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Physical Activity and the Prevention of Weight Gain in Adults: A Systematic Review

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Abstract

Purpose.—To conduct a systematic literature review to determine if physical activity is associated with prevention of weight gain in adults.

Methods.—The primary literature search was conducted for the 2018 Physical Activity Guidelines Advisory Committee and encompassed literature through June 2017, with an additional literature search conducted to include literature published through March 2018 for inclusion in this systematic review.

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Results.—The literature review identified 40 articles pertinent to the research question. There is strong evidence of an association between physical activity and prevention of weight gain in adults, with the majority of the evidence from prospective cohort studies. Based on limited evidence in adults, however, there is a dose-response relationship and the prevention of weight gain is most pronounced when moderate-to-vigorous intensity physical activity (≥ 3 METS) is above 150 minutes per week. While there is strong evidence to demonstrate that the relationship between greater time spent in physical activity and attenuated weight gain in adults is observed with moderate-to-vigorous intensity physical activity, there is insufficient evidence available to determine if there is an association between light-intensity activity (<3 METS) and attenuated weight gain in adults.

Conclusions.—The scientific evidence supports that physical activity can be an effective lifestyle behavior to prevent or minimize weight gain in adults. Therefore, public health initiatives to prevent weight gain, overweight, and obesity should include physical activity as an important lifestyle behavior.

Keywords

obesity; overweight; exercise; physical activity; weight gain

Introduction

Excessive body weight is associated with numerous negative health outcomes that include, but are not limited to cardiovascular disease (CVD), diabetes, some forms of cancer, and musculoskeletal disorders (1, 2). Recent estimates indicate that the prevalence of overweight (body mass index (BMI) 25 to 30 kg/m^2) in the United States for adult men is approximately 39 percent and 27 percent for adult women (3), with estimates of obesity (BMI $\geq 30 \text{ kg/m}^2$) for men being approximately 38 percent and for women being 40 percent (4).

Given the high prevalence of overweight and obesity, there is an ongoing need for effective treatment and prevention methods. The 2008 Physical Activity Guidelines Advisory Committee (PAGAC) Report concluded physical activity was associated with modest weight loss of approximately 3 kg, prevention of weight gain following weight loss, and reductions in total and regional adiposity (5). Moreover, professional organizations have also identified physical activity as an important behavior that contributes to body weight regulation (6–8).

Evidence from the CARDIA Study has demonstrated that the average weight gain across a 25-year period was approximately 0.5–0.8 kg per year. This magnitude of weight gain has the potential to lead to overweight and obesity as individuals transition from young (18–30 years of age) to middle-aged (43–55 years of age) adults (9), and therefore weight gain prevention efforts may be of importance. The 2018 PAGAC, recognizing the public health importance of the prevention of weight gain, examined the existing literature regarding the relationship between physical activity and prevention of weight gain in adults (10). In addition, within the context of this overall examination of the literature, the PAGAC also examined whether the relationship between physical activity and weight gain varied by age,

sex, race/ethnicity, socioeconomic status, or weight status, and whether the relationship varied based on levels of light (<3 metabolic equivalent tasks [METs]), moderate (3-<6 METs), vigorous (≥ 6 METs), or the combination of moderate-to-vigorous (≥ 3 METs) physical activity.

METHODS

The overarching methods used to conduct systematic reviews informing the 2018 PAGAC Scientific Report are described in detail elsewhere (10, 11). The searches were conducted using electronic databases (PubMed®, CINAHL, and Cochrane). An initial search to identify systematic reviews, meta-analyses, and pooled analyses examining the relationship between physical activity and weight gain did not identify sufficient literature to answer the proposed research question. Therefore, a *de novo* search of original research was conducted through June 2017 for the 2018 PAGAC Report. This *de novo* search of original research was expanded to include literature through March 2018 for inclusion in this manuscript. Eligibility criteria for the *de novo* search included original research studies published in English; study designs that included randomized trials and prospective cohort studies; studies that were at least 1 year in duration; and outcomes of weight, weight change, weight control, weight gain, weight maintenance, weight regulation, weight stability, and weight status. Physical activity included all types and intensities of physical activity including lifestyle activities, leisure activities, and sedentary behavior. The full search strategy is available at https://health.gov/paguidelines/second-edition/report/supplementary_material/pdf/Cardiometabolic_Q1_Weight_Status_Evidence_Portfolio.pdf.

