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The Association of Retirement and Leisure-time Physical Activity among Middle-aged and Older US Adults

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The Association of Retirement and Leisure-time Physical Activity among Middle-aged and Older US Adults

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Abstract

The Association of Retirement and Leisure-time Physical Activity among Middle-aged and Older US Adults

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Background: Retirement, one of the major life transitions for middle-aged and older people, results in changes in the individual's daily routine and time allocation. Previous findings suggested that retirement provides a good opportunity for people to adapt to a new lifestyle, and physical activity (PA) increases with retirement. However, the impact of PA on the older population over 75 years old remains unclear, and evidence regarding the type and intensity of PA is inconsistent in the previous literature. **Purpose:** To examine the association of retirement and Leisure-time physical activity (LTPA) among middle-aged and older US adults. **Methods:** The study sample consisted of participants aged 55 years and older (N = 148,849; Female = 52.9%) from the Behavioral Risk Factor Surveillance System (2017). Employment status, LTPA, and other social-demographic characteristics were self-reported by participants. The primary outcome was LTPA, for which we included 3 aspects -- PA participation, guidelines compliance, and PA intensity -- to capture the characteristics of LTPA. Binary logistic regression was conducted to explore the relationship between retirement and LTPA variables in each 5-

year age group for both genders. **Results:** Overall 88,293 participants were retired (M = 44.5%, F = 55.5%). Retired men had higher odds (OR 1.04; 95% CI 1.00-1.07) of participating in the exercise in the past 30 days relative to employed men; retired women had lower odds (OR 0.77; 95% CI 0.75-0.80) relative to employed women to exercise in the past 30 days. Retirement was associated with higher odds of meeting the aerobic recommendations for both men (OR 1.33; 95% CI 1.29-1.37) and women (OR 1.06; 95% CI 1.03-1.09) and the same association was observed in most of the age groups. Retirement was associated with higher odds for men (OR 1.04; 95% CI 1.00-1.07) and lower odds for women (OR 0.91; 95% CI 0.88-0.94) of meeting the muscle-strengthening recommendations; the associations, however, varied by age group for both genders. Additionally, retirement was associated with lower odds of participating in moderate PA, but higher odds of participating in vigorous PA. **Conclusion:** Retirement is associated with an increase in LTPA for both genders. Aerobic activity is the major contributor to the LTPA with retirement, while muscle-strengthening activity is less influenced by the retirement status, which highlights the need for promoting muscle-strengthening activity among the middle-aged and older population.

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Chapter 1: Introduction

Even though physical activity (PA) provides multiple health benefits, 31.1% of adults (age 15 and older) worldwide are physically inactive (Hallal et al., 2012). PA is not always the same. The change of environment, employment status, marital status, physical status, family structure, relationship, etc., will affect people's engagement and the time allocation of PA. Retirement is a typical life transition that is associated with changes in time allocation, particularly in older people. Previous studies suggested that retirement offers an excellent opportunity for older people to adapt to a new healthy lifestyle. Therefore, it is essential to promote PA at this stage effectively to generate beneficial outcomes.

With the influence of multiple factors from individual, interpersonal, and environmental levels, however, the trend of retirement age seems to increase throughout the years. The labor force participation rate of people aged 55 and older has been increasing during the past 10 years, which suggests that middle-aged and older adults are staying in or returning to the labor force (A Profile of Older Americans (2018), *Labor force participation rate US Bureau of Labor Statistics*). Retirement is a crucial time point for a lifestyle change. However, based on the current retirement trends, it is unknown whether early retirement and late retirement would make a difference in PA participation and patterns in retirees. Considering both the employment status and age would be helpful for us to promote physical activity to a specific subgroup. Further, a larger study sample that can better represent the current US population would be beneficial to capture different aspects of the leisure-time physical activity (LTPA) under different employment status.

The purpose of the current study is to analyze the effect of employment status and age on leisure-time physical activity, among middle-aged and older US adults, using the 2017 Behavioral Risk Factor Surveillance System (BRFSS) data.

RESEARCH OBJECTIVES AND HYPOTHESES

Aim 1. Compare the effects of retirement on LTPA participation for men and women, and within each age group for both genders.

Hypothesis 1: Retirees are more likely to engage in PA, compared with employed individuals in each age group.

Aim 2. Compare the effects of retirement on meeting the 2008 Guidelines for men and women, and within each age group for both genders.

Hypothesis: Retirees are more likely to meet either or both the aerobic recommendations and muscle-strengthening recommendations, compared with employed individuals in each age group.

Aim 3. Compare the effects of retirement on LTPA intensity for men and women, and within each age group for both genders.

Hypothesis: Retirees are more likely to participate in moderate- or vigorous-intensity LTPA, compared with employed individuals in each age group.

Chapter 2: Literature Review

There is a huge amount of evidence to show the effectiveness of physical activity (PA) on preventing, delaying, and treating chronic diseases, particularly for older people. Retirement begins at middle-to-older age for most people. As one of the major life transitions, it is believed that retirement would bring about changes in lifestyle, physical activity. Previous studies suggest that retirement is a factor that changes PA patterns. This literature review includes previous studies that examined the relationship between retirement and PA. To be specific, this review categorized studies into 3 sections based on the primary PA outcomes: 1) LTPA, 2) Domain-Specific PA, and 3) Total PA. **(Full list of literature review see Appendix B)**

LTPA

To synthesize the literature with similar outcomes, three subgroups were constructed under this LTPA section: 1) Participation, 2) Guidelines Compliance, and 3) Intensity/Frequency/Volume, including 11, 4, and 6 studies in each subgroup, respectively.

Participation

The majority of the previous longitudinal studies from different countries indicate that retirement is associated with an increase in LTPA participation. The study conducted by SjöSten et al. (2012) examined the trajectories of PA related to retirement. Two analyses were done in the study. Analysis 1 examined the annual prevalence of higher LTPA (defined as walking ≥ 5km/week) from 4 years before to 4 years after retirement. Analysis 2 examined the changes in LTPA engagement, frequency and manner from pre-retirement and post-retirement. Retirement status was determined by the pension and only those who retire on a statutory basis were included in the study. The results for analysis 1 showed that higher LTPA increased by 36% in men and 61% in women during the transition to retirement (peri-retirement period). For analysis 2, the results showed that the likelihood of LTPA engagement and frequency increased during the post-retirement compared with pre-retirement, and people were more likely to engage in group activities than exercise alone. Evenson and colleagues (2002) examined the influence of retirement on leisure activity over 6 years among White and African-American. The study population was participants in the Atherosclerosis Risk in Communities (ARIC) Study, which consisted of persons aged 45-64 years at recruitment in 1986-1989. Physical activity was measured subjectively with the Baecke questionnaire, and the scores for sport and leisure were estimated. Participants were asked whether they participated in any sport or exercise (yes or no) at baseline and 6 years later. Further, participants were categorized into 4 groups: “maintainers” (reported “yes” at both time points), “sedentary” (reported “no” at both time points), “adopters” (reported “no” at baseline, and “yes” at follow-up) and “stoppers” (reported “yes” at baseline, and “no” at follow-up). Regarding occupational status, all participants were self-reported as “employed” at baseline, and reported as “employed”, “retired and working” or “retied and not working” 6 years later. Results indicated that among those who reported sport/exercise participation, retirees have a higher probability of being “maintainers” rather than “stoppers” compared to people who continued to work, across all race-gender groups. Among those who reported no sport/exercise participation, retirees also have a higher probability to be “adopters” instead of “sedentary” compared to people who continued to work, across all race-gender groups except for African-American women.

Three studies examined the PA trajectories from pre-retirement to post-retirement. The study conducted by Henning et al. (2020) examined the LTPA engagement trajectory among Swedish adults aged 60-66 years. LTPA was measured at 4 time points: 1 year before retirement, retirement, 1 year after retirement, and 2 years after retirement. LTPA engagement was estimated by the reported frequency of participation in a list of PA, such as outdoor activities, gardening, exercise etc. Participants were defined as retired if they perceived themselves as retired. LTPA engagement increased after retirement, but the increase was relatively stable during the post-retirement period. The long-term trajectories of sport participation, recreational activity, and walking were studied by Aggio et al. (2019) among middle-aged British men. Employment status was reported by the participants at each wave, either employed or not employed. LTPA was measured with a questionnaire. Sport participation was categorized by frequency (none, occasional = less than once/month, and frequent = once a month or more). The recreational activity was categorized as low (< 4h/weekend), moderate (4h/weekend), and high (> 4h/ weekend). Walking was categorized as low (< 20min/d), moderate (21-60min/d), and high (> 60min/d). Retirement was associated with an increase in PA, which is largely due to the increase in sports/exercise participation among those who already played sports. Oshio and Kan (2017) studied the impact of retirement on health using a 10-year longitudinal panel survey data in Japan. Participants were classified as engaging in LTPA if they reported doing moderate- or vigorous-intensity aerobic activity at least 2 days/week. LTPA participations were presented 5 years before and 5 years after retirement. The results show that the prevalence of LTPA increases after retirement for both genders. The immediate increase in LTPA engagement was remarkable at the retirement transition (from 1 year before retirement to retirement) and gradually stable during the 5-year post-retirement.

Instead of measuring PA participation, a previous study investigated no PA participation after retirement. Celidoni et al. (2017) examined lifestyle changes after retirement in Europe. Two variables were used to measure PA engagement: “No activities” (never or almost never practicing any activity requiring either a moderate or substantial level of energy), and “No vigorous activity” (never or almost never taking part in sports or vigorous activities). Participants were considered as retired once they self-reported the status, and the study assumed they would remain retired. The study found that the probability of no activities or no vigorous activities significantly decreases after retirement.

