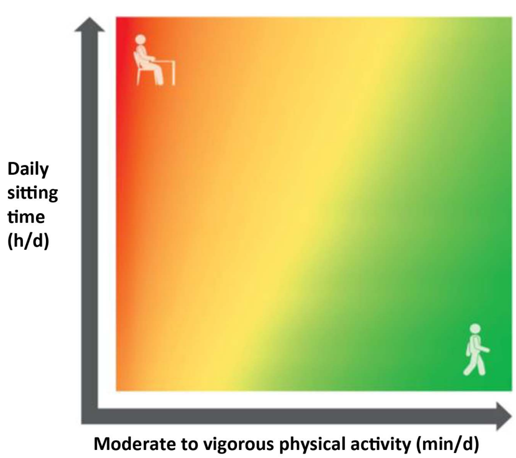

Figure 5 — Relationship among moderate-to-vigorous physical activity, sitting time, and risk of all-cause mortality. The risk of all-cause mortality declines moving from high sitting and low moderate-to-vigorous physical activity (dark gray color [red color in Online version], high risk) to low sitting and high moderate-to-vigorous physical activity (light gray color [green color in Online version], low risk). Replacing sitting time with light-intensity physical activity moves down the vertical axis; adding moderate-to-vigorous physical activity moves rightward along the horizontal axis. Source: 2018 Physical Activity Guidelines Advisory Committee.[1] The figure was developed from data presented in Ekelund et al.[31]

Strategies for Promoting Physical Activity

Numerous intervention strategies, delivered through diverse communication channels and aimed at multiple population sectors and demographic subgroups, have been effective in increasing physical activity (Table 3).[47] They include interventions aimed at individuals, interventions delivered in community settings, and programs delivered through a range of information and communication technology channels; elements of the built environment are also associated with increased physical activity. Although a number of interventions have small effect sizes (ie, d in the range of 0.2–0.4),[47] some, such as telephone-assisted advice and support and mobile phone interventions, have produced effect sizes in the medium range or stronger (ie, $d \geq 0.5$).[48,49] Some sedentary behavior worksite interventions that targeted physical changes to work stations (eg, sit–stand workstations) have also had medium to large effect sizes (ie, $d \geq 0.5$).[50]

Discussion

This study provides an overview of the process used to develop the 2018 PAGAC Scientific Report and highlights topic areas not addressed in the 2008 Report (eg, brain health, prevention of weight gain, sedentary behavior, aspects of physical activity dose, new strategies for promoting physical activity). The benefits of physical activity include a reduced risk of many of the most common, severe, and expensive health outcomes (eg, heart disease, stroke, hypertension, dementia, type 2 diabetes, cancer, depression, and fall-related injuries in older adults). Benefits and risk

Table 3 Selected Types of Interventions Shown to Increase Physical Activity or Reduce Sedentary Behavior

Social ecological level	Type of physical activity intervention
Individual	Interventions targeting youth, particularly if families are incorporated
	Behavior theory-based interventions aimed at adults and older adults
	Peer-led behavioral self-management interventions for older adults and individuals with chronic disease
Community	Community-wide interventions including intensive contact with a majority of targeted population
	School-based interventions that aim to increase physical activity during physical education classes
	Multicomponent school-based interventions aimed at increasing student physical activity throughout the school day
Communication environment	Wearable activity monitors in combination with goal setting and other behavioral strategies
	Telephone-assisted interventions in the general adult population including older adults
	Internet-delivered interventions that include educational components
	Computer-tailored print interventions in the general adult population
	Mobile phone programs that include text messaging for adults
	Smartphone applications for children and adolescents
Physical environment and policy	Point-of-decision prompts to use stairs versus escalators or elevators
	Built environment infrastructure and elements to enable active transport and support recreational physical activity among children and adults
	Access to parks and outdoor or indoor recreational facilities for children and adults
	Interventions to reduce sedentary behavior
Community	School-based interventions that aim to reduce television viewing and other screen time behaviors through counseling, parental involvement, tailored feedback, and use of screen allowance devices at home
	Worksite interventions targeting sedentary behavior including physical changes to workstations

reductions were observed across the entire age spectrum. People with established chronic conditions also receive preventive health benefits (eg, reduced risk for other conditions, improved physical function). In addition to the range of health benefits listed in Tables 1 and 2, more physically active people of all ages enjoy greater physical function, enabling them to conduct their daily lives with more energy and without undue fatigue.[1] Indeed, the array of physical, mental, and functional health benefits conferred by regular physical activity establish it as both a "best buy in public health"[51] and a worthy prescription tool for clinicians.

