2021

Global impact of physical inactivity and implications for public health nursing

Elizabeth Moxley
Northern Illinois University, emoxley@niu.edu

Kashica Webber-Ritchey
DePaul University, kwebberr@depaul.edu

Laura Hayman
University of Massachuse, laura.hayman@umb.edu

Original Citation

Moxley, E., Webber-Ritchey, K. J., & Hayman, L. L. (2022). Global impact of physical inactivity and implications for public health nursing. Public Health Nursing, 39(1), 180-188. https://doi.org/10.1111/phn.12958

Abstract

Physical inactivity has been a public health problem worldwide for more than a decade. Of those who are physically active, a substantial percentage engage solely in low or very low physical activity (PA) levels. In the last three decades, the prevalence of PA in the United States has decreased with approximately 80% of adults not meeting the recommended guidelines for aerobic and muscle strengthening PA. The PA levels of youth have dramatically decreased with 85% of adolescents reporting *no* PA. Regular PA participation can aid in preventing chronic diseases. A strong inverse dose-response relationship exists between PA and the incidence of cardiovascular disease, all-cause and cardiovascular mortality. Moreover, low cardiorespiratory fitness levels are a risk factor for cardiovascular diseases: the leading cause of death and disability globally. Conversely, high amounts of moderate-to-vigorous intensity PA at levels 3 to 5 times recommended in guidelines reduce risk for all cause mortality. Socio-ecological determinants of PA are essential considerations for promoting across the life course. In health care and community settings, public health nurses have opportunities to promote PA through a socio-ecological approach across the life course of individuals and diverse populations.

Keywords: physical activity, prevention, risk factors, life course, public health nursing, social ecological model

Introduction

Epidemiologic evidence suggests exercise is the ‘real polypill’ (Fiuza-Luces et al., p. 330, 2013). Yet the lack of physical activity (PA) is an urgent worldwide concern (World Health Organization [WHO], 2021) and perhaps the most important public health problem of the 21st century (Blair, 2009). Current global estimates reveal one in four adults and 81% of adolescents do not engage in adequate quantities of PA (WHO, 2021) and this estimate is increasing (Guthold et al., 2018). Moreover, approximately 80% of U.S. adults currently do not meet the recommended PA guidelines according to the U.S. Department of Health and Human Services, of at least 150 to 300 minutes per week of moderate intensity aerobic and muscle strengthening activity (Centers for Disease Control and Prevention [CDC], 2021; U.S. Department of Health and Human Services. [USDHHS], 2018). Of those who are physically active, a substantial percentage engage in low or very low levels of PA (Katzmarzyk et al., 2017). Physical inactivity (PI) or insufficient PA is similar to sedentary behavior (Table 1).

*****Insert Table 1 here*****

The current sociodemographics for PI are staggering and include 17.3 to 47.7% of U.S. adults, irrespective of age, culture, race, gender and ethnic background as inactive (CDC, 2021). Non-White populations consistently report lower PA levels (Sallis et al., 2013), suggesting disparities according to subgroups (23.4% of non-Hispanic White adults, 30.3% non-Hispanic Black, and 31.7% of Hispanic adults) exist (CDC, 2021). Perhaps most concerning is the dramatic decrease in the fitness levels of U.S. youth (CDC, 2016); youth PA is categorized according to gender, age, ability, and environmental factors (i.e., neighborhood) (Tremblay et al., 2016; Table 2) with only one in four U.S. children (CDC, 2016) and 19% of adolescents (WHO, 2021) currently meeting requirements. Most adolescents (11-17 years) on a global scale, 81%,

also do not meet the current PA guidelines, irrespective of country income (Guthold et al., 2020). The lowest PA prevalence was found in high income western countries for boys (72.1%) and south Asia for girls (77%) and amongst 80 countries, the most contributing factor to moderate-vigorous intensity PA was from work/household tasks rather than travel or leisure domains across 104 countries that were analyzed (Guthold et al., 2020).

*****Insert Table 2 here*****

PI in U.S. adults and youth is one of six leading causes of mortality, morbidity and associated with the social problems of 1) unintentional injuries and violence; 2) tobacco use; 3) alcohol and other drug use; 4) sexual behaviors related to unintended pregnancy and sexually transmitted infections; and 5) unhealthy dietary behaviors (Kann et al., 2016). These findings were sufficient for the WHO (2021) to warrant interventions to increase PA levels be a greater priority. A thorough understanding of the benefits of PA is therefore necessary to avoid the insidious consequences of PI, especially given the lack of well-established routine nurse-delivered PA interventions (Olsen et al., 2018). The aim of this paper is to review PA-related concepts and provide an example of the social ecological model (SEM) as a basis to influence the global health issue of the low PA levels and lack of PA participation.

Public Health Nursing

Public health nurses are in a unique position to address the global health problem of PI at the individual and community level. Societal changes impacting PA stem from several levels of economic development: changing transport patterns, increased use of technology for work and recreation, and the subsequent increase in sedentary behaviors. With the recent shift in healthcare to the community, public health nurses are well-positioned for policy reform, community

building, environment and physical system-level interventions involving social determinants of health to address health disparities in marginalized communities.