A couple of previous studies found different results. Biernat, Skrok, and Krzepota (2019) investigated how retirement duration: short-term (up to 2 years after retirement) and medium-term (2-4 years after retirement) affects sport/exercise activity (S/EA) among people in Poland. Retirement was defined as a declaration of the retirement benefit as a main source of income without any supplementary income from work in any form. Men and women were analyzed separately, and all participants were categorized into either retired (for those who were retired in 2013), or nonretired (for those who were not retired in 2013). There was no short-term (2011 to 2013) effect of retirement on S/EA on both genders among retirees. Regarding the medium term (the following 2-3 years from 2013), S/EA was significantly lower among male retirees, compared to male non-retirees. Zhu (2016) examined the causal-effects of retirement status and retirement duration on health-related behaviors, using first eleven waves (2001-2011) data from the Household, Income and Labor Dynamics in Australia (HILDA) Survey. In this study, the sample consisted of 3,771 Australian women aged between 50 and 75. Retirement status was self-reported by participants, for which, if a participant reports that she was not in the labor force, then she was considered to be retired. Two variables about exercising were determined by the following questions: whether participants take any PA; whether participants engage in PA at least three times per week (regular physical exercise). There was no difference in different employment status and retirement duration on whether participants take any PA. A longitudinal study in Netherlands conducted by Koeneman et al. (2012) investigated the influence of major life events on PA among older adults. Participants who had a paid job at baseline, but did not at follow-up were classified as retired, whereas participants who had a paid job and continued to work at follow-up were classified as stable employed. Sports participation and the duration of moderate-to-vigorous physical activity (MVPA) (min/day) were assessed with a self-report questionnaire. Retirement was significantly associated with an increase in MVPA duration, but not sports participation, compared with those who continued to work. There was a greater increase in MVPA in older retirees. A cross-sectional study in Norway conducted by Skogen, Øverland, and Knudsen (2016) compared the probability of weekly PA participation among individuals during pre-, peri- and post-age retirement period. Compared with the age retirement, those who retired before participating in the original survey were divided into 4 groups (24–18 months, 17.9–12 months, 11.9–6 months and 5.9 months–30 days before), and those who were not retired before participating in the original survey were also divided into 4 groups (individuals will retire in 30 days–5.9 months, 6–11.9 months, 12–17.9 months or 18–24 months after participation). Individuals in the peri-age-retirement period were centered in the middle of the 8 groups. There were no differences in PA participation probability of pre-, peri- and post-old-age retirement.

In summary, some studies did not observe a PA engagement change after retirement (Koeneman et al., 2012; Skogen et al., 2016; Zhu, 2016), and even a decrease in the engagement was found 2-4 years post-retirement (Biernat et al., 2019). However, women were more likely to engage in regular PA after retirement (Zhu, 2016), and MVPA duration was increased after retirement (Koeneman et al., 2012). Similar findings were also shown among middle-age men (Aggio et al., 2019). It is likely that retirement motivates those who are already engaged in PA to be even more active.

PA participation is the most commonly used measurement in the literature, probably because it is easier for participants to report in the survey and be computed in the analysis, especially in the long-term longitudinal study. A large body of the literature support that LTPA/ sport & exercise participation increases after retirement, while there remain some studies with opposite findings.

Guidelines Compliance

The 2018 Physical Activity Guidelines for Americans recommends that older people should do at least 150 min/week of moderate-intensity, or 75 min/week of vigorous-intensity aerobic PA, or an equivalent combination of moderate- and vigorous-intensity aerobic activity, for substantial health benefits (*2008 Physical Activity Guidelines for Americans*, n.d.).

Two studies conducted among US adults measured the 2008 Guidelines compliance. King et al. (2017) examined the association between retirement and the PA level among aged 55-70 years US adults, based on the 2009-2012 National Health and

Nutrition Examination Survey (NHANES) data. Moderate to vigorous recreational PA level was categorized as ideal (meet the aerobic guidelines), intermediate (do not meet the aerobic guidelines), and poor (no PA). Results indicated that retirees were more likely to be physically active than non-retirees. However, there were no differences in the prevalence of PA level between retirees and non-retirees. The study did not compare the probability of meeting the guidelines, but it did indicate that retirees had a greater PA level. Kämpfen & Maurer (2016) estimated the causal effects of retirement on meeting the 2008 Guidelines based on the data from the Health and Retirement Study (HRS). The study analyzed the 2004-2010 HRS data (waves 7-10), of which only information for participants aged 50-80 years without any missing survey item was included. The final sample consisted of 13,491 individuals for 47,336 observations in total. Three questions were asked in the HRS about the frequency and intensity of activities. The study combined the reported frequency of moderate- and vigorous-intensity activity into a single binary indicator, to indicate the compliance with the 2008 Guidelines. Retirement status was determined by the following four different definitions: (1) participants are not for pay at present; (2) participants' self-assessment of being retired; (3) current labor market status: self-reported to be retired; (4) current labor market status: considering those who report being "retired", "unemployed" , "disabled" or "not in the labor force" as retired. The results showed marked drops in the percentage of individuals working for pay around the early and normal retirement age. Overall, the percentage of people aged 55-75 years meeting the 2008 Guidelines decline with age, but there was a small increased trend around early and normal retirement age, which suggested that retirement may even out part of the PA decline with age around early and normal retirement age. The causal analyses indicated that the probability of meeting the 2008 Guidelines increased by 20-40 percentage points with retirement for both men and women. Individuals with higher education levels or higher household wealth were more likely to meet the 2008 Guidelines after retirement.

The other two studies made comparisons to the UK PA recommendations (e.g., at least 2.5h/week of M/VPA). Murtaghs et al. (2015) studied the association between physical inactivity and retirement among Irish adults aged 60 and older. PA was evaluated by the International Physical Activity Questionnaire (IPAQ) short form, which included multiple PA domains. Participants were defined as inactive if they did not meet the UK PA recommendations; otherwise, they were defined as active. The findings showed that retirement was associated with lower odds of being physically inactive among men, and higher odds of being physically inactive among women. Mein et al. (2005) studied the relationship between work, retirement, and PA among 6,224 UK civil servants. PA was assessed by the 4 main PA categories: 1) Sports and games, 2) Gardening, 3) Housework, 4) Do-it-yourself. PA duration/week and the prevalence of meeting UK PA recommendations were presented in the results. Retirement status and working status were asked in the survey. Retirement was associated with a higher prevalence of meeting the PA recommendations for both men and women. Higher odds of meeting the recommendations were found in those who either work part time or not at all during retirement. The frequency of different types of PA was associated with different occupational grades.

The 2008 Guidelines and the UK PA recommendations made similar suggestions for the weekly PA. The majority of the findings indicate that retirement tends to make older people more active for both genders, except for the results of women in the Murtagh et al. (2015) study.

Intensity/Frequency/Duration

Six previous studies focused on the intensity, frequency, or duration of leisure-time physical activity (LTPA), among which 4 studies used the weekly duration of moderate-intensity physical activity (MPA), vigorous-intensity physical activity (VPA), and/or moderate-to-vigorous physical activity (MVPA), one study calculated the differences in duration (h) and intensity (MET), and one study used weekly LTPA frequency, as the primary outcomes.

Previous literature indicates that the weekly duration of MVA or MVPA increases with retirement, whereas the results for VPA are not consistent in the previous studies, for which findings suggest a decrease or no change with retirement.

A longitudinal study conducted by Holstila et al. (2017) in Finland examined the effects of retirement transition and post-retirement on LTPA. The study was based on the HHS (Helsinki Health Study) data. Phase 1 (baseline) was conducted in 2000, 2001 and, 2002, targeting all employees of the City of Helsinki aged 40, 45, 50, 55, and 60. Two follow-up time phase 2 and phase 3 were conducted in 2007 and 2012, respectively. Eventually, 2902 participants were included in the study (Among all employees, those who retired during the follow-up, only individuals entering statutory retirement were included). Retirement status was classified into three groups: continuously employed (continued to work during the entire follow-up), retired 1 (people retired at the first follow-up period; phase 1-2), and retired 2 (people retired at the second follow-up period; phase 2-3). LTPA (including commuting) was measured by asking participants how many hours a week, on average, they had spent performing PA during the past year, on four grades of intensity equivalent to walking, brisk walking, running, and jogging. The moderate-to-vigorous LTPA (min/week) was estimated by summing up the duration of each grade. During the first period (phase 1 to 2), the retired 1 group had a significantly greater increase in weekly LTPA time than the continued employed group, while no difference between the retired 2 group and the continued to be employed group. During the second period (phase 2 to 3), weekly LTPA time continued to increase in the retired 2 group, whereas there was a decrease in the continued employed and retired 1 group. There were no significant differences in the change of LTPA time between the retired group and the continued employed group. The results suggested that LTPA increased immediately after the retirement transition, but the positive change didn't last long. Even though at phase 3, LTPA decreased to the level of baseline among the retired 1 group, the LTPA level was similar to those who continued to employed, which indicated that the increased LTPA after retirement could counteract the PA decrease with aging.