The titles and abstracts of the identified articles were independently screened by two reviewers who were members of the 2018 PAGAC. The full-text of relevant articles were also reviewed by at least two members of the PAGAC to identify and include those meeting the inclusion criteria. Discrepancies in article selection or data abstractions were resolved by discussion between the two reviewers or by a third reviewer, if needed, to achieve agreement. The protocol for this review was registered with the PROSPERO database registration (CRD42018096694).

For the 2018 PAGAC Report, 33 original studies published through June 2017 that examined the relationship between physical activity and weight gain were included as sources of evidence (12–44). The additional search conducted through March 2018 resulted in an additional seven original research studies being included in the literature review (45–51). Thus, 40 original research studies were included, and a summary of the articles included in this review is shown in Figure 1.

RESULTS

The studies reviewed provided substantial information to allow for evaluation of an overall association between physical activity and either weight gain, increase in BMI, or development of obesity. Although data were available to examine whether these associations were influenced by sex and age, very limited information was provided within the studies reviewed to examine the influence of race/ethnicity, socioeconomic status, initial weight

status, or dietary intake and eating behaviors, on the relationship between physical activity and weight gain. Moreover, although substantial information was provided for moderate-to-vigorous intensity physical activity, few studies provided data for light-intensity physical activity.

Overall Association between Physical Activity and Attenuation of Weight Gain

Most (N=29) of the studies showing an association between greater physical activity and attenuated weight gain were prospective cohort studies (12, 13, 15, 16, 18, 20–22, 25–29, 32–34, 36–44, 49–51), with follow-up periods ranging from 1 to 22 years and one study involving 6-year follow-up after a block randomized controlled trial (14). For the studies not showing an effect (N=11), cohort studies had a follow-up period ranging from 1 to 20 years (17, 19, 23, 24, 30, 31, 35, 45–48), with three of these studies having follow-up periods of 2 or fewer years (19, 22, 23, 31), and one was a secondary analysis of data from a randomized study (24).

Of studies showing an inverse association with weight gain, eight studies assessed physical activity at one time point to examine the association with weight gain (15, 20, 25, 26, 29, 33, 39, 51), whereas 21 studies assessed physical activity at two or more time points to allow physical activity to be examined using individual time points or between time points across the observation period (12–14, 16, 18, 21, 22, 27, 28, 32, 34, 36–38, 40–44, 49, 50). There were studies that examined the association with weight gain but did not show an effect, with some studies measuring physical activity at one time point (19, 30, 31, 45–48) and other studies measuring physical activity at multiple time points (17, 23, 24, 35).

Physical Activity Volume and Dose-Response

There were 12 studies that reported data for the volume of physical activity where the effect on prevention of weight gain was observed (15, 18, 25, 27, 28, 32, 34, 38, 39, 41, 44, 52). The evidence, however, for a specific volume threshold of physical activity that is associated with prevention of weight gain in adults is inconsistent. For example, some evidence supports the need to achieve at least 150 minutes per week of moderate intensity physical activity (27, 28) or achieve 10,000 steps per day (41) to minimize weight gain or to prevent increases in BMI. However, other studies support greater amounts physical activity to prevent or minimize weight gain, with some studies reporting this effect with greater than 150 minutes per week at a moderate intensity (3 METS, similar to brisk walking) (450 MET-minutes per week at a 3-MET intensity) (34), at least 167 minutes per week (500 MET-minutes per week) (18, 39), or more than 300 minutes per week (>900 MET-minutes per week) (15, 25, 32).

The amount of physical activity necessary to prevent weight gain and the development of obesity may depend on the intensity of the physical activity. For example, at least 1 hour per week of moderate intensity physical activity was shown to reduce the risk of developing obesity in both normal weight women (incidence rate ratio (IRR)=0.81; 95% confidence interval (CI): 0.71–0.93) and overweight women (IRR=0.88; 95% CI: 0.81–0.95) (37); however, a lower duration of physical activity may be necessary if vigorous intensity rather than moderate intensity. For example, Williams and Wood (44) have reported that running

equivalent to 4.4 km per week (~2.8 miles per week (~28 minutes per week at a 10-minute per mile pace) in men and 6.2 km per week (~3.8 miles per week (~38 minutes per week at a 10-minute per mile pace) in women may be sufficient to prevent weight gain associated with aging.