PA is complex with multiple determinants influencing behavior; therefore, SEM is beneficial to guide interventions (King et al., 2002) and determinants by implementing the social ecological model (SEM) as a theoretical framework. The SEM can be used to guide health promotion efforts because of the multiple levels that influence behavior: intrapersonal (biological and personal factors), interpersonal (relationships and social networks), community (neighborhood), and social/political (Stokols, 2004). The SEM may be utilized to encourage PA participation (Mehtala et al., 2014) across the life course (Condello et al., 2016) and to identify unfavorable PA patterns such as lack of PA participation (Sallis et al., 2008; Condello et al., 2016). Adverse patterns of behaviors and other factors known to affect PA participation are influnced at most levels of the SEM. There are six distinct clusters (Intra-Personal Context and Wellbeing, Family and Socioeconomic Status; Policy and Provision; Cultural Context and Media; Social Support and Modelling, and Supportive Environment) that mediate or moderate PA behaviors across the life course (Condello et al., 2016). Although the SEM is a comprehensive theoretical model to guide interventions targeting individual, interpersonal, social/policy, and environmental factors that impact PA behavior, the utilization of concept mapping is necessary in identifying how these factors interact with each other across the life course (Stokols, 2004; Condello et al., 2016). Public health nurses are encouraged to think about and apply the SEM in promoting PA participation. PHNs are also strongly encouraged to consider the components of the SEM in working with individuals and populations with the intended goal of tailoring interventions to increasing PA.

Understanding Physical Activity Requirements

To more thoroughly understand the duration and intensity of PA necessary for health, the current PA guidelines must be clarified according to age. The PA guidelines specific to children and adolescents are applicable across the lifespan (USDHHS, 2018); children and adolescents aged 6 through 17 years require at least 60 minutes (1 hour) of moderate-to-vigorous intensity PA per day, while adults require a minimum of 150 minutes to 300 minutes per week of moderate-intensity PA or 75 to 150 minutes of vigorous-intensity aerobic PA (USDHHS, 2018). The guidelines for children and adolescents have remained consistent in the past two decades although adult recommendations have been updated several times (USDHHS, 2018). Examples of moderate intensity exercise are presented in Table 2 and 3.

To improve cardiorespiratory fitness, any PA dose component of frequency, intensity, or time may be adjusted (ACSM, 2021; Strath et al., 2013). Although PA and exercise are often used interchangeably, they are not the same (Table 1). PA is any activity, and exercise is structured activity with a consideration of fitness (Table 1). Any PA is beneficial for health compared to none at all (Moxley & Habtzghi, 2019); however, PA is often considered useful rather than essential (Moxley & Kruk, 2016). Integrating PA into routine tasks, such as chores or work-related activities, may be necessary to sustain health. The greatest health-related benefits have actually been found in sedentary individuals who begin to exercise on a regular basis (Moxley & Habtzghi, 2019). However, the USDHHS guidelines recommend PA of at least a moderate intensity. Aerobic PA energy expenditure consistent with the PA guidelines is measured in metabolic equivalents (Table 2) or METs, which are the unit to describe energy expenditure of activities, or the ratio of the rate of energy expended during an activity to the rate of energy expended at rest. Examples of how METs translate into activities of daily living are presented in Table 3 and may be measured as light, moderate or vigorous activity.

*****Insert Table 3 here*****

Physical Activity and Physical Inactivity: Morbidity and Mortality Risks

The health benefits from PA are not only well established, but are irrefutable (Bowden Davies et al., 2019; Lavie et al., 2019; Fletcher et al., 2018), providing sufficient justification to control risk factors early in life (Adams et al., 2017). In youth, the effects from short-term PI are reversible if habitual PA is resumed; however, this is less evident in older adults (Bowden Davies, 2019). Engaging in quantities of PA consistent with the guidelines demonstrates biological and disease-specific benefits such as improved mitochondria, skeletal, cardiac muscle and endothelial function (Carbone et al., 2019) and a healthy weight (WHO, 2010). Whereas, total time spent in sedentary behavior, specifically sitting (6-8 h/day) and television viewing (3-4 h/day), independent of PA, increase all-cause and cardiovascular disease (CVD) mortality risk (Patterson et al., 2018; Ekelund et al., 2019), (type 2 diabetes) T2DM and cancer (Ekelund et al., 2019).

Cardiovascular Disease, Atherosclerosis, Stroke and Cholesterol Levels

CVD is the leading cause of death on a global scale (Martinez-Gomez, 2019). According to an extensive review of 47 studies, PI was found to contribute to CVD risk as the relative risk of CVD-related PI was found to be similar in magnitude to the CVD risk factors of hypertension (HTN), hypercholesterolemia, and smoking (Fletcher et al., 2018), whereas a strong inverse dose-response relationship existed between routine PA and CVD risk and fatal and non-fatal CVD events (Fletcher et al.; Lavie et al., 2019). In addition, numerous studies demonstrated that higher cardiorespiratory fitness (CRF) has a significant protective effect on overall mortality (Chu et al., 2020).

The benefit of PA on CV health was demonstrated several decades ago in Paffenbarger et al's. (1986) landmark studies. A steady decline in early death associated with CVD in longevity of San Francisco longshoremen was found to correspond with increased PA of less than 500 to 3500 kcal/week. Specifically, those expending at least 2000 kcal per week had a 25-35% lower mortality compared to less active individuals. METs (Table 2) are units describing the energy expenditure of a specific activity; the ratio of the rate of energy expended during an activity to the rate of energy expended at rest. For example, 1 MET is the amount of oxygen consumed and the calories expended at rest (ACSM, 2017).

PA also reduces ischemic stroke risk (Oza et al., 2017) and prevents stroke recurrence in post-stroke patients (Han et al., 2017). PA is associated with improvement in serum triglycerides, increased high density lipoproteins, and decreased low-density lipoprotein (Halverstadt et al., 2007), and post-prandial lipid response was found to be significantly lower in Amish individuals who had higher levels of routine PA than their sedentary counterparts (Mitchell et al., 2019).