A 20 years follow-up study conducted by Stenholm and colleagues (2016) examined within-individual changes in PA during the transition from full-time work to retirement. The study analyzed data from the Finnish Public Sector study, and the sample included employees who responded to at least one survey in 2000/2002, 2004/2005, or 2008/2009 and retired between 2000 and 2008. The actual day of retirement was set at year 0. The years before retirement were set as years -10, -6, and -2, and the years after retirement were set as years +2, +6, and +10. Three retirement periods were defined as pre-retirement (-10 to -6), retirement transition (-2 to +2), and post-retirement (+6 to +10). In this study, the retirement transition (-2 to +2) comprised 9,488 individuals, among which 80% were women. PA was estimated by asking participants about their average weekly hours of LPTA (including commuting) within the previous year in walking, brisk walking, jogging, and running, or their equivalent activities. Among those who transited into statutory retirement, there was a significant increase for total LTPA

(MET-h/week) during the four years retirement transition, while a significant decrease was observed during the post-retirement. Additionally, MPA (h/week) increased significantly during the retirement transition and slightly declined during the post-retirement, but the MPA level was still higher in post-retirement than pre-retirement. Nevertheless, VPA (h/week) kept declining with increasing age from the pre-retirement to post-retirement. Older retirement age (age > 64) was associated with a greater increase in total LTPA (MET-h/week) (2.91, 95% CI 1.40 to 4.42) between the pre-retirement and the retirement transition compared to those aged < 60 (0.78, 95% CI-1.10 to 2.66), and aged 60-64 (1.76, 95% CI 1.05 to 2.47). Lahti et al. (2011) investigated the effects of retirement on LTPA. Average weekly duration on moderate- or vigorous-intensity LTPA/exercise (including commuting) within the previous 12 months were self-reported by participants at the baseline and follow-up. Participants were classified as inactive if the PA volume was under 840 MET-mins/week. Employment status, date of retirement, and the type of retirement pension were determined at the follow-up, and those who were not on part-time retirement and working part-time were considered as full-time retirees. Among employees, changes in PA were minor from the baseline to follow-up. Old-age (> 60 years) retirees had a marked increase in time spent on moderate-intensity LTPA. Also, old-age female retirees had lower odds for physical inactivity at the follow-up after adjusting for baseline physical inactivity relative to aged 55-60 female employees. Brown et al. (2009) examined the relationships between specific life events and changes in MVPA over 3 years in three cohorts of Australian women. The study was based on the Australian Longitudinal Study on Women's Health (ALSWH), which included young (N = 7,173; age 22-27 year), middle-age (N = 8,762; age 51-56 years), and older (N = 6,600; age 73-78 years) participants. For each cohort, two waves of surveys with a 3-year interval were selected and referred as “time 1” (T1) and “time 2” (T2). PA was measured by asking questions about frequency and duration in three PA categories: walking briskly (assigned intensity: 3.0 MET), moderate-intensity LTPA (assigned intensity: 4.0 MET), and vigorous-intensity LTPA (assigned intensity: 7.5 MET) in the last week. A PA score (MET-min per week) was calculated and categorized as: none (< 40); low (40- < 600); or active (≥ 600). PA change was defined according to PA score categories at T1 and T2 as: consistently sedentary (none at both time points); consistently low active (low at both time points); consistently active (active at both time points); decreasing (moved from a higher category to a lower one); increasing (moved from a lower category to a higher one). Retirement was one of the life-event variables in the middle-age cohort. The result showed that retirement was associated with increasing MVPA compared to those who were not retired in the middle-aged women.

The changes in PA duration and intensity with retirement were affected by gender and age differences. Kats et al. (2020) studied the LTPA trajectories from mid- to late-life among the US population. LTPA engagement, duration (h/week), and intensity (MET) were reported and estimated at baseline and each follow-up. Retirement was associated with greater engagement in LTPA among older adults. Specifically, retired men engaged in more hours of LTPA compared to employed men aged 70-75 years. Retired women reported more 1.5 MET higher weekly LTPA intensity compared to employed women aged 70-75 years. No significant differences were found in other 5-year age groups.

A higher PA frequency was associated with retirement. Syse et al. (2017) studied the effects of retirement on health and health behavior. Participants were classified as retired if they stated that they were occupational pensioners, early contractual pensioners, or ordinary old-age pensioners. LTPA level was determined by participants’ indoor and outdoor exercise or training, and computed to a binary variable: at least weekly or less than weekly. Those who retired at a 5-year follow-up were more likely to increase outdoor PA relative to those still working.

DOMAIN-SPECIFIC PA

Six studies measured domain-specific PA with weekly duration (h/week or min/week) and/or volume (MET-h/week or MET-min/week), among which 4 studies included all 4 PA domains, one study reported leisure-time (LTPA) and occupational PA (OPA), and one study reported LTPA and transport-related PA (TPA).

Retirement was associated with an increase (Jones et al., 2018; Touvier et al., 2010), or not decrease in LTPA (Slingerland et al., 2007). However, retirees had significantly higher odds for a decrease in work-related transportation and non-sports LTPA, relative to those who remain employed (Slingerland et al., 2007). Jones et al. (2018) examined the impacts of retirement status on longitudinal patterns in overall MVPA (MET-min/week) and domain-specific PA. Individuals in the study were participants in the Multi-Ethnic Study of Atherosclerosis (MESA). Retirees were more likely to be male and reported more MVPA and transport walking at baseline. MVPA declined over time at the rage of -4% to -6% per 5 years regardless of retirement status. Retirement was associated with a 10% decrease in MVPA, a 13% increase in recreational walking, a 29% increase in household/yard activity, and a 48% decrease in occupational/volunteer MVPA.

Apart from the change of domain-specific PA with retirement, some studies also capture the change of total PA. Biernat et al. (2014) examined the relationship between retirement and changes in domain-specific and total PA (MET-h/week). The findings showed that retirement was associated with a decrease in overall activity in both manual and non-manual classes. Besides, retirement was associated with a decrease in OPA and TPA, and an increase in household and recreational PA. A longitudinal study conducted by Touvier et al. (2010) investigated the relationship between retirement and 3-year changes in PA patterns in middle-aged French adults. PA in the past 12 months during leisure time and at work was assessed. Results suggested that there was no difference in baseline LTPA level and in the proportion of subjects meeting total PA recommendations between those who retired and those who continued to work. LTPA increased by 2 h/week in those who were retired, while no change in people continued to work, and the positive change in retired people was mainly related to the increase in activities of moderate intensity. The total PA among retirees decreased by 50.7 MET-h/week in men and 41.8 MET-h/week in women between baseline and follow-up. Both studies found a decrease in total PA with retirement, suggesting the increase in LTPA did not compensate for the loss of other domains.

Two studies suggested that the duration of retirement played a role in LTPA change. Van Dyck, Cardon, and De Bourdeaudhuij (2016) studied the differences of longitudinal changes in PA of Belgium retirees. Baseline and follow-up data were collected in 2012/2013 and 2014/2015, respectively. Participants for this study were either retired (Retired at baseline; > 6 months, < 5 years of retirement), or retiring (Retired between baseline and follow-up), at baseline. Retired individuals needed to be full-time retired from their main occupation, but engaging in voluntary work was allowed. PA was measured with the IPAQ long version. Retiring adults had higher voluntary/work-related walking and MVPA at baseline than recently retired adults. However, the voluntary/work-related walking and MVPA decreased strongly between baseline and follow-up among retiring adults, while slightly increased among recently retired adults. Leisure-time cycling increased in retiring participants, while decreased in recently retired participants even though they had higher leisure-time cycling at baseline. Menai et al. (2014) studied the effects of retirement on changes in sedentary behaviors and PA. PA (h/week) at baseline and follow-up was determined by questionnaire. Total, moderate, and vigorous LTPA, and other specific types of PA were measured. Participants were grouped into 3 groups based on their self-reported retirement status: 1) subjects who were not retired in 2001 and 2007, 2) subjects who were retired between 2001 and 2007, 3) subjects who were retired in 2001 and 2007. The study found that participants who retired between 2001 and 2007 had the greatest increase in time spent in LTPA, except for swimming and biking, compared with the other groups. Participants who were not retired in 2001 and 2007 had a higher change in total and moderate LTPA compared to participants who retired in 2001 and 2007. In summary, the increased LTPA was only found in people retiring during follow-up (a short-term post-retirement); those who retired at baseline (a longer-term post-retirement) had a decrease in LTPA, they but may engage in some voluntary/work-related PA.

TOTAL PA

A series of studies that examined the effect of retirement on total PA showed inconsistent findings. Richards et al. (2019) found that retirement was associated with a greater PA, but as the individuals aged, retirement was associated with a decrease in PA. Those who retired were less active than people who worked full-time at baseline, but the transition to full retirement was associated with an increase in PA at follow-up regardless of intensity, while PA did not change much among employed individuals (Feng et al., 2016). The results from Chung et al. (2009) indicated that the increased PA was only found on those who retired from the sedentary job, and in those who retired from the physically demanding job, PA decreased with retirement. In contrast, retirees had a lower PA level than those who were working full-time (Tan et al., 2017). One study suggested that retirees had lower odds of insufficient PA, while another study indicated that retirees had higher odds of low PA (Najdi et al., 2011). Regarding the total VPA, there was no relationship between retirement status and participation in VPA (Nekuda, 2009).

Although total PA was the primary outcome for all of the literature above, the measurements of total PA were different in studies. Some studies estimated total PA based on the weekly PA frequency, while others estimated the weekly PA duration or volume. Regarding PA domains, some studies included all 4 domains in their survey, while others focused on specific domains. The differences in the measurements could be an explanation for the inconsistent results in the literature.

AGE

Whether people decide to retire or not at a certain age will be affected by multiple endogenous and exogenous factors. Financial stability could be a key consideration for people to decide whether to leave the workforce or not. The most common options for retirees to support themselves after retirement are retirement plans offered by an employer, savings and investments of their own, and social security (*Retirement| USAGov*). In the US, age 62 is the earliest a person can start receiving Social Security retirement benefits, and the original full retirement age to claim full social security benefits is 65 (for those born in 1937 or earlier). Currently, the full retirement age rises gradually. For people born in 1955, the full retirement age will be 66 and 2 months, and for those born in 1960 and later, the full retirement age reaches 67. Although people can claim their Social Security benefits as early as age 62, the reduction of the benefits will be higher for those with older full retirement age (*Benefits Planner: Retirement | Full Retirement Age | Social Security Administration*).

Currently, full retirement age (2019) in the US is 66 years, while in some European countries such as Austria (M = 65, W = 60), Poland (M = 65, W = 60) and Switzerland (M = 65, W = 64), the full retirement ages are earlier than the US, and earlier in women than men (*Retirement Ages | ETK*). It is unknown whether these differences in full retirement age around the world would impact people differently.