Preventing or Minimizing Weight Gain.—Some of the reviewed studies provided data on the dose-response relationship of physical activity and weight gain (15, 25, 34, 39). Sims et al. (39) reported a trend ($P<0.08$) for minimized weight gain in women engaging in more than 8.3–20 MET-hours per week (>167–400 minutes per week at a 3-MET intensity) or more than 20 MET-hours per week (>400 minutes per week at a 3-MET intensity) of physical activity, compared with those engaged in less than 1.7 MET-hours per week (<33 minutes per week at a 3-MET intensity). A physical activity volume of 1.7–8.3 MET-hours per week (33–167 minutes per week at a 3-MET intensity) was not protective against weight gain.

Two studies provide evidence of a dose-response to prevent weight gain of approximately 2 kg. Moholdt et al. (34) identified four groups based on physical activity (“Inactive”: no leisure-time physical activity; “Below Recommended”: active <150 minutes per week in moderate intensity or <60 minutes per week in vigorous intensity leisure-time physical activity; “Recommended”: active at 150 minutes per week in moderate intensity or 60 minutes per week in vigorous intensity leisure-time physical activity; “Above Recommended”: active >150 minutes per week in moderate intensity or >60 minutes per week in vigorous intensity leisure-time physical activity). For men, compared with those in the “Inactive” category, the risk of gaining 2.3 kg was 0.97 (95% CI: 0.87–1.08) for those in the “Recommended” category and 0.79 (95% CI: 0.69–0.91) for those in the “Above Recommended” category. A similar pattern was observed in women, with the risk of 0.97 (95% CI: 0.88–1.07) for those in the “Recommended” category and 0.69 (95% CI: 0.59–0.82) for those in the “Above Recommended” category. Gebel et al. (25) reported a 10 percent reduction in the odds of 2kg weight gain with 300 or more minutes per week of moderate-to-vigorous intensity physical activity compared with less than 150 minutes per week of moderate-to-vigorous intensity physical activity; however, 150–249 minutes per week was not predictive of weight change.

Blanck et al. (15) reported relatively high levels of physical activity may be needed to reduce the odds of gaining 10 or more pounds (4.5 kg). In women, with the reference group defined as those with an activity level of 0 to <4 MET-hours per week, the odds of gaining 10 or more pounds (4.5 kg) was significantly lower with 18 or more MET-hours per week (0.88; 95% CI: 0.77–0.99). Compared to the reference, however, the odds of gaining this magnitude of weight did not differ with 0 MET-hours per week (1.01; 95% CI: 0.82–1.01), 4 to less than 10 MET-hours per week (0.93; 95% CI: 0.80–1.08), and 10 to less than 18 MET-hours per week (0.99; 95% CI: 0.87–1.14).

Maintaining a Healthy Weight.—Brown et al. (18) report on a dose-response relationship for physical activity and the odds of maintaining a healthy weight (i.e., BMI of 18.5 to <25 kg/m²). Compared with less than 0.7 MET-hours per week, the odds ratio for maintaining a normal BMI was 1.18 (95% CI: 1.00–1.40) for 0.7 to less than 8.3 MET-hours

per week, 1.23 (95% CI: 1.03–1.47) for 8.3 to less than 16.7 MET-hours per week, and 1.44 (95% CI: 1.20–1.72) for 16.7 or more MET-hours per week (18) (Figure 2).

Overweight or Obesity.—Su et al. (50) reported on the dose-response relationship leisure-time physical activity (MET-hours per week) and the odds of overweight and obesity in the China Health and Nutrition Survey. The reference category was defined as 15 MET-hours per week, which was then compared to 7.5 to <15 MET-hours per week, >0 to 7.5 MET-hours per week, and 0 MET-hours per week. In men, the odds ratio of overweight and obesity were 1.0, 1.54 (95% CI: 0.97–1.99), 1.88 (95% CI: 1.15–2.51), and 2.01 (95% CI: 1.41–3.03) in these physical activity categories, respectively. For women, the odds ratio of overweight and obesity were 1.0, 1.24 (95% CI: 0.94–1.62), 1.63 (95% CI: 1.29–2.21), and 1.69 (95% CI: 1.37–2.27) in these physical activity categories, respectively.