Obesity

Obesity has emerged as an enormous public health problem, ironically a more significant global health concern than hunger (Poirier & Eckel, 2002), and leading cause of worldwide death and disability (Bhupathiraju & Hu, 2016). The WHO (2018) considers pediatric obesity the most serious health problem of this century. A major contributer to obesity in children is a progressive lack of PA. In 1975, just under 1% of children and adolescents aged 5-19 years were obese; however, by 2016, 6% of girls and 8% of boys were considered obese, with 13% of adults considered overweight, irrespective of gender (39%, men; 40%, women) on a global scale (WHO, 2021). Conversely, greater quantities of PA are likely associated with attenuation of weight gain in adults (USDHHS, 2018) and higher levels associated with a healthy weight status

in children and adolescents (Poitras et al., 2016). In fact, engaging in adequate levels of PA has been found to contribute to weight loss and minimizes CVD risk independent of simultaneous changes in BMI or percent body fat (Martinez-Gomez et al., 2019).

Diabetes

Paralleling the obesity epidemic is type 2 diabetes (T2DM). The incidence of diabetes has doubled in recent decades with an estimated 13 percent of all U.S. adults who are diagnosed (CDC, 2020). Spending for diabetes and its sequelae far outpace other diagnoses (ADA, 2018). Several mechanisms like adipose tissue remodeling link obesity to T2DM (Carbone et al., 2019), especially abdominal obesity which is associated with insulin resistance and compromised insulin sensitivity (Bacchi et al., 2014).

PI is a greater problem in a setting of T2DM (Bowden Davis et al., 2019). Regular PA improves fasting blood glucose, and insulin resistance and/or glycemic control (hemoglobin A1c, HbA1c) in type 1 diabetes (T1DM) and T2DM (Colberg et al., 2016), and improving CRF (i.e., MET) more effectively reduces HbA1c levels (Wing et al., 2013). The importance of PA in preventing T2DM was perhaps best demonstrated in the Diabetes Prevention Program (DPP), a multi-center randomized prospective intervention trial that aimed to determine the effects of 150+ minutes of weekly PA on the prevention of T2DM. The outcomes of the DPP demonstrated that a lifestyle including dietary modification and exercise increased insulin sensitivity, thereby delaying progression to T2DM (Knowler et al., 2002).

Strategies to Increase Physical Activity Participation

Relevance of Physical Activity for Public Health Nurses (PHNs)

PI is a public health problem (Ainsworth & Macera, 2018) of significant magnitude in which the need for health professionals and policy makers to develop strategies to increase PA

participation are imminent (Alves et al., 2016). Evidence-based beneficial interventions (Tuso, 2015) to increase PA engagement to quantities consistent with the guidelines (USDHHS, 2018), while simultaneously reducing PI and sedentary behavior (Panahi & Tremblay, 2018) may target either the individual or community level.

In primary care settings, PHNs play a key role in counseling patients for optimization of healthy behaviors (Shuval et al., 2017). Receiving training in PA counseling may also be beneficial for PHNs to increase their knowledge and competencies in motivating individuals (Issakainen et al., 2020). PHNs may benefit from collaborating with care management nurses (CMs) who are integral in interdisciplinary management to improve self-care over time (Luther et al., 2019). CMs assess and promote PA practices to reduce risk and manage diseases such as obesity, hypercholesterolemia and T2DM (Luther et al., 2019). For example, PA interventions may include establishing specific goals and monitoring progress, seeking social support from friends or family for maintenance of PA, use of rewards and positive self-talk to reinforce progress, and integrating problem-solving strategies to prevent relapse (USDHHS, 2018). The PAR-Q (Warburton et al., 2015) was developed as a simple tool that may be used to assess PA readiness with only 7 questions and a yes/no assessment about medications, health conditions and implications for physical response.

PHNs can provide virtual coaching by utilizing technology-based approaches (i.e., text, telephone, or internet) to establish and achieve PA-related goals (USDHHS, 2018). Realistic goals are recommended for those individuals who are currently inactive to improve sustainability – for example, walking 5–10 minutes per session and gradually increasing intensity or duration (Khoury et al., 2019). Walking is an excellent exercise for nearly everyone; it is free and accessible and can usually be performed at any intensity (Moxley & Kruk, 2016). Specifically,

CMs may promote PA behavior educating and coaching patients, monitoring progression toward improving health outcomes, offering comprehensive health assessments and recognizing changes in health status (Lamb, 2014).

PHNs may collaborate with the community, the fitness industry and schools (CDC, 2019) to implement safe, developmentally appropriate PA interventions, PHNs who are experts in population health and knowledgeable of community settings can provide expertise and skills to successfully implement PA by initially addressing challenges with PA engagement such as a lack of safe access to activity, communities not designed for PA, or environments in which chronic diseases or physical limitations impair access to PA engagement, barriers to PA can be reduced.

The SEM can be used to guide interventions by addressing factors that influence PA behavior. Focused strategies (Figure 1) may facilitate the implementation of community level PA programs and promote greater sustainability for change, which consists of five interventions: Point-of-Decision Prompts, School Policies and Practices, Access to indoor or Outdoor Recreation Facilities or Outlets, Community-Wide Campaign, and Community Design.