SUMMARY

Most of the previous researches that determined the relationship between retirement and PA were longitudinal studies. Only 3 studies were using cross-sectional design (King & Xiang, 2017; Najdi et al., 2011; Skogen et al., 2016), among which 1 study used the US National Health and Nutrition Examination Survey (NHANES) (King & Xiang, 2017). Seven longitudinal studies were conducted among the US population with data from one of the following longitudinal surveys: the Atherosclerosis Risk in Communities (Kats et al., 2020; Evenson et al., 2002), the US Health and Retirement Survey (HRS) (Chung et al., 2009; Feng et al., 2016; Kämpfen & Maurer, 2016), the Multi-Ethnic Study of Atherosclerosis (MESA) (Jones et al., 2018), and the Americans' Changing Lives (ACL) survey (Richards et al., 2019).

ARIC recruited people aged 45-64 years in 1986-1989 from 4 communities: Washington County, Maryland; northwest suburbs of Minneapolis, Minnesota; Jackson, Mississippi; and Forsyth County, North Carolina. HRS is a longitudinal biennial study that began in 1992 and comprised approximately 43,000 people nationally, and represent Americans aged 50 years and older (Fisher & Ryan, 2018). MESA is a prospective, longitudinal cohort study of subclinical cardiovascular disease, which consisted of 6,914 adults aged 45-84 years. Participants in the MESA were recruited from 6 sites in the US: Forsyth County, North Carolina; Northern Manhattan and the Bronx, New York; Baltimore City and Baltimore Country, Maryland; St. Paul, Minnesota; Chicago, Illinois; and Los Angeles County, California. ACL is an ongoing nationally representative longitudinal study that comprised 5 waves of data, and each wave was collected in 1986, 1989, 1994, 2001/02, and 2011/12, respectively (House, 2018). Wave I consisted of 3,617 adults aged 25 and older, among which Black Americans and people aged 60 and over were oversampled at twice the rate as others (House, 2018). Survivors have been re-interviewed by telephone or face-to-face during each follow-up (House, 2018).

The sample sizes of the ARIC and MESA were relatively small. Additionally, participants recruited from specific sites may not be generalized to the national population. More studies needed to be done by analyzing a large sample size and nationwide data.

The associations of LTPA participation and vigorous LTPA with retirement are not clear. Previous studies used different definitions and measurements of exposure and outcome, which may be a reason for the divergent findings.

Both aerobic and muscle-strengthening activities are beneficial to health. According to the recommendations of the 2008 Guidelines, apart from aerobic activities, adults should participate in moderate- or high-intensity muscle-strengthening activities that involve all major muscle groups on 2 or more days/week, for additional health benefits (*2008 Physical Activity Guidelines for Americans*, n.d.). However, guidelines compliance was only identified in 4 previous studies, and no studies included muscle-strengthening recommendations in the outcome measures, which highlights a gap with respect to the activity types, and the association between retirement status and different types of LTPA.

It is also essential to consider the potential effects of age. Retirement status may have different effects on LTPA for people of different ages. Previous literature included participants mostly around 50-70 years old, and the population over 75 years old are underrepresented in the research. The relationship between PA and retirement status among older adults needs further investigation.

There are multiple possible reasons why retirement is associated with an increase in physical activity. The time barrier for individuals to engage in PA does not exist anymore, and people will have greater flexibility in daily time allocation. Furthermore, with aging, retirees may have more concern about their health, independence, and quality of life. Therefore, engaging in a healthier lifestyle would be beneficial in the long-term. With retirement, people also face changes in their daily routine and social networks. Participating in LTPA could be a good start forming new routines and making new connections. The objective of this study is to determine the effects of retirement on LTPA using large representative data, which will further our understanding of the impact of retirement on physical activity patterns among the US population.

Chapter 3: Methods

STUDY DESIGN

This study used data from the 2017 Behavioral Risk Factor Surveillance System (BRFSS), a nation's premier system of health-related telephone surveys that collect state data about US residents. The purpose of this study is to examine the effect of age and working status on leisure-time physical activity among middle-aged and older US adults. The present study is based on deidentified public open data that were published on the CDC website, and therefore required no review from the Institutional Review Board (IRB) of the University of Texas at Austin.

DATA SOURCE

BRFSS was established by the Centers for Disease Control and Prevention (CDC) in 1984, and 15 states initially participated in monthly data collection. The CDC developed a standard core questionnaire for the state to collect data that could be compared across states, and questions included smoking, alcohol use, physical inactivity, diet, hypertension, seat belt use, and optional modules for specific topics. In 1993, BRFSS became a nationwide surveillance system, and the questionnaire was redesigned to include rotating fixed core and rotating core questions and up to five emerging core questions. Currently, BRFSS collects data in all 50 states, the District of Columbia, and 3 US territories. More than 400,000 surveys are completed each year (*CDC - About BRFSS*).

Adults 18 years or older are asked to participate in the survey. The surveys are conducted through the in-house interview or the telephone call through the year. Each state uses a standardized core questionnaire (fixed core, questions are asked every year), optional modules (rotating core, questions are asked every other year), state-added questions, and other emerging core questions for high priority topics.

MEASURES

Physical Activity

Leisure-time physical activity (LTPA) is the primary outcome for this study. Eight questions were asked in the 2017 BRFSS about exercise, recreation, or physical activities other than regular job duties.

> Q1: "During the past month, other than your regular job, did you participate in any physical activities or exercise such as running, calisthenics, golf, gardening, or walking for exercise?"

This question determines whether participants engage in exercise/physical during the past month. Those who answer "No", "Don't know/Not sure", or "Refused" skip the following 6 questions and answer the 8th question.

Questions 2 to 4 ask about the primary specific type of exercise/physical activity, while questions 5 to 7 ask about the exercise/physical activity participation of secondary specific type.

> **Q2: "What type of physical activity or exercise did you spend the most time doing during the past month?"**

If the respondents answer "Yes", the specific type of physical activity will be determined and assigned to one of the 76 types or other. A corresponding MET value will be assigned based on the type.

For questions 2 to 7, if respondents answer "Don't know/Not sure, "Refused", or "No other activity", then skip the following questions and go to the 8th question.

> Q3: "How many times per week or per month did you take part in this activity during the past month?"

This question measures the frequency of the specific type of exercise/physical activity, which expressed as times per week and times per month.

> Q4: "And when you took part in this activity, for how many minutes or hours did you usually keep at it?"

This question measures the duration of the specific type of exercise/physical activity that respondents engage in every time, and expressed as hours and minutes.

> Q5: "What other type of physical activity gave you the next most exercise during the past month?"

> Q6: "How many times per week or per month did you take part in this activity during the past month?"

> Q7: "And when you took part in this activity, for how many minutes or hours did you usually keep at it?"

> Q8: "During the past month, how many times per week or per month did you do physical activities or exercise to STRENGTHEN your muscles? Do NOT count aerobic activities like walking, running, or bicycling. Count activities using your own body weight like yoga, sit-ups or push-ups and those using weight machines, free weights, or elastic bands."

This question measures the frequency of respondent's participation in muscle-strengthening exercise and expressed times per week and times per month.

In summary, the original 8 questions ask about the 2 most frequent PA or exercise that the respondent did in the past month, including the type, frequency, and duration of the PA or exercise. Apart from the aerobic activities, the last question asks about the frequency of muscle-strengthening activities.

Six categorical variables were computed based on the questions above: 1) Exercise in the Past 30 Days, 2) Meet Aerobic Recommendations, 3) Meet Muscle Strengthening Recommendations, 4) Intensity for the First Activity, and 5) Intensity for the Second Activity, 6) Meet the 2008 Guidelines.

Exercise in the Past 30 Days. This dichotomous variable is computed from the Q1, indicating whether the respondent had PA or exercise in the last 30 days or not.

Meet Aerobic Recommendations. Respondents who reported doing at least 150 minutes moderate (or vigorous equivalent) physical activity per week was considered meeting aerobic recommendations. Total physical activity minutes/week was estimated by the sum of the 2 most frequent PA or exercise. Frequency (Q3; Q6) and duration (Q4; Q7) were self-reported. The intensity was estimated based on activity type (Q2; Q5), gender, and age of the respondent.

Meet Muscle-Strengthening Recommendations. This dichotomous variable is derived from Q8. Respondents who reported doing the muscle-strengthening activity for 2 or more times/week were considered meeting the muscle-strengthening recommendations.

Meet the 2008 Guidelines. This categorical variable is computed from Meet Aerobic Recommendations and Meet Muscle-Strengthening Recommendations. Participants were grouped into 3 levels: 1) None: did not meet any recommendations, 2) Either: meet either of the recommendations, and 3) Both: meet both recommendations.

Intensity for the First Activity and Intensity for the Second Activity. These two categorical variables were estimation of the intensity of the 2 most frequent activities, based on activity type, and gender and age of the respondent. The relative intensity is estimated by comparing the reported activity intensity (Actual METs) to the functional capacity (FC_METs), which was calculated based on age and gender. If the Actual METs ≥ FC_METs, then the intensity will be defined as vigorous; If the Actual METs ≥ 3.0, then the intensity will be defined as moderate; If the Actual METs ≥ 0, then the intensity will be defined as no (no exercise in the past 30 days, or no moderate or vigorous activity).

Employment Status

Working status was asked in the 2017 BRFSS, and participants self-reported being in one of the 8 categories. Only those who identified themselves as “employed for wages”, “self-employed”, or “retired” will be included in the analysis. “Employed” group includes participants who were “employed for wages” and “self-employed”, and the “Retired” group includes participants self-reported as “retired” in the BRFSS.

Other Variables

Sociodemographic Variable

Sociodemographic variables include age, gender, race/ethnicity, income, education level, marital status, BMI. Age was categorized into 6 five-year age groups: 1) 55-59, 2) 60-64, 3) 65-69, 4) 70-74, 5) 75-79, and 6) ≥ 80. Race/ethnicity includes 6 categories: 1) Caucasian, 2) African American, 3) Asian, 4) American Indian/Alaskan Native, 5) Hispanic, and 6) Other race. Income was computed to 5 categories: 1) Less than $15,000, 2) $15,000-less than 25,000, 3) $25,000-less than $35,000, 4) $35,000-less than $50,000, and 5) $50,000 or more. Education level includes 4 categories: 1) Did not graduate High School, 2) Graduated High school, 3) Attended College or Technical School, 4) Graduated from college or Technical School. Marital status was computed into a dichotomized variable: 1) Married. 2) Not married. BMI was calculated based on self-reported weight and height and computed into 4 categories: 1) Underweight, 2) Normal Weight, 3) Overweight, and 4) Obese.