Rosenberg et al. (37) reported on the dose-response relationship for vigorous intensity physical activity (e.g. basketball, swimming, running aerobics) and the likelihood of developing obesity. In women with normal weight and overweight, when compared to less than 1 hour per week, the incidence of developing obesity was significantly reduced in a graded manner, with vigorous intensity activity of 1 to 2 hours per week (0.87; 95% CI: 0.81–0.93), 3 to 4 hours per week (0.82; 95% CI: 0.75–0.88), 5 to 6 hours per week (0.79; 95% CI: 0.71–0.87), and 7 or more hours per week (0.77; 95% CI: 0.69–0.85) (Figure 3).

Evidence on Specific Factors

Age.—In general, the studies in which a significant inverse association between physical activity and weight gain was observed encompassed a broad age range that included young, middle-aged, and older adults. Six studies analyzed the data specifically by age, with the evidence suggesting attenuation of this association with increasing age in some (32, 33, 39, 42), but not all studies (34, 43).

Macinnis et al. (33) reported a significant inverse association between physical activity and magnitude of weight gain across a mean follow-up of approximately 12 years in adults ages 40 to 49 years, with this association not observed in adults ages 50 to 59 years or 60 to 69 years. Williams (42) reported that running attenuated weight gain in men younger than 55 years of age and in women younger than 50 years of age.

These results are not consistent with the finding of Moholdt et al. (34), who reported that physical activity was significantly associated with reduced odds of gaining 2.3 kg in both men and women, but the odds of a 2.3 kg weight gain in physically active adult men was significant for those 40 years or older but not in those younger across a follow-up period of approximately 22 years. In contrast, the inverse association between physical activity and odds of a 2.3 or more kg weight gain was observed across the age spectrum (younger than age 40 years, age 40 to 59 years, and age 60 years and older) in women.

Williams and Thompson (43) reported that the weight gain associated with the cessation of running, across a follow-up period of approximately 7 years, was consistent between men less than 45 years of age and 45 years or older. However, among women, weight gain was greater in women ages 45 years or older compared with their younger counterparts. Two

studies examined the association between physical activity and weight gain only in women. Lee et al. (32) examined data from the Women's Health Initiative study and reported a trend for greater weight gain, across a follow-up period of approximately 13 years, with lower levels of activity in women younger than age 64 years, but not in women ages 65 years and older. Similar findings were reported by Sims et al. (39) in a study of post-menopausal women ages 50 to 79 years, which showed attenuated weight gain across a follow-up period of 8 years with greater amounts of physical activity in women ages 50 to 59 years, but not in those of ages 60 to 69 years or 70 to 79 years.

Sex.—The studies in which a significant inverse association between physical activity and weight gain was observed included either women (12, 14, 15, 18, 20, 26, 29, 32, 37, 39) or both men and women (13, 16, 21, 22, 25, 27, 38, 41–44, 49, 50). Of the studies that included both men and women, some did not analyze the data separately by sex (16, 22, 25, 27, 38, 41). Of the studies that presented findings separately by sex, some reported that the association between physical activity and weight gain was consistent for both men and women (13, 21, 28, 33, 34, 36, 40, 42–44, 50).

Race/ethnicity.—In general, the studies in which a significant inverse association between physical activity and weight gain was observed encompassed diverse races and ethnicities. When specified, for studies conducted based on adults residing in the United States, a broad range of races and ethnicities appeared to be represented in the study samples (16, 22, 28, 29, 39) or the sample included only black/African Americans (37, 45). Some of the studies were conducted in countries outside of the United States, including Australia (18, 25, 33, 41), China (50), France (40), Great Britain (36), Norway (34), South Africa (26), Spain (13), Sweden (21), and the Philippines (12, 20). Although some studies included race or ethnicity as a covariate in the analyses, none of them presented data separately by race or ethnicity to allow for comparisons.

Socioeconomic status.—Of those studies showing an inverse association between physical activity and weight gain, some studies provided a measure of socioeconomic status as a descriptive variable or as a covariate in analyses. Only one study isolated the effect of socioeconomic status on the association between physical activity and weight gain, and it was reported that socioeconomic status attenuated this association even though it remained statistically significant (16).