*****Insert Figure 1 here*****

Point-of-Decision Prompts provide signs or other prompts to encourage PA. School policies can improve physical education by providing classroom PA and programs, space, or equipment for PA before and after school and building behavioral skills for PA participation. Promoting PA in children at early ages is recommended to develop patterns for healthy lifestyle habits that are sustainable throughout adulthood (CDC, 2021). The Youth Physical Activity Toolkit was designed by the CDC (2019) to encourage age appropriate and enjoyable PA participation to acquire basic motor skills, social skills of teamwork and sportsmanship, learn self-discipline, self-esteem, and leadership, through play, recreation and sports.

Community-wide campaigns can improve PA by including outreach efforts to increase awareness of PA locations or facilities, promote access to indoor or outdoor recreation facilities and walking trails, and encourage support groups. Design interventions promote PA, particularly for transportation, which entails locating destinations such as schools, stores, or public transportation near homes or workplaces to accommodate walkers, bicyclists, or wheelchair users (USDHHS, 2018).

Implications for Public Health Nursing Practice

Coordination of care or collaboration with multidisciplinary teams by PHNs is key for long-term improvements in decreasing coronary disease risk, one of the primary benefits of increasing PA. These interventions are suggested in the classic EUROACTION Trial provides an example of a multidisciplinary, family-based, nurse-led intervention that demonstrated improved lifestyle and a reduction in cardiovascular risk among individuals who were at a high risk of developing CVD. In six hospitals in eight European countries, it was found that of 10 000 high risk patients, nurse-led interventions were more effective than usual care to achieve guideline recommendations associate with coronary disease risk reduction, i.e., PA, nutritional intake, cholesterol targets and smoking cessation (Wood et al., 2008). Application of the SEM is, however, essential as patients must be ready cognitively, emotionally and behaviorally to make changes. To achieve optimal outcomes, it is critical for the coordination of a team, such as CMs to collaborate with PHNs for successful behavioral interventions to occur (Piepoli et al., 2016).

Future Research

Although the health benefits from PA are well established, most of the studies evaluating exercise-related outcomes are not randomized studies. Evidence is lacking on biological factors (i.e., genetics) as potential determinants of PA (Lightfoot et al., 2018). Further exploration of

interventions most effective for increasing PA knowledge and PA engagement as well as the optimal dosing of PA interventions (Olsen et al., 2018) is necessary. Additional research on tailoring interventions for diverse populations is currently warranted.

Conclusion

Physical activity improves health and decreases the risk for chronic disease. PA is attractive as an alternative to pharmacological interventions to manage cardiovascular risk factors with added benefits of fewer and less severe side effects. Most individuals currently engage in too little PA rather than too much. PHNs can promote and expedite change in existing patterns of PA by implementing creative promotion strategies at the individual or community level. Thoughtful communication, assessment, education and goal setting on the part of PHNs are necessary to assist patients in increasing PA. On a global scale, nurse-led interventions to coordinate care have demonstrated an improvement in risk factors as well as patient outcomes. To increase PA engagement, perhaps the most important intervention is the simplest: motivating people to change their lifestyle. The rewards are well worth the effort.

Acknowledgements: We would like to thank the Principal Investigator Academy at XXXX University for their support of this research.

References

Adams, V., Reich, B., Uhlemann, M., & Niebauer, J. (2017). Molecular effects of exercise training in patients with cardiovascular disease: focus on skeletal muscle, endothelium, and myocardium. *American Journal of Physiology. Heart and Circulatory Physiology*, *313*(1), H72–H88. https://doi.org/10.1152/ajpheart.00470.2016

Ainsworth, B. E., & Macera, C. A. (2018). Promoting physical activity in a public health context. *Journal of Sport and Health Science*, *7*(1), 1–2. https://doi.org/10.1016/j.jshs.2017.10.004

Alves, A. J., Viana, J. L., Cavalcante, S. L., Oliveira, N. L., Duarte, J. A., Mota, J., Oliveira, J., & Ribeiro, F. (2016). Physical activity in primary and secondary prevention of cardiovascular disease: Overview updated. *World Journal of Cardiology*, *8*(10), 575–583. https://doi.org/10.4330/wjc.v8.i10.575

American College of Sports Medicine. (2017). *ACSM's guidelines for exercise testing and prescription*. (11th ed.). Lippincott Williams & Wilkins.

American Diabetes Association. (2018). Economic costs of diabetes in the U.S. in 2017. *Diabetes Care 41*(5), 917-928. doi:10.2337/dci18-0007

American Public Health Association. (2017). Supporting the updated national physical activity plan. https://www.apha.org/policies-and-advocacy/public-health-policy statements/policy-database/2018/01/18/supporting-the-updated-national-physical activity-plan

Bacchi, E., Negri, C., Tarperi, C., Baraldo, A., Faccioli, N., Milanese, C., Zanolin, M. E., Lanza, M., Cevese, A., Bonora, E., Schena, F., & Moghetti, P. (2014). Relationships between cardiorespiratory fitness, metabolic control, and fat distribution in type 2 diabetes subjects. *Acta Diabetologica*, *51*(3), 369–375. https://doi.org/10.1007/s00592-013-0519 1

Bhupathiraju, S. N., & Hu, F. B. (2016). Epidemiology of obesity and diabetes and their cardiovascular complications. *Circulation Research*, *118*(11), 1723–1735. https://doi.org/10.1161/CIRCRESAHA.115.306825

Blair S. N. (2009). Physical inactivity: the biggest public health problem of the 21st century. *British journal of sports medicine, 43*(1), 1–2.