Health Behaviors

Current smoking (Yes or No) and Heavy alcohol consumption (Yes or No) were included as indicators for health behaviors. Individuals who are a former smoker or never smoke are classified as no current smoking. Heavy alcohol consumption is defined as having more than 14 drinks per week for adult men and more than 7 drinks per week for adult women.

Chronic Diseases

Four chronic diseases: arthritis, high blood pressure, coronary heart disease (CHD) and myocardial infarction (MI), and asthma were self-reported by participants. Participants without any of the four chronic diseases were considered as "No" chronic diseases, whereas if they reported having one or more, they will be considered as "Yes".

STUDY SAMPLE

Participants were selected into the study using the following inclusion criteria: 1) age $\geq$ 55 years; 2) Self-reported employment status as "Employed for wages", "Self-employed", or "Retired"; 3) No missing data for demographic variables; 4) No missing data for the question asking about "Exercise in the Past 30 Days"; 5) No missing data of other physical activity variables.

The original 2017 BRFSS sample contained 450,016 participants, among which 254,546 (56.6%) were age 55 and older. For the sample aged $\geqslant$ 55 years, 87.9 % of the participants met the employment status inclusion criteria and resulting in a new sample of 157,904 individuals. Participants were then excluded if they had missing demographic variables or missing data for "Exercise in the Past 30 Days", leading to a sample size of 154,875 individuals. Finally, participants were excluded if they were missing physical

Table 1. Overview of Study Sample

Source	Size
Original record BRFSS 2017	N = 450,016
Limited by age ≥55 years	N = 254,546
Limited by employment status (“employed for wages”, or “self-employed”, or “retired”)	N[1] = 212,424
Limited by deleting missing cases of demographic variables.	N[2] = 157,904
Limited by deleting missing cases of “Exercise in the Past 30 days”.	N = 154,875
Limited by deleting missing cases of other physical activity variables.	N[3] = 148,849

activity variables, resulting in the final sample size of 148,849 participants. **(For detail, see Table 1, Table 2, Table 3.1, and Table 3.2)**.

Note. [1] For the sample age ≥ 55 year (N = 254,546), 87.9 % of the participants met the employment status inclusion criteria (Table 2). [2] Missing cases were deleted based on the variables: Sex, BMI, Education, Income, Current Smoking status, and Heavy Alcohol Consumption (Table 3.1). [3] Missing cases were deleted based on other physical activity variable (Table 3.2).

Table 2. Employment Status for People Age ≥ 55 years

Value	N	%
Employed for wages	60,697	23.8
Self-employed	20,433	8
Out of work for 1 year or more	5,104	2
Out of work for less than 1 year	2,629	1
A homemaker	12,011	4.7
A student	279	0.1
Retired	131,294	56.1
Unable to work	20,521	8.1
Refused	1,577	0.6
Not asked or Missing	1	0
Total	254,546	

Table 3.1 Demographics Missing Cases

Variable	N	%
Sex	99	0
BMI	14,595	6.9
Education	613	0.3
Income	37,470	17.6
Current Smoking status	7,824	3.7
Heavy Alcohol Consumption	12,326	5.8

Table 3.2 Physical Activity Variables Missing Cases

Variable	N	%
Meeting Aerobic Recommendation	4,037	2.6
Meeting Muscle Strengthening Recommendation	2,144	1.4
Intensity for the Frist Activity	810	0.5
Intensity for the Second Activity	2,166	1.4

STATISTICAL ANALYSIS

The sociodemographic variables and chronic conditions were summarized using frequencies and percentages for the overall study sample and based on employment status. Binary logistic regression was used to determine the association between physical activity variables and employment status for men and women in each age group. The odds ratio and 95% confidence interval will be presented for each comparison. The significance level was set at 0.05. All statistical analyses were conducted using IBM SPSS Statistics 26.0 for Windows.

Chapter 4: Results

SOCIO-DEMOGRAPHICS

A total of 148,849 participants aged 55 and older were included in this study, among which more participants were retired (59.32%) compared to employed (40.68%) **(Table 4)**. In the employed group, 37.5% were 55-59 years old, 31.9% were 60-64 years old, 17.1% were 65-69 years old, and the remaining 13.5% of participants aged 70 and older. In the retired group, 24.6% were 65-69 years old, 24.1% were 70-74 years old, 20% were aged 80 and older, 17.3% were 75-79 years old, and the participants aged under 65 years only accounted for 14%. For the total sample, more females (52.9%) than males (47.1%). Among males, more people were employed (50.8%), whereas, among females, more people were retired (55.5%). The majority of the study sample was Caucasian (85.7%), which outweighed the other races/ethnicities, and African American (6%) was the second-highest contributor for the study sample. Over half (51%) of the participants reported income of $50,000 and over, 15.2% reported income between $15,000 and less than $25,000, 6% of people reported less than $15,000. For education, 42.5% of participants were graduated from college or technical school, 27.5% had attended college or technical school, 25.4% were graduated from high school. Over half (56.6%) of the participants were married. Less than 1/3 of the participants were normal-weight (28.7%), 39.4% were overweight, and 30.7% were obese. The prevalence of current smoking (9.9%) or heavy alcohol consumption (5.2%) was less than 10% in the study population. There were only 1.3% of the participants reported without chronic diseases, and 98.7% of the participants had at least one chronic disease.

Table 4. Sociodemographic Characteristics of Study Participants

Variable		Employed n (%)	Retired n (%)	Total n (%)
Total		60556 (40.68)	88293 (59.32)	148849
Age group	55-59	22716 (37.5)	2700 (3.1)	25416 (17.1)
	60-64	19315 (31.9)	9639 (10.9)	28954 (19.5)
	65-69	10328 (17.1)	21700 (24.6)	32028 (21.5)
	70-74	4867 (8)	21309 (24.1)	26176 (17.6)
	75-79	2149 (3.5)	15287 (17.3)	17436 (11.7)
	≥ 80	1181 (2)	17658 (20)	18839 (12.7)
Gender	Male	30789 (50.8)	39322 (44.5)	70111 (47.1)
	Female	29767 (49.2)	48971 (55.5)	78738 (52.9)
Race/Ethnicity	Caucasian	51726 (85.4)	75774 (85.8)	127500 (85.7)
	African American	3340 (5.5)	5547 (6.3)	8887 (6)
	Asian	982 (1.6)	1084 (1.2)	2066 (1.4)
	American Indian/Alaskan Native	802 (1.3)	1060 (1.2)	1862 (1.3)
	Hispanic	2474 (4.1)	3081 (3.5)	5555 (3.7)
	Other	1232 (2)	1747 (2)	2979 (2)
Income	< $15,000	1636 (2.7)	7328 (8.3)	8964 (6)
	$15,000~ < $25,000	5511 (9.1)	17111 (19.4)	22622 (15.2)
	$25,000~ < $35,000	5149 (8.5)	12185 (13.8)	17334 (11.6)
	$35,000~ < $50,000	8354 (13.8)	15697 (17.8)	24051 (16.2)
	≥ $50,000	39906 (65.9)	35972 (40.7)	75878 (51)

Table 4 (continued)

Education	Did not graduate High School	1872 (3.1)	4825 (5.5)	6697 (4.5)
	Graduated from High School	13804 (22.8)	24060 (27.3)	37864 (25.4)
	Attended College or Technical School	16612 (27.4)	24343 (27.6)	40955 (27.5)
	Graduated from College or Technical School	28268 (46.7)	35065 (39.7)	63333 (42.5)
Marital Status	Married	38523 (63.6)	45656 (51.7)	84179 (56.6)
	Not Married	22033 (36.4)	42637 (48.3)	64670 (43.4)
BMI	Underweight	551 (0.9)	1271 (1.4)	1822 (1.2)
	Normal	16422 (27.1)	26363 (29.9)	42785 (28.7)
	Overweight	24274 (40.1)	34332 (38.9)	58606 (39.4)
	Obese	19309 (31.9)	26327 (29.8)	45636 (30.7)
Current Smoking	No	53632 (88.6)	80079 (90.7)	133711 (89.8)
	Yes	6924 (11.4)	8214 (9.3)	15138 (10.2)
Heavy Alcohol Consumption	No	56617 (93.5)	83794 (94.9)	140411 (94.3)
	Yes	3939 (6.5)	4499 (5.1)	8438 (5.7)
Chronic Diseases	No	483 (0.8)	1469 (1.7)	1952 (1.3)
	Yes	60073 (99.2)	86824 (98.3)	146897 (98.7)

EMPLOYMENT STATUS AND PHYSICAL ACTIVITY

Binary logistic regression was used to analyze the association between employment status (Retired vs. Employed) and physical activity dependent variables: 1) Exercise in the Past 30 Days, 2) Meet Aerobic Recommendations, 3) Meet Muscle-Strengthening Recommendations, 4) Meet the 2008 Guidelines, 5) Intensity for the First Activity, 6) Intensity for the Second Activity.

The total population was first stratified by gender and then stratified by age. For the first 3 binary variables, “No” was set as the reference group. To make comparisons among 3 levels of “Meet the 2008 Guidelines” variable, “None” was set as the reference group, and the analyses were conducted for “Either vs. None”, and “Both vs. None”. For the last 2 intensity variables, “No” was set as the reference group, and the analyses were conducted for “Moderate vs. No”, and “Vigorous vs. No”.

The counts and proportions were displayed in tables, and the odds ratio was showed in the figures **(Table 5.1–10.2; Figure 1-6)**.

Exercise in the Past 30 Days

The prevalence of reporting exercise was 73.8% in men and 70.8% in women. Older age groups (75-79 and ≥ 80) in both genders had lower prevalence compared with the total sample **(Table 5.1, Table5.2)**.