Weight status.—The studies in which a significant inverse association between physical activity and weight gain was observed included adults of normal, overweight, and obese weight status. However, studies do not show a consistent pattern of findings that favor one category of initial weight status over others. Some studies reported that the association did not differ by weight status (39, 53), some reported the association to be more favorable in adults who had normal weight versus overweight or obesity (15, 29, 32), and some studies reported results showing a more favorable pattern in adults with overweight or obese compared to those with normal weight (13, 34).

Physical Activity Intensity and Mode

In the studies in which a significant inverse association between physical activity and weight gain was reported, data were reported for a number of physical activity domains. These included leisure-time/recreational activity, occupational activity, household activity, walking, and total steps of physical activity, with some studies also reporting on various intensities of physical activity (light, moderate, vigorous, moderate-to-vigorous).

Total leisure-time physical activity was consistently inversely associated with weight change across the studies reviewed (15, 21, 32, 33, 36, 39, 40). Studies reporting on moderate intensity (13, 22), vigorous intensity (16, 26, 27, 33, 37, 42–44), and moderate-to-vigorous intensity (18, 25–29, 34, 38) physical activity showed consistent patterns of inverse associations with weight gain. Light-intensity physical activity, however, was not associated with prevention of weight gain (22, 23, 27).

Walking was not consistently associated with change in weight or BMI (26, 33) or with the incidence of developing obesity (37). Smith et al. (41), however, reported that achieving 10,000 steps or more per day attenuated weight gain compared with not achieving 10,000 steps per day. These results may suggest that high volumes of walking need to be achieved to attenuate weight gain.

Studies also examined occupational and household activity. Moderate-to-vigorous occupational activity was inversely associated with weight gain (12, 33), but not with light-intensity occupational activity (12). In studies of household activity, the evidence does not support that this mode of physical activity minimizes weight gain (20, 33).

DISCUSSION

Summary and Public Health Impact

The evidence contained in this review expands the information contained in the 2008 PAGAC Report (5) by summarizing the literature related to the association between physical activity and weight gain, incidence of obesity, and maintenance of BMI within a range of 18.5 to <25 kg/m². The literature includes primarily evidence from prospective observational studies that met the inclusion criteria for this review. The evidence supports the following conclusions:

1. There is strong evidence to demonstrate a relationship between greater amounts of physical activity and attenuated weight gain in adults. There is also some evidence to support that this relationship is most pronounced when physical activity exposure is above 150 minutes per week.
2. There is limited evidence to support a dose-response relationship between physical activity and the risk of weight gain in adults.
3. There is limited evidence suggesting that the relationship between greater amounts of physical activity and attenuated weight gain in adults varies by age, with the effect diminishing with increasing age.

4. There is moderate evidence to indicate that the relationship between greater amounts of physical activity and attenuated weight gain in adults does not appear to vary by sex.
5. There is insufficient evidence available to determine whether the relationship between greater amounts of physical activity and attenuated weight gain in adults varies by race/ethnicity, socioeconomic status, or initial weight status.
6. With regard to intensity of physical activity, there is strong evidence to demonstrate that the relationship between greater time spent in physical activity and attenuated weight gain in adults is observed with moderate-to-vigorous intensity physical activity. There is, however, insufficient evidence available to determine if there is an association between light-intensity activity and attenuated weight gain in adults.

Public Health Impact

Weight gain that results in overweight or obesity is associated with increased risk for numerous chronic conditions. This is a significant health concern in the United States due to the high prevalence of both overweight and obesity. Thus, while it is important to focus on effective treatments for overweight and obesity, there is also a need to implement effective public health strategies to prevent the approximately 0.5–1 kg of annual weight gain in adults (9) and the onset of both overweight and obesity. The scientific evidence supports that physical activity can be an effective lifestyle behavior to prevent or minimize weight gain in adults. Therefore, public health initiatives to prevent weight gain, overweight, and obesity should include physical activity as an important lifestyle behavior.

Needs for Future Research

The evidence from this review supports that physical activity contributes to the prevention of weight gain and obesity, and the maintenance of a healthy body weight. The review of evidence also has identified a number of areas for additional research, and these research needs are described below.