Bowden Davies, K. A., Pickles, S., Sprung, V. S., Kemp, G. J., Alam, U., Moore, D. R., Tahrani, A. A., & Cuthbertson, D. J. (2019). Reduced physical activity in young and older adults: metabolic and musculoskeletal implications. *Therapeutic Advances in Endocrinology and Metabolism, 10*. https://doi.org/10.1177/2042018819888824

Bryan, A. D., Jakicic, J. M., Hunter, C. M., Evans, M. E., Yanovski, S. Z., & Epstein, L. H. (2017). Behavioral and psychological phenotyping of physical activity and sedentary behavior: Implications for weight management. *Obesity 25*(10), 1653–1659. https://doi.org/10.1002/oby.21924

Carbone, S., Del Buono, M. G., Ozemek, C., & Lavie, C. J. (2019). Obesity, risk of diabetes and role of physical activity, exercise training and cardiorespiratory fitness. *Progress in Cardiovascular Diseases, 62*(4), 327–333. https://doi.org/10.1016/j.pcad.2019.08.004

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Reports 100*(2), 126–131.

Centers of Disease Control and Prevention. (2020). Global Health Protection and Security. https://www.cdc.gov/globalhealth/healthprotection/ncd/cardiovascular-diseases.html#:~:text=Cardiovascular%20diseases%2C%20a%20group%20of%20heart%20and%20blood,overlooked%20because%20it%20typically%20does%20not%20produce%20symptoms

Centers of Disease Control and Prevention. (2020a). Adult physical inactivity prevalence maps by race/ethnicity. https://www.cdc.gov/physicalactivity/data/inactivity-prevalence maps/index.html

Centers for Disease Control and Prevention. (2020b). Prevalence of self-reported physical inactivity among US adults by race/ethnicity, state and territory, https://www.cdc.gov/physicalactivity/data/inactivity-prevalence-maps/

Centers for Disease Control and Prevention. (2021). About Physical Activity**.** https://www.cdc.gov/physicalactivity/about-physical-activity/index.html

Chu, D. J., Al Rifai, M., Virani, S. S., Brawner, C. A., Nasir, K., & Al-Mallah, M. H. (2020). The relationship between cardiorespiratory fitness, cardiovascular risk factors and atherosclerosis. *Atherosclerosis*, *304*, 44–52. https://doi.org/10.1016/j.atherosclerosis.2020.04.019

Colberg, S. R., Sigal, R. J., Yardley, J. E., Riddell, M. C., Dunstan, D. W., Dempsey, P. C., Horton, E. S., Castorino, K., & Tate, D. F. (2016). Physical activity/exercise and diabetes: A position statement of the American Diabetes Association. *Diabetes Care*, *39*(11), 2065–2079. https://doi.org/10.2337/dc16-1728

Condello, G., Ling, F. C., Bianco, A., Chastin, S., Cardon, G., Ciarapica, D., Conte, D., Cortis, C., De Craemer, M., Di Blasio, A., Gjaka, M., Hansen, S., Holdsworth, M., Iacoviello, L., Izzicupo, P., Jaeschke, L., Leone, L., Manoni, L., Menescardi, C., Migliaccio, S., … (2016). DEDIPAC Consortium (2016). Using concept mapping in the development of the EU-PAD framework (EUropean-Physical Activity Determinants across the life course): A DEDIPAC-study. *BMC Public Health*, *16*(1), 1145. https://doi.org/10.1186/s12889-0163800-8

Centers for Disease Control and Prevention. (2020). Diabetes and prediabetes. https://www.cdc.gov/chronicdisease/resources/publications/factsheets/diabetes prediabetes.htm.

Centers for Disease Control and Prevention. (2019). Youth PA Guidelines Toolkit. CDC, 2019. Youth Physical Activity Guidelines | Physical Activity Healthy Schools | CDC.

Ekelund, U., Brown, W. J., Steene-Johannessen, J., Fagerland, M. W., Owen, N., Powell, K. E., Bauman, A. E., & Lee, I. M. (2019). Do the associations of sedentary behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. *British Journal of Sports Medicine*, *53*(14), 886–894. https://doi.org/10.1136/bjsports 2017-098963

Fiuza-Luces, C., Garatachea, N., Berger, N. A., & Lucia, A. (2013). Exercise is the real polypill. *Physiology 28*(5), 330–358. https://doi.org/10.1152/physiol.00019.2013

Fletcher G.F., Landolfo C., Niebauer J., Ozemek C., Arena R., & Lavie C.J. (2018). Promoting physical activity and exercise: JACC health promotion series. *Journal of American College Cardiology 72*(14), 1622-1639. doi: 10.1016/j.jacc.2018.08.2141. PMID: 30261965.

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2018). Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. *The Lancet. Global health*, *6*(10), e1077–e1086. https://doi.org/10.1016/S2214-109X(18)30357-7

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys

with 1·6 million participants. *The Lancet. Child & adolescent health*, *4*(1), 23–35. https://doi.org/10.1016/S2352-4642(19)30323-2

Han P., Zhang W., Kang L., et al. (2017). Clinical evidence of exercise benefits for stroke. *Advances in Experimental Medicine and Biology 1000,* 131–151. doi: 10.1007/978-981 10-4304-8_9

Halverstadt, A., Phares, D. A., Wilund, K. R., Goldberg, A. P., & Hagberg, J. M. (2007). Endurance exercise training raises high-density lipoprotein cholesterol and lowers small low-density lipoprotein and very low-density lipoprotein independent of body fat phenotypes in older men and women. *Metabolism: Clinical and Experimental*, *56*(4), 444–450. https://doi.org/10.1016/j.metabol.2006.10.019