Table 5.1 Exercise in the Past 30 Days and Employment Status among Males at Each Age Group

Age group	Exercise in the past 30 days	Employed	Retired	Total
		n (%)	n (%)	n (%)
55-59	Yes	8308 (73.8)	989 (77.8)	9297 (74.2)
	No	2950 (26.2)	282 (22.2)	3232 (25.8)
60-64	Yes	7157 (74.2)	3438 (78.3)	10595 (75.5)
	No	2493 (25.8)	952 (21.7)	3445 (24.5)
65-69	Yes	4018 (74.2)	7580 (77.1)	11598 (76)
	No	1399 (25.8)	2257 (22.9)	3656 (24)
70-74	Yes	1853 (70.7)	7297 (75.9)	9150 (74.8)
	No	768 (29.3)	2313 (24.1)	3081 (25.2)
75-79	Yes	813 (69.7)	4817 (71.3)	5630 (71)
	No	353 (30.3)	1943 (28.7)	2296 (29)
≥ 80	Yes	437 (64.5)	5007 (67.2)	5444 (67)
	No	240 (35.5)	2447 (32.8)	2687 (33)
Total	Yes	22586 (73.4)	29128 (74.1)	51714 (73.8)
	No	8203 (26.6)	10194 (25.9)	18397 (26.2)

Table 5.2 Exercise in the Past 30 Days and Employment Status among Females at Each Age Group

Age group	Exercise in the past 30 days	Employed	Retired	Total
		n (%)	n (%)	n (%)
55-59	Yes	8657 (75.6)	1113 (77.9)	9770 (75.8)
	No	2801 (24.4)	316 (22.1)	3117 (24.2)
60-64	Yes	7230 (74.8)	4007 (76.3)	11237 (75.3)
	No	2435 (25.2)	1242 (23.7)	3677 (24.7)
65-69	Yes	3599 (73.3)	8760 (73.8)	12359 (73.7)
	No	1312 (26.7)	3103 (26.2)	4415 (26.3)
70-74	Yes	1571 (69.9)	8220 (70.3)	9791 (70.2)
	No	675 (30.1)	3479 (29.7)	4154 (29.8)
75-79	Yes	644 (65.5)	5578 (65.4)	6222 (65.4)
	No	339 (34.5)	2949 (34.6)	3288 (34.6)
≥ 80	Yes	326 (64.7)	6004 (58.8)	6330 (59.1)
	No	178 (35.3)	4200 (41.2)	4378 (40.9)
Total	Yes	22027 (74)	33682 (68.8)	55709 (70.8)
	No	7740 (26)	15289 (31.2)	23029 (29.2)

Compared with the employed men, overall, the retired men had 4% (OR 1.04; 95% CI 1.00-1.07) higher odds of participating in the exercise in the past 30 days. On the age groups: 55-59 (OR 1.25; 95% CI 1.08-1.43), 60-64 (OR 1.26; 95% CI 1.16-1.37), 65-69 (OR 1.17; 95% CI 1.08-1.26) and 70-74 (OR 1.31; 95% CI 1.19-1.44), retired men were more likely to participate in PA, compared with the employed men in the same age group. Compared with the employed women, the retired women had 23% (OR 0.77; 95% CI 0.75-0.80) lower odds of participating in PA in the past 30 days. When stratified by age groups, retired women in the 60-64 age group had 9% (OR 1.09; 95% CI 1.01-1.18) higher odds, while retired women in the ≥ 80 age group had 22% (OR 0.78; 95% CI 0.65-0.94) lower odds of participating in PA, compared with the employed women in the same age group **(Figure 1)**.

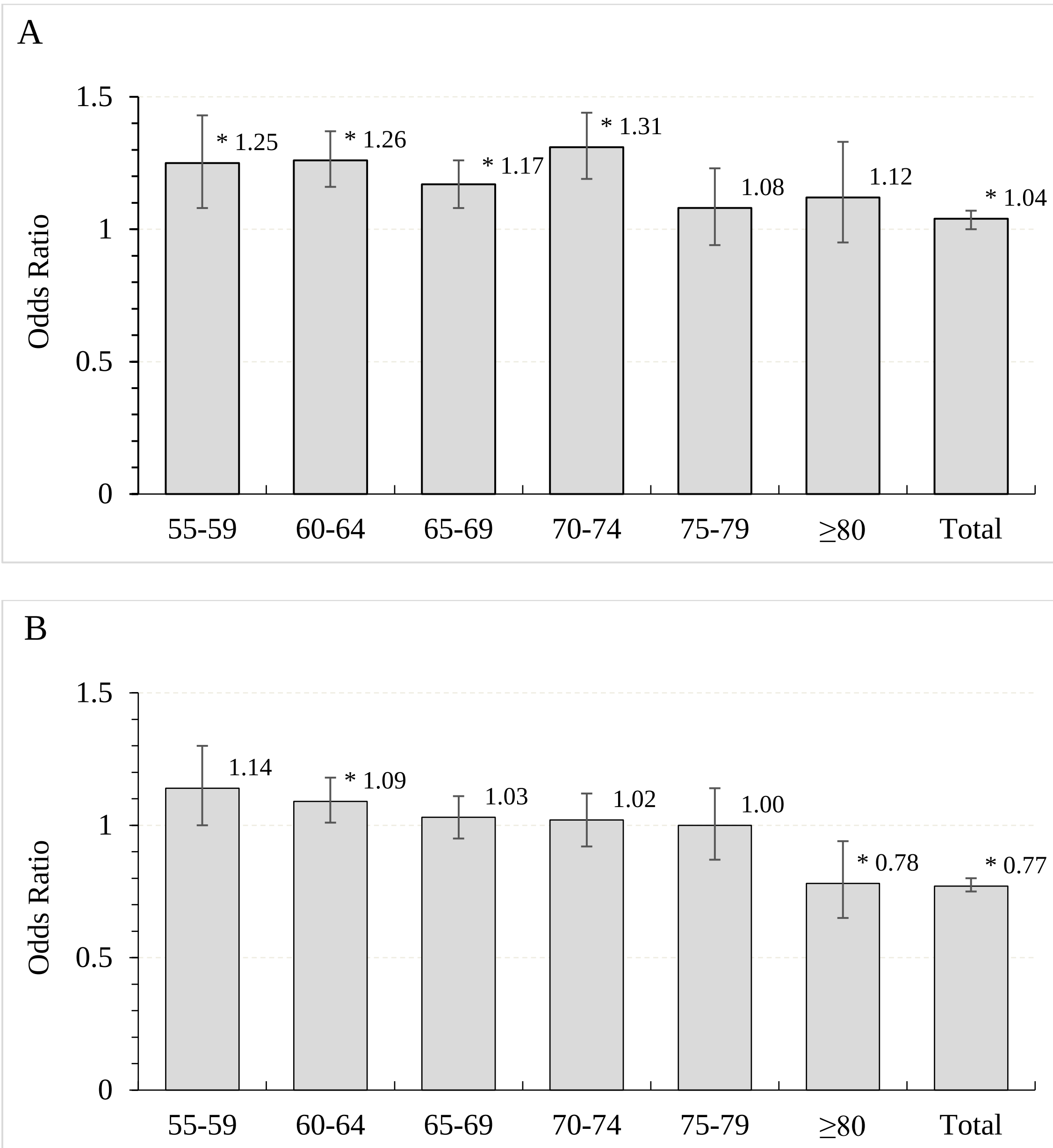


Figure 1. Association between Exercise in the past 30 days and Employment Status. (Retired vs. Employed) (A) Male; (B) Female. *P < 0.05.

Meet Aerobic Recommendations

Over half of the participants met the aerobic recommendations, and the prevalence was higher in men (59%) than women (54.4%). The prevalence in each age group was consistent with the overall sample for both genders **(Table 6.1, Table 6.2)**.

Table 6.1 Meet Aerobic Recommendations and Employment Status among Males at Each Age Group

Age group	Meet Aerobic Recommendations	Employed	Retired	Total
		n (%)	n (%)	n (%)
55-59	Yes	6057 (53.8)	785 (61.8)	6842 (54.6)
	No	5201 (46.2)	486 (38.2)	5687 (45.4)
60-64	Yes	5332 (55.3)	2767 (63)	8099 (57.7)
	No	4318 (44.7)	1623 (37)	5941 (42.3)
65-69	Yes	3037 (56.1)	6100 (62)	9137 (59.9)
	No	2380 (43.9)	3737 (38)	6117 (40.1)
70-74	Yes	1474 (56.2)	6188 (64.4)	7662 (62.6)
	No	1147 (43.8)	3422 (35.6)	4569 (37.4)
75-79	Yes	703 (60.3)	4240 (62.7)	4943 (62.4)
	No	463 (39.7)	2520 (37.3)	2983 (37.6)
≥ 80	Yes	356 (52.6)	4298 (57.7)	4654 (57.2)
	No	321 (47.4)	3156 (42.3)	3477 (42.8)
Total	Yes	16959 (55.1)	24378 (62)	41337 (59)
	No	13830 (44.9)	14944 (38)	28774 (41)

Table 6.2 Meet Aerobic Recommendations and Employment Status among Females at Each Age Group

Age group	Meet Aerobic Recommendations	Employed	Retired	Total
		n (%)	n (%)	n (%)
55-59	Yes	6201 (54.1)	831 (58.2)	7032 (54.6)
	No	5257 (45.9)	598 (41.8)	5855 (45.4)
60-64	Yes	5252 (54.3)	3135 (59.7)	8387 (56.2)
	No	4413 (45.7)	2114 (40.3)	6527 (43.8)
65-69	Yes	2565 (52.2)	6768 (57.1)	9333 (55.6)
	No	2346 (47.8)	5095 (42.9)	7441 (44.4)
70-74	Yes	1152 (51.3)	6345 (54.2)	7497 (53.8)
	No	1094 (48.7)	5354 (45.8)	6448 (46.2)
75-79	Yes	535 (54.4)	4783 (56.1)	5318 (55.9)
	No	448 (45.6)	3744 (43.9)	4192 (44.1)
≥ 80	Yes	272 (54)	5082 (49.8)	5354 (50)
	No	232 (46)	5122 (50.2)	5354 (50)
Total	Yes	15977 (53.7)	26944 (55)	42921 (54.5)
	No	13790 (46.3)	22027 (45)	35817 (45.5)