Conduct longitudinal research in observational or randomized controlled trials that include objective measures of physical activity and that are specifically designed to examine the association between physical activity and prevention of weight gain. The majority of the studies included in this review were from observational prospective studies with physical activity measured using questionnaires or other self-reported measures. Thus, confirming these findings with additional study designs and with objective measures of physical activity would provide clarity on the role of physical activity to prevent weight gain and obesity.

Conduct longitudinal research on lower exposure levels of physical activity to allow for an enhanced understanding of the dose-response associations between physical activity and weight gain across a wider spectrum of exposure. There is limited evidence available on the effect of physical activity of less than 150 minutes per week on prevention of weight gain. This knowledge will inform public health recommendations regarding the minimum

physical activity exposure that can be effective for preventing weight gain or the development of obesity.

Conduct large research trials with ample sample sizes to allow for stratum-specific analyses to determine whether the influence of physical activity on the prevention of weight gain varies by age, sex, race/ethnicity, socioeconomic status, or initial weight status. Based on the literature reviewed, there is limited evidence on whether the influence of physical activity on weight gain varies by age, sex, race/ethnicity, socioeconomic status, weight status. Moreover, little is known about whether the influence of physical activity varies when the exposure to physical activity is consistent across individuals with different demographic characteristics. Thus, adequately designed and statistically powered studies are needed to allow for comparisons across the various stratum of demographic characteristics to examine whether the influence of physical activity on weight gain and obesity prevention varies by these factors. This may require multiple studies to be conducted that allow for these characteristics to be examined in a feasible manner rather than one large comprehensive study.

Conduct experimental research on varying intensities (light, moderate, and vigorous) of physical activity, while holding energy expenditure constant, to determine the independent effects of physical activity intensity on weight gain. Limited evidence is available on whether the influence of physical activity on weight gain is consistent across intensities (light, moderate, vigorous) when total energy expenditure is held constant, and only limited evidence is available on the influence of light-intensity physical activity on weight gain. This information will inform public health recommendations regarding whether the emphasis to prevent weight gain should be on total volume of physical activity regardless of intensity, or whether the emphasis needs to be on volume of physical activity that is performed at a specific intensity.

Conduct observational and experimental research that quantifies energy intake and eating behavior to determine whether these factors influence the association between physical activity and weight gain. The majority of the literature reviewed either did not report that diet and eating behavior were measured or considered in the analysis. It is important to understand whether the physical activity exposure necessary to limit weight gain will vary based on diet or eating behavior patterns.

Conduct studies to examine the relationship of physical activity to other indices of unhealthy weight or fat gain. This review used the following search terms: weight, weight change, weight control, weight gain, weight maintenance, weight regulation, weight stability, and weight status. Thus, measures of adiposity (total body, visceral) were not a focus of this search or review. However, measures of adiposity, particularly visceral and abdominal adiposity, may provide important information beyond what is obtained solely when considering body weight.

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Conflicts of Interest and Source of Funding

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Role of the Funder/Sponsor

HHS staff provided general administrative support to the Committee and assured that the

Committee adhered to the requirements for Federal Advisory Committees. HHS also contracted with ICF, a global consulting services company, to provide technical support for the literature searches conducted by the Committee. HHS and ICF staff collaborated with the Committee in the design and conduct of the searches by assisting with the development of the analytical frameworks, inclusion/exclusion criteria, and search terms for each primary question; using those parameters, ICF performed the literature searches.