Issakainen, M., Schwab, U., Lamminpää, R. (2020). Qualitative study on public health nurses'experience and assessment of nutritional and physical activity counseling of women with gestational diabetes. European Journal of Midwifery, 4(September), 1-7.https://doi.org/10.18332/ejm/127123

Kann, L., McManus, T., Harris, W. A., Shanklin, S. L., Flint, K. H., Hawkins, J., Queen, B., Lowry, R., Olsen, E. O., Chyen, D., Whittle, L., Thornton, J., Lim, C., Yamakawa, Y., Brener, N., & Zaza, S. (2016). Youth risk behavior surveillance - United States, 2015. *Morbidity and Mortality Weekly Report 65*(6), 1–174. https://doi.org/10.15585/mmwr.ss6506a1

Katzmarzyk, P. T., Lee, I. M., Martin, C. K., & Blair, S. N. (2017). Epidemiology of physical activity and exercise training in the United States. *Progress in Cardiovascular Diseases*, *60*(1), 3–10. https://doi.org/10.1016/J.Pcad.2017.01.004

Khoury, S. R., Evans, N. S., & Ratchford, E. V. (2019). Exercise as medicine. *Vascular Medicine 24*(4), 371–374. https://doi.org/10.1177/1358863X19850316

King, A. C., Stokols, D., Talen, E., Brassington, G. S., & Killingsworth, R. (2002). Theoretical approaches to the promotion of physical activity: forging a transdisciplinary paradigm. *American journal of preventive medicine, 23*(2 Suppl), 15–25. https://doi.org/10.1016/s0749-3797(02)00470-1

Knowler, W. C., Barrett-Connor, E., Fowler, S. E., Hamman, R. F., Lachin, J. M., Walker, E. A., Nathan, D. M., & Diabetes Prevention Program Research Group (2002). Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *New England Journal of Medicine, 346*(6), 393–403. https://doi.org/10.1056/NEJMoa012512

Lamb, G. (2014). Care coordination: The game changer. Silver Spring, MD: American Nurses Association.

Lavie, C. J., Ozemek, C., Carbone, S., Katzmarzyk, P. T., & Blair, S. N. (2019). Sedentary behavior, exercise, and cardiovascular health. *Circulation Research, 124*(5), 799–815. https://doi.org/10.1161/CIRCRESAHA.118.312669

Look AHEAD Research Group, Wing, R. R., Bolin, P., Brancati, F. L., Bray, G. A., Clark, J. M., Coday, M., Crow, R. S., Curtis, J. M., Egan, C. M., Espeland, M. A., Evans, M., Foreyt, J. P., Ghazarian, S., Gregg, E. W., Harrison, B., Hazuda, H. P., Hill, J. O., Horton, E. S., Hubbard, V. S., … Yanovski, S. Z. (2013). Cardiovascular effects of intensive lifestyle intervention in type 2 diabetes. *New England Journal of Medicine*, *369*(2), 145–154. https://doi.org/10.1056/NEJMoa1212914

Luther, B., Barra, J. & Martial, M. (2019). Essential Nursing Care Management and Coordination Roles and Responsibilities. *Professional Case Management, 24*(5), 249 258. doi: 10.1097/NCM.0000000000000355.

Martinez-Gomez, D., Lavie, C. J., Hamer, M., Cabanas-Sanchez, V., Garcia-Esquinas, E.,Pareja Galeano, H., Struijk, E., Sadarangani, K. P., Ortega, F. B., & Rodríguez-Artalejo, F. (2019). Physical activity without weight loss reduces the development of cardiovascular disease risk factors - a prospective cohort study of more than one hundred thousand adults. *Progress in Cardiovascular Diseases*, *62*(6), 522–530. https://doi.org/10.1016/j.pcad.2019.11.010

Mehtälä, M. A., Sääkslahti, A. K., Inkinen, M. E., & Poskiparta, M. E. (2014). A socio ecological approach to physical activity interventions in childcare: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity*, *11*, 22. https://doi.org/10.1186/1479-5868-11-22

Mitchell, B. D., Kalra, G., Ryan, K. A., Zhang, M., Sztalryd, C., Steinle, N. I., Taylor, S. I., Snitker, S., Lewis, J. P., Miller, M., Shuldiner, A. R., & Xu, H. (2019). Increased usual physical activity is associated with a blunting of the triglyceride response to a high-fat meal. *Journal of Clinical Lipidology*, *13*(1), 109–114. https://doi.org/10.1016/j.jacl.2018.11.006

Moxley, E. A., & Kruk, A. (2016). The free diabetes prescription: Encouraging exercise engagement. *American Nurse Today*, *11(*12). https://www.americannursetoday.com/24754-2/

Moxley, E., Habtzghi, D., Klinkhamer, N., Wang, H., Donnelly, S., & Dykhuizen, J. (2019). Prevention and treatment of pediatric obesity: A strategy involving children, adolescents

and the family for improved body composition. *Journal of Pediatric Nursing*, *45*, 13–19. https://doi.org/10.1016/j.pedn.2018.12.010

Olsen, J. M., Horning, M. L., Thorson, D., & Monsen, K. A. (2018). Relationships between public health nurse-delivered physical activity interventions and client physical activity behavior. *Applied Nursing Research 40*, 13–19. https://doi.org/10.1016/j.apnr.2017.12.005

Omura, J. D., Carlson, S. A., Brown, D. R., Hopkins, D. P., Kraus, W. E., Staffileno, B. A., Thomas, R. J., Lobelo, F., Fulton, J. E., & American Heart Association Physical Activity Committee of the Council on Lifestyle and Cardiometabolic Health; Council on Cardiovascular and Stroke Nursing; and Council on Clinical Cardiology (2020). Built environment approaches to increase physical activity: A science advisory from the American Heart Association. *Circulation*, *142*(11), e160–e166. https://doi.org/10.1161/CIR.0000000000000884

Oza, R., Rundell, K., & Garcellano, M. (2017). Recurrent ischemic stroke: Strategies for prevention. *American Family Physician*, *96*(7), 436–440.