Compared with the employed men, the retired men had a 33% (OR 1.33; 95% CI 1.29-1.37) higher probability of meeting the aerobic recommendations. On the age groups: 55-59 (OR 1.39; 95% CI 1.23-1.56), 60-64 (OR 1.38; 95% CI 1.28-1.49), 65-69 (OR 1.28; 95% CI 1.20-1.37), 70-74 (OR 1.41; 95% CI 1.29-1.54), and ≥ 80 (OR 1.23; 95% CI 1.05-1.44), retired men were 23%-41% more likely to meet the aerobic recommendations, relative to the employed men in the same age group. Retired women, in general, had a 6% (OR 1.06; 95% CI 1.03-1.09) higher probability of meeting the aerobic recommendations than the employed women. On the age groups: 55-59 (OR 1.18; 95% CI 1.05-1.32), 60-64 (OR 1.25; 95% CI 1.16-1.33), 65-69 (OR 1.22; 95% CI 1.14-1.30), and 70-74 (OR 1.13; 95% CI 1.03-1.23), retired women were 13%-25% more likely to meet the aerobic recommendations, relative to the employed women in the same age group **(Figure 2)**.

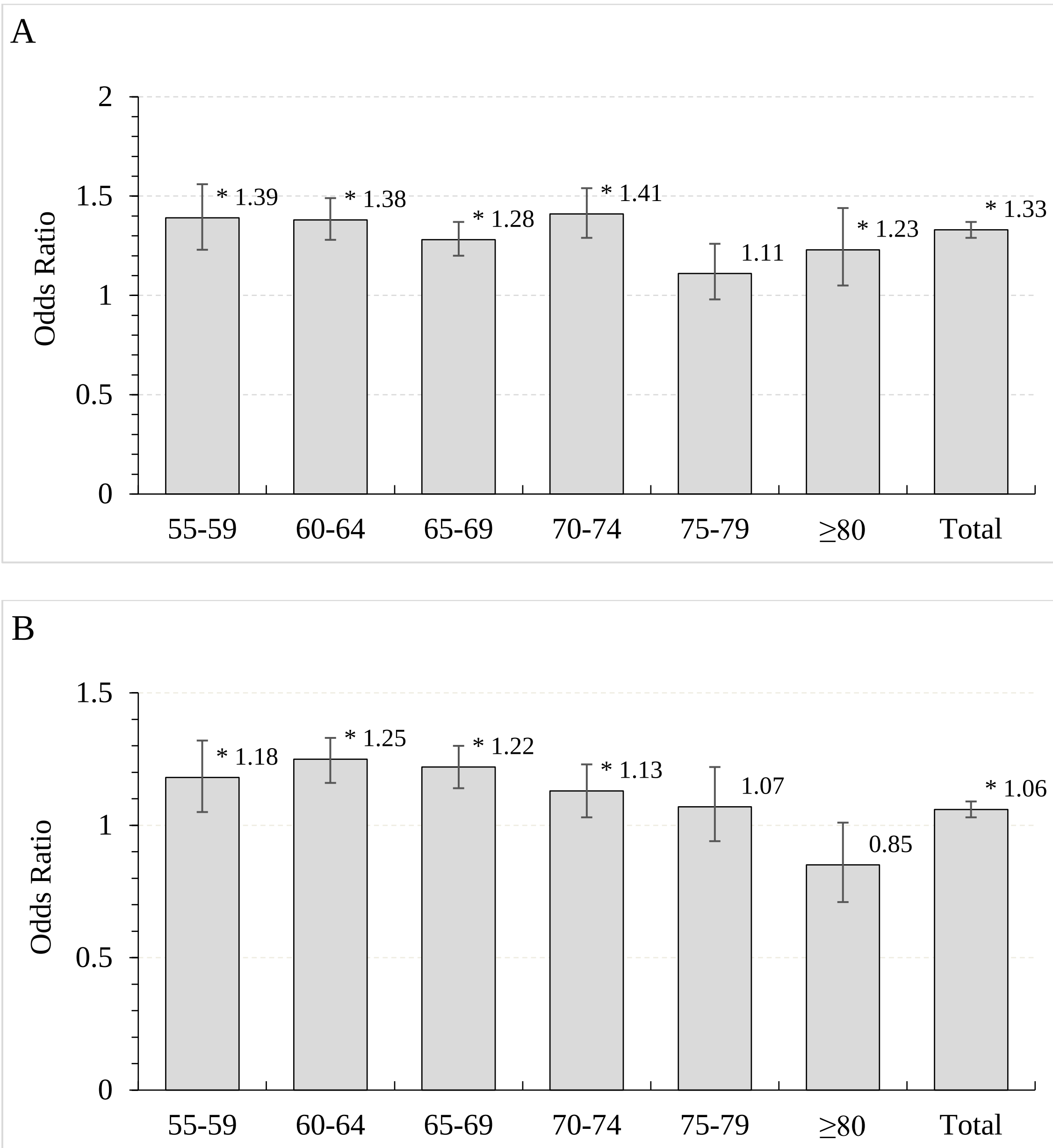


Figure 2. Association between Meet Aerobic Recommendations and Employment Status. (Retired vs. Employed) (A) Male; (B) Female. *P < 0.05.

Meet Muscle-Strengthening Recommendations

Results indicated that less than 1/3 of the study sample met the muscle-strengthening recommendation, and the prevalence of meeting the recommendations was higher in men (27.5%) than women (24.7%) **(Table 7.1, Table 7.2)**.

Table 7.1 Meet Muscle-Strengthening Recommendations and Employment Status among Males at Each Age Group

Age group	Meet Muscle-Strengthening Recommendations	Employed	Retired	Total
		n (%)	n (%)	n (%)
55-59	Yes	3057 (27.2)	415 (32.7)	3472 (27.7)
	No	8201 (72.8)	856 (67.3)	9057 (72.3)
60-64	Yes	2553 (26.5)	1239 (28.2)	3792 (27)
	No	7097 (73.5)	3151 (71.8)	10248 (73)
65-69	Yes	1490 (27.5)	2752 (28)	4242 (27.8)
	No	3927 (72.5)	7085 (72)	11012 (72.2)
70-74	Yes	751 (28.7)	2732 (28.4)	3483 (28.5)
	No	1870 (71.3)	6878 (71.6)	8748 (71.5)
75-79	Yes	317 (27.2)	1847 (27.3)	2164 (27.3)
	No	849 (72.8)	4913 (72.7)	5762 (72.7)
≥ 80	Yes	185 (27.3)	1963 (26.3)	2148 (26.4)
	No	492 (72.7)	5491 (73.7)	5983 (73.6)
Total	Yes	8353 (27.1)	10948 (27.8)	19301 (27.5)
	No	22436 (72.9)	28374 (72.2)	50810 (72.5)

Table 7.2 Meet Muscle-Strengthening Recommendations and Employment Status among Females at Each Age Group

Age group	Meet Muscle-Strengthening Recommendations	Employed	Retired	Total
		n (%)	n (%)	n (%)
55-59	Yes	3088 (27)	411 (28.8)	3499 (27.2)
	No	8370 (73)	1018 (71.2)	9388 (72.8)
60-64	Yes	2443 (25.3)	1461 (27.8)	3904 (26.2)
	No	7222 (74.7)	3788 (72.2)	11010 (73.8)
65-69	Yes	1278 (26)	3126 (26.4)	4404 (26.3)
	No	3633 (74)	8737 (73.6)	12370 (73.7)
70-74	Yes	532 (23.7)	2794 (23.9)	3326 (23.9)
	No	1714 (76.3)	8905 (76.1)	10619 (76.1)
75-79	Yes	218 (22.2)	1876 (22)	2094 (22)
	No	765 (77.8)	6651 (78)	7416 (78)
≥ 80	Yes	138 (27.4)	2101 (20.6)	2239 (20.9)
	No	366 (72.6)	8103 (79.4)	8469 (79.1)
Total	Yes	7697 (25.9)	11769 (24)	19466 (24.7)
	No	22070 (74.1)	37202 (76)	59272 (75.3)

Compared with the employed men, the retired men overall had 4% (OR 1.04; 95% CI 1.00-1.07) higher odds to meet the muscle-strengthening recommendations. In the age groups 55-59 (OR 1.3; 95% CI 1.15-1.47) and 60-64 (OR 1.09; 95% CI 1.01-1.18), retired men were 30% and 9%, respectively, more likely to meet the muscle-strengthening recommendations, relative to the employed men in the same age group. Retired women, in general, had 9% (OR 0.91; 95% CI 0.88-0.94) lower odds to meet the muscle-strengthening recommendations than the employed women. When stratified by age, retired women in the 60-64 group had 14% (OR 1.14; 95% CI 1.16-1.33) higher odds, while retired women ≥ 80 had 31% (OR 0.69; 95% CI 0.56-0.84) lower odds to meet the muscle-strengthening recommendations, relative to the employed women in the same age group **(Figure 3)**.