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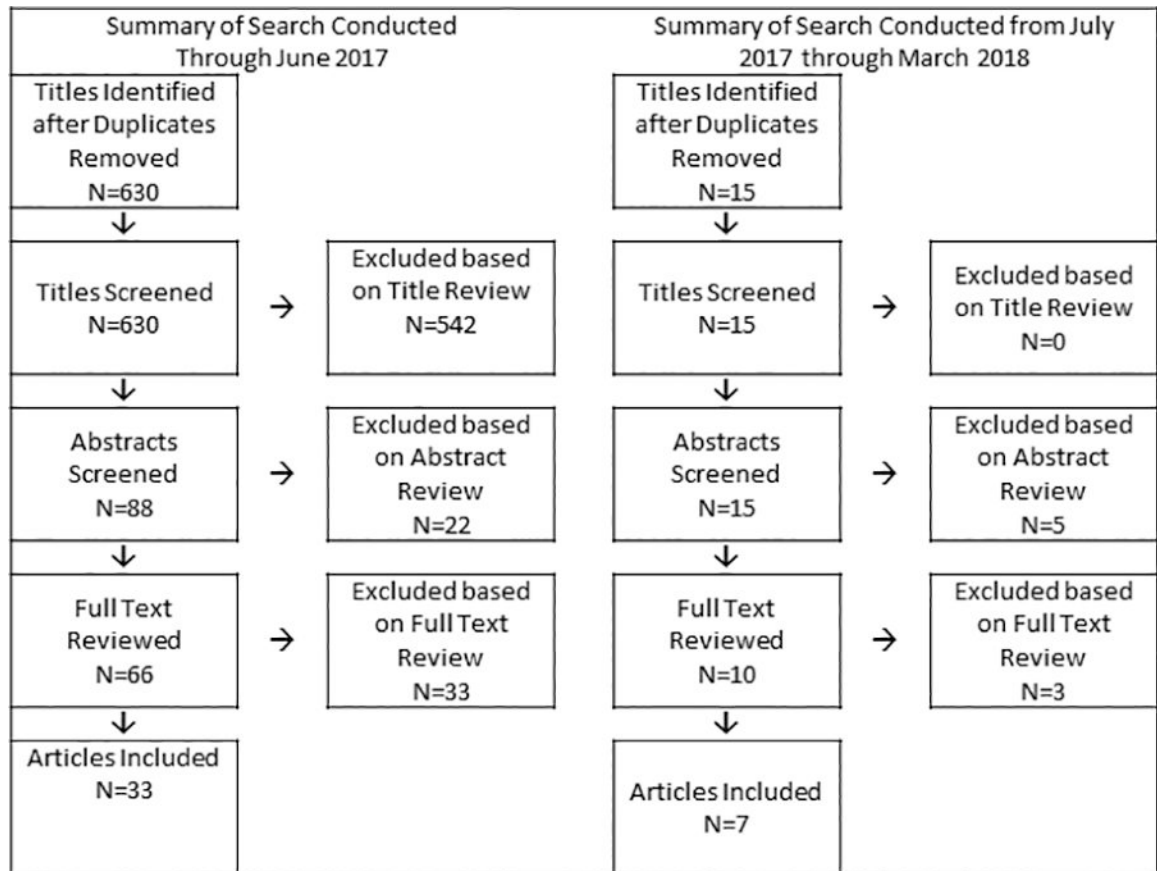


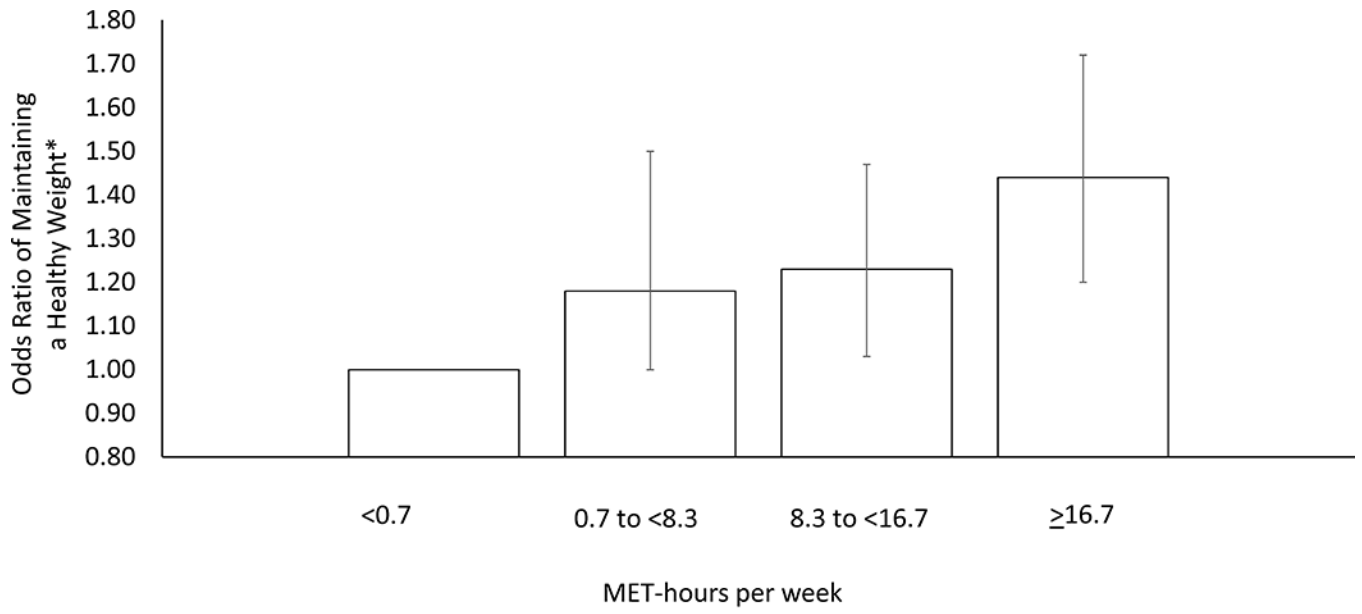
Figure 1.
Summary of literature search.