Panahi, S., & Tremblay, A. (2018). Sedentariness and health: Is sedentary behavior more than just physical inactivity? *Frontiers in Public Health*, *6*, 258. https://doi.org/10.3389/fpubh.2018.00258

Paffenbarger, R. S., Jr, Hyde, R. T., Wing, A. L., & Hsieh, C. C. (1986). Physical activity, all-cause mortality, and longevity of college alumni. *New England Journal of Medicine*, *314*(10), 605–613. https://doi.org/10.1056/NEJM198603063141003

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., Buchner, D., Ettinger, W., Heath, G. W., & King, A. C. (1995). Physical activity and public health. A

recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA, 273*(5), 402–407. https://doi.org/10.1001/jama.273.5.402

Patterson, R., McNamara, E., Tainio, M., de Sá, T. H., Smith, A. D., Sharp, S. J., Edwards, P., Woodcock, J., Brage, S., & Wijndaele, K. (2018). Sedentary behaviour and risk of all cause, cardiovascular and cancer mortality, and incident type 2 diabetes: A systematic review and dose response meta-analysis. *European Journal of Epidemiology, 33*(9), 811 829. https://doi.org/10.1007/s10654-018-0380-1

Piepoli, M. F., Hoes, A. W., Agewall, S., Albus, C., Brotons, C., Catapano, A. L., Cooney, M. T., Corrà, U., Cosyns, B., Deaton, C., Graham, I., Hall, M. S., Hobbs, F., Løchen, M. L., Löllgen, H., Marques-Vidal, P., Perk, J., Prescott, E., Redon, J., Richter, D. J., … ESC Scientific Document Group (2016). 2016 European Guidelines on cardiovascular disease prevention in clinical practice: The Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts) Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). *European heart journal*, *37*(29), 2315–2381. https://doi.org/10.1093/eurheartj/ehw106

Poitras, V. J., Gray, C. E., Borghese, M. M., Carson, V., Chaput, J. P., Janssen, I., Katzmarzyk, P. T., Pate, R. R., Connor Gorber, S., Kho, M. E., Sampson, M., & Tremblay, M. S. (2016). Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Applied Physiology,*

Nutrition, and Metabolism 41(6 Suppl 3), S197–S239. https://doi.org/10.1139/apnm 2015-0663

Poirier, P., & Eckel, R. H. (2002). Obesity and cardiovascular disease. *Current Atherosclerosis Reports, 4*(6), 448–453. https://doi.org/10.1007/s11883-002-0049-8

Sallis J.F. & Owen N. (1999). *Physical activity and behavioural medicine*. Sage Publications.

Sallis, J. F., Floyd, M. F., Rodríguez, D. A., & Saelens, B. E. (2012). Role of built environments in physical activity, obesity, and cardiovascular disease. *Circulation*, *125*(5), 729–737. https://doi.org/10.1161/CIRCULATIONAHA.110.969022

Shuval, K., Leonard, T., Drope, J., Katz, D. L., Patel, A. V., Maitin-Shepard, M., Amir, O., & Grinstein, A. (2017). Physical activity counseling in primary care: Insights from public health and behavioral economics. *CA: A Cancer Journal for Clinicians*, *67*(3), 233–244. https://doi.org/10.3322/caac.21394

Stokols, D. (2004). Ecology and health. In N. J. Smelser & P. B. Bolten (Eds.), *International encyclopedia of the social and behavioral sciences* (pp. 4030–4035). Elsevier, Ltd.

Strain, T., Wijndaele, K., Garcia, L., Cowan, M., Guthold, R., Brage, S., & Bull, F. C. (2020). Levels of domain-specific physical activity at work, in the household, for travel and for leisure among 327 789 adults from 104 countries. *British journal of sports medicine*, *54*(24), 1488–1497. https://doi.org/10.1136/bjsports-2020-102601

Strath, S. J., Kaminsky, L. A., Ainsworth, B. E., Ekelund, U., Freedson, P. S., Gary, R. A., Richardson, C. R., Smith, D. T., Swartz, A. M., & American Heart Association Physical Activity Committee of the Council on Lifestyle and Cardiometabolic Health and Cardiovascular, Exercise, Cardiac Rehabilitation. (2013). Guide to the assessment of physical activity: Clinical and research applications: a scientific statement from the American Heart

Association. *Circulation*, *128*(20), 2259–2279. https://doi.org/10.1161/01.cir.0000435708.67487.da

Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., Chastin, S., Altenburg, T. M., Chinapaw, M., & SBRN Terminology Consensus Project Participants. (2017). Sedentary behavior research network (SBRN) – Terminology Consensus Project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1), 75. https://doi.org/10.1186/s12966-017-0525-8

Tuso P. (2015). Strategies to increase physical activity. *Permanente Journal*, *19*(4), 84–88. https://doi.org/10.7812/TPP/14-242

U.S. Department of Health and Human Services. (2018). *Physical activity guidelines for Americans* (2nd ed.). https://health.gov/paguidelines/secondedition/pdf/Physical_Activity_Guidelines_2nd_edition.pdf