For the past 10 years, the federally recommended guidelines for physical activity have been 150 to 300 minutes per week of moderate-intensity activity, 75 to 150 minutes per week of vigorous-intensity activity, or an equivalent mixture of both. Those people performing this recommended volume of activity or more achieve substantial health benefits.[1,5] Less well appreciated, however, is that the 30% to 50% of US adults[52] who perform little or no MVPA can achieve some valuable health benefits by performing MVPA in amounts below the target range or by substituting light-intensity physical activity for sitting time. The interactions observed among sedentary time, light-intensity physical activity, and MVPA over the course of the day provide additional flexibility in the ways that physical activity behaviors can be modified to reduce the risk of all-cause mortality and other chronic conditions. This added flexibility in achieving federal guidelines for physical activity may be a good way for some people to begin increasing the overall volume of their weekly physical activity.[5]

The curvilinear, inverse dose–response relationship between physical activity and health was previously described in 2008 only for all-cause mortality.[5] The most recent 2018 PAGAC Scientific Report now provides evidence of similarly shaped curves for cardiovascular mortality and incidence, as well as for the incidence of type 2 diabetes.[22,29] There is insufficient information to depict dose–response curves for other health benefits at this time. It seems likely that the dose–response curves will be similarly shaped, although the maximal reductions in risk may be greater or lesser and may be reached at greater or lesser volumes of activity.

The social ecological model has been used as a framework for conceptualizing, studying, and implementing interventions to improve health behaviors, including physical activity. This model posits that health behaviors are influenced not only by person-level characteristics but also a broad range of social, community, and societal factors as well. Physical activity interventions, operating at all levels of the social ecological model, have been tested and found to be effective in increasing physical activity.[47] In recent literature, many of the successful approaches have been directed toward individuals via specific channels, such as telephone-based advice and support, text messaging, smartphone apps, and other forms of electronic communication. The explosion of physical activity-relevant information and novel communication technologies provides an unprecedented opportunity to expand the reach, the tailored "touch," and the sustained impact of interventions to those who could benefit most. In addition, a large amount of evidence indicates that activity-friendly physical and social environments are associated with more physically active lifestyles across age groups, settings (school, workplace), and different forms of activity (recreation, active transport). Because effect sizes for specific interventions have been modest, it is likely that multiple strategies operating at all levels of the social ecological model will be needed to shift the population's current physical activity behaviors to healthier levels. Thus, interventions that produce only modest change by themselves may contribute importantly to larger cumulative efforts.[53]

Table 4 Leading Causes of Death, Most Prevalent Chronic Conditions, and Most Expensive Medical Conditions for Which Greater Participation in Physical Activity Would Be Expected to Reduce Incidence, Prevalence, and Expense Indicated by Shading and Bold Type

Ten leading causes of death[54]	Ten most prevalent chronic conditions[55]	Ten most expensive medical conditions[56]
Heart disease	**Hypertension**	**Heart conditions**
Cancer	**Hyperlipidemia**	**Trauma disorders[a]**
Chronic lung diseases	Upper respiratory conditions[b]	**Cancer**
Unintentional injuries[a]	**Arthritis**	**Mental disorders**
Stroke	**Mood disorders**	Asthma/COPD
Alzheimer's disease	**Diabetes**	**Hypertension**
Diabetes	**Anxiety disorders**	**Type 2 diabetes**
Influenza and pneumonia	Asthma	**Arthritis**
Kidney disease	**Coronary artery disease**	Back problems
Suicide	Thyroid disorders	Healthy childbirth

Note: Conditions in bold and shaded cells are favorably influenced by greater participation in regular physical activity.
[a]Includes falls. [b]Includes allergies and sinusitis.

Conclusion

In sum, findings from the 2018 Scientific Report underscore the public health impact of increasing population levels of regular physical activity and provide a firm foundation for the development of federal physical activity guidelines for the general US population. The list of health benefits attributable to greater amounts of physical activity continues to grow longer and applies to all segments of the US population. The public health burden associated with insufficient physical activity is substantial. Many of the most common causes of death, most prevalent chronic conditions, and most expensive medical conditions in the United States are favorably influenced by regular participation in physical activity (Table 4).[54–57] Thus, even small increases in regular MVPA, especially if made by the least physically active individuals, would appreciably reduce the burden and cost of disease in the United States. More difficult to quantify are the physical activity benefits associated with improved cognition, better perceived quality of life, fewer symptoms of depression and anxiety, enhanced quality of sleep, and improved physical function across the full life span. Yet, these are the benefits that affect everyone on a daily basis and contribute not only to greater life satisfaction but also to enhanced productivity and fewer visits to health care providers.[55,58]

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