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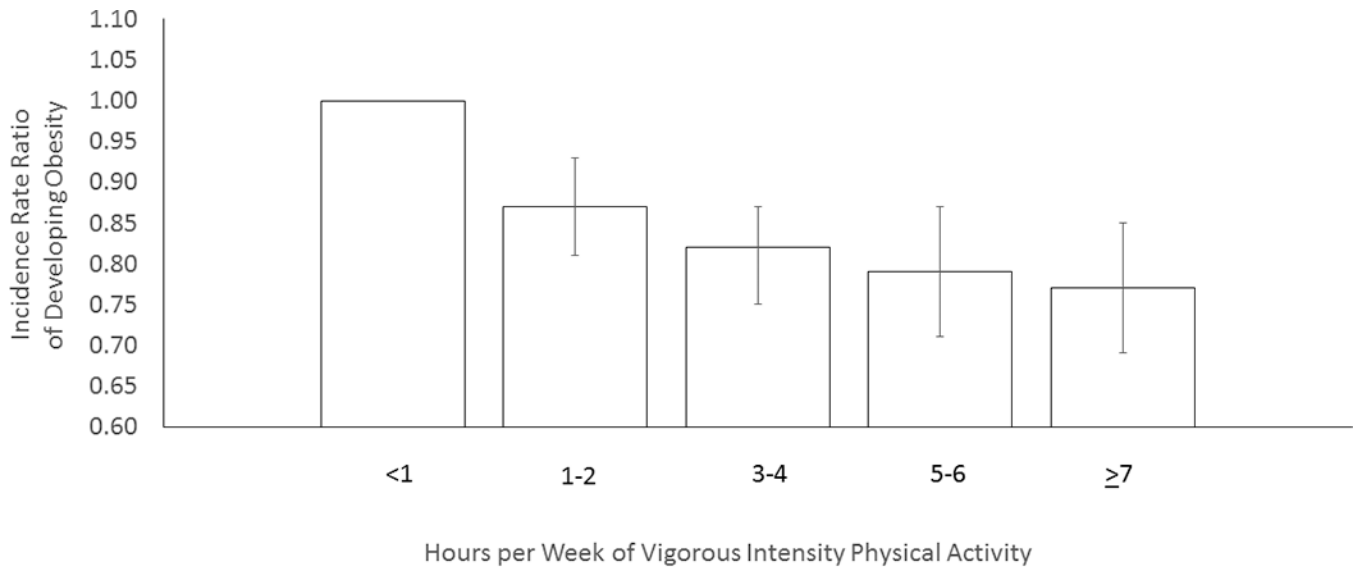


*Maintaining a Healthy Weight defined as Body Mass Index of ≥ 18.5 to < 25 kg/m².

Source: Adapted from data found in Brown et al., 2016.

Figure 2.

Odds of Maintaining a Healthy Weight by Level of Physical Activity.



Source: Adapted from data found in Rosenberg et al., 2013.

Figure 3. Incidence Rate Ratio of Developing Obesity at Various Levels of Vigorous Physical Activity.