Chapter 3: Active Children and Adolescents. 2018 Physical Activity Guidelines for Americans. U.S. Department of Health and Human Services. https://health.gov/paguidelines/secondedition/pdf/Physical_Activity_Guidelines_2nd_edition.pdf

Warburton, D. E. R., Jamnik, V., Bredin, S. S. D., Shephard, R. J., & Gledhill, N. (2015). The 2015 Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and electronic Physical Activity Readiness Medical Examination (ePARmed-X+). *The Health &Amp; Fitness Journal of Canada*, *8*(1), 53–56. https://doi.org/10.14288/hfjc.v8i1.194

Webber-Ritchey, K.J., Moxley, E., Hwang, S., Habtzghi, D., & Yalla, S. Perceived neighborhood characteristics and parental role in physical activity of African American

Youth. *Journal of Nursing Practice Applications and Reviews of Research* *11*(1), 27-42. https://doi.org/10.13178/jnparr.2021.11.01.1005

Wood, D. A., Kotseva, K., Connolly, S., Jennings, C., Mead, A., Jones, J., Holden, A., De Bacquer, D., Collier, T., De Backer, G., Faergeman, O., & EUROACTION Study Group (2008). Nurse-coordinated multidisciplinary, family-based cardiovascular disease prevention programme (EUROACTION) for patients with coronary heart disease and asymptomatic individuals at high risk of cardiovascular disease: a paired, cluster randomised controlled trial. *Lancet (London, England)*, *371*(9629), 1999–2012. https://doi.org/10.1016/S0140-6736(08)60868-5

World Health Organization. (2010). Global recommendations on physical activity for health.

World Health Organization (2018). Global Strategy on Diet, Physical Activity and Health http://www.who.int/dietphysicalactivity/childhood/tools/en/.

World Health Organization. (2021a). Physical activity. https://www.who.int/health topics/physical-activity#tab=tab_1. 2021.

World Health Organization. (2021b). Prioritizing areas for action in the field of population-based prevention of childhood obesity.http://www.who.int/dietphysicalactivity/childhood/tools/en/

Table 1. Glossary of Terminology

Term	Definition
Physical Activity	Any bodily movement produced by skeletal muscles that requires energy expenditure, expressed by MET (Caspersen, 1985); activity involving bodily movement, playing, working, chores and recreation (WHO, 2018).
Metabolic Equivalent of Task (MET)	A unit describing the energy expenditure of a specific activity; the ratio of the rate of energy expended during an activity to the rate of energy expended at rest (USDHHS, 2018).
Exercise	Planned, structured, and repetitive bodily movement done to improve or maintain one of more components of PA (Caspersen et al.).
Physical Inactivity	Not participating in recommended quantity of regular PA (Trembley et al., 2017)
Sedentary Behavior	Waking behavior characterized by low level of energy expenditure (less than or equal to 1.5 METs) while sitting, reclining, or lying (self-reported sitting; leisure-time, occupational, total), television viewing, screen time, low levels of movement measured by devices that assess movement or posture (USDHHS, 2018; Pate et al., 1995).

Physical Activity Intensity	Rate of energy expenditure and an indicator of the metabolic demand of an activity (Strath et al., 2013).
Fitness	Ability to carry out daily tasks with vigor and without fatigue to enjoy leisure and respond to emergencies (USDHHS, 2018).

Table 2. Influences on Physical Activity*

Individual Factors	**Environmental Factors**
Age and demographic	Access to PA facilities (gyms and recreation centers)
Health status and biologic	Presence of sidewalks
Intention to exercise and self-efficacy	Neighborhood aesthetics
Educational attainment	Infrastructure (access to sidewalks and trails, intersection design, sufficient street lighting, and landscaping)
Culture (preferences for and opportunities to engage in PA and shared familial, genetic or environmental)	Social environment
Psychological, cognitive and emotional	Physical environment

*(Adapted from Bryan et al., 2017; Fletcher et al., 2018; Omura et al., 2020; Sallis & Owen, 1999; Webber-Ritchey et al., 2021)

Table 3. METs of common activities as very light, light, moderate or vigorous intensity (ACSM, 2017)

Very Light 1.5 METs	**Light** 2-< 3 METs	**Moderate** 3-6.0 METs	**Vigorous** 6.0-8.8 METs	**Maximum** ≥8.8 METs
Sitting at computer or light hand tools = 1.5	Washing dishes, ironing, cooking = 2.5	Walking = 3.0 Walking at very brisk pace = 5.0	Walking; extremely brisk pace (4.5 mph) = 6.3 hiking = 7.0-8.0	Jog 5mph = 8 Run 7 mph = 11.5 Competitive soccer = 10.0
Arts and crafts, playing cards, = 1.5	Billiards, croquet, darts = 2.5	Carpentry = 3.6 Carrying wood = 5.5	Shoveling = 7.0 Heavy farming = 8.0	Ski cross country skiing = 7.0 - 9.0
Walking slowly around home or office = 2	Fishing = 2.5 Sail boating = 3.0	Shooting baskets = 4.5 fast dancing = 4.5	Bicycling, flat surface - moderate effort;12-14 mph = 6.0	Bicycle race (14-16 mph) = 10
Playing musical instruments = 2.0-2.5	Slow dancing = 3.0	Golf, walking with clubs = 4.3	Leisurely swimming = 6.0	Moderate - hard swimming = 8.0-11.0

Figure 1 caption

Note. Using a socioecological framework as a guide, the two inner ovals represent intrapersonal factors and interpersonal level influences. These interventions should be implemented at the community level (the largest oval) where five physical activity strategies are recommended for longer lasting change in PA. (This figure was adapted from Stokols (2000, 2004).