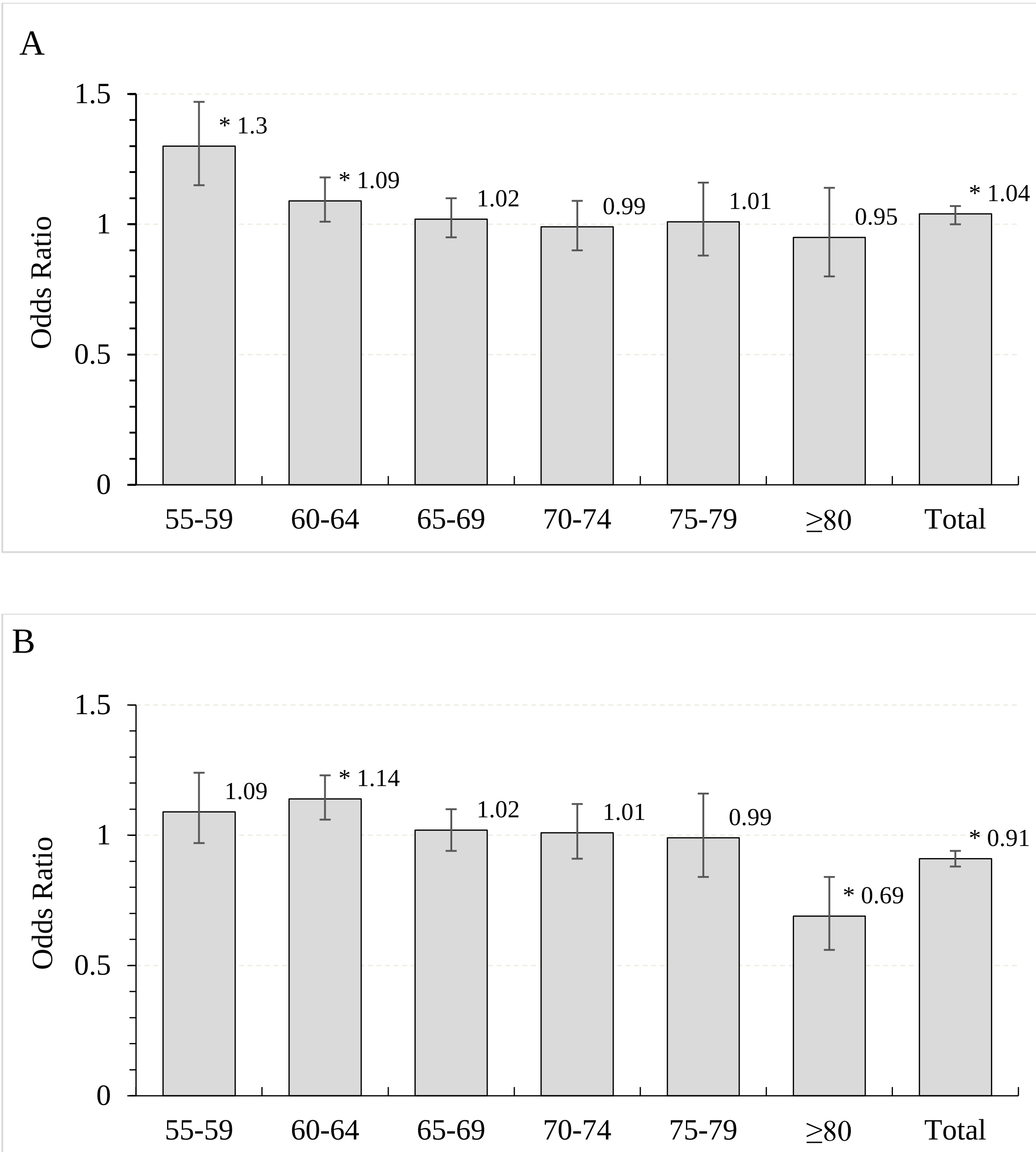


Figure 3. Association between Meet Muscle-Strengthening Recommendations and Employment Status. (Retired vs. Employed) (A) Male; (B) Female. *P < 0.05.

Meet the 2008 Guidelines

Over 1/3 of the individuals did not meet either the aerobic or muscle-strengthening guidelines, and the prevalence was higher in women (39%) than men (34.7%). Approximately 1/5 of the study participants met both guidelines, for which men (21.2%) are higher than women (18.2%) **(Table 8.1, Table 8.2)**.

Table 8.1 Meet the 2008 Guidelines and Employment Status for Males at Each Age Group

Age group	Meet the 2008 Guidelines	Employed	Retired	Total
		n (%)	n (%)	n (%)
55-59	None	4343 (38.6)	399 (31.4)	4742 (37.8)
	Either	4716 (41.9)	544 (42.8)	5260 (42)
	Both	2199 (19.5)	328 (25.8)	2527 (20.2)
60-64	None	3672 (38.1)	1351 (30.8)	5023 (35.8)
	Either	4071 (42.2)	2072 (47.2)	6143 (43.8)
	Both	1907 (19.8)	967 (22)	2874 (20.5)
65-69	None	1999 (36.9)	3131 (31.8)	5130 (33.6)
	Either	2309 (42.6)	4560 (46.4)	6869 (45)
	Both	1109 (20.5)	2146 (21.8)	3255 (21.3)
70-74	None	983 (37.5)	2888 (30.1)	3871 (31.6)
	Either	1051 (40.1)	4524 (47.1)	5575 (45.6)
	Both	587 (22.4)	2198 (22.9)	2785 (22.8)
75-79	None	402 (34.5)	2171 (32.1)	2573 (32.5)
	Either	508 (43.6)	3091 (45.7)	3599 (45.4)
	Both	256 (22)	1498 (22.2)	1754 (22.1)

Table 8.1 (continued)

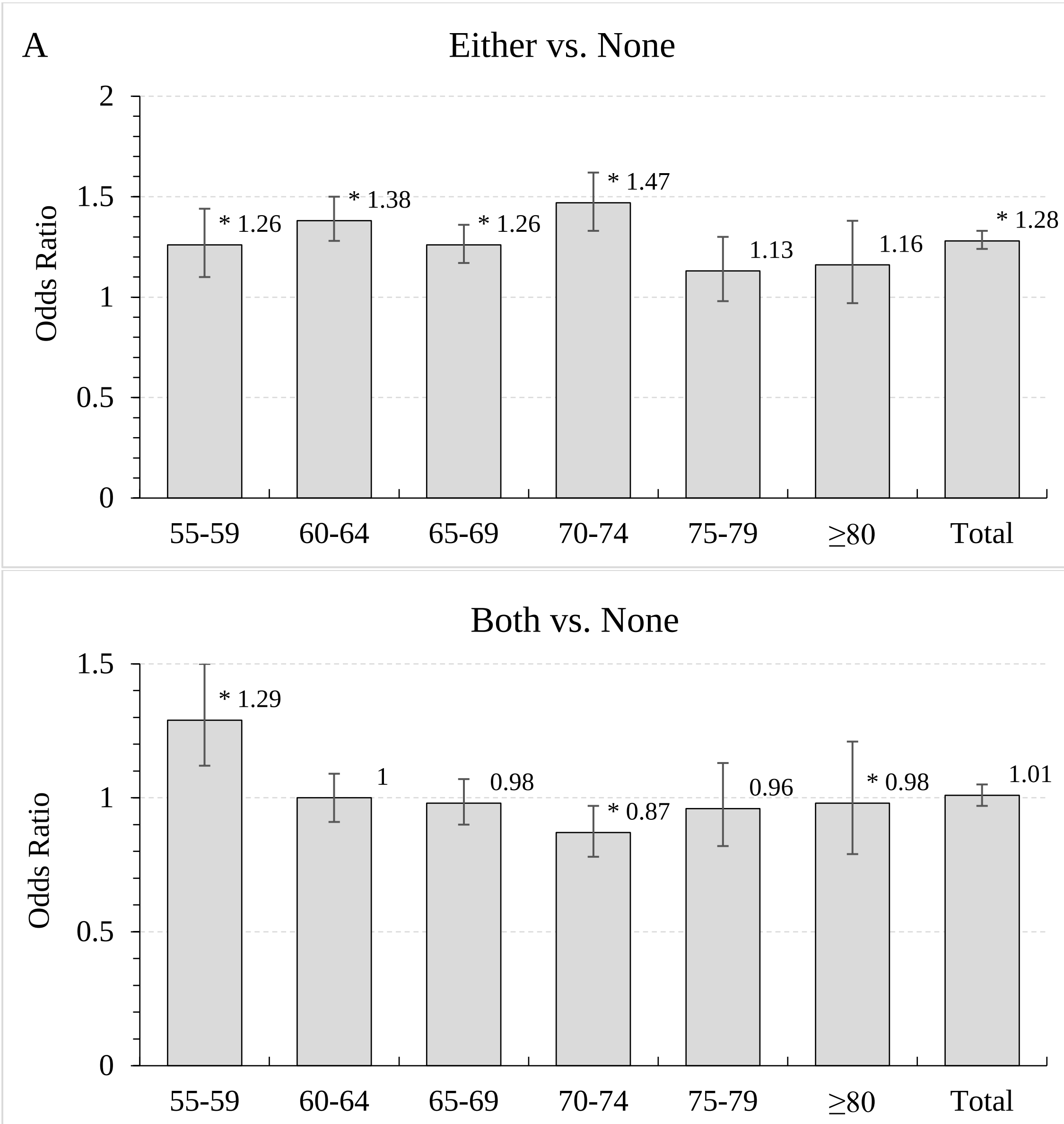
≥ 80	None	270 (39.9)	2727 (36.6)	2997 (36.9)
	Either	273 (40.3)	3193 (42.8)	3466 (42.6)
	Both	134 (19.8)	1534 (20.6)	1668 (20.5)
Total	None	11669 (37.9)	12667 (32.2)	24336 (34.7)
	Either	12928 (42)	17984 (45.7)	30912 (44.1)
	Both	6192 (20.1)	8671 (22.1)	14863 (21.2)

Table 8.2 Meet the 2008 Guidelines and Employment Status for Females at Each Age Group

Age group	Meet the 2008 Guidelines	Employed	Retired	Total
		n (%)	n (%)	n (%)
55-59	None	4436 (38.7)	500 (35)	4936 (38.3)
	Either	4755 (41.5)	616 (43.1)	5371 (41.7)
	Both	2267 (19.8)	313 (21.9)	2580 (20)
60-64	None	3763 (38.9)	1782 (33.9)	5545 (37.2)
	Either	4109 (42.5)	2338 (44.5)	6447 (43.2)
	Both	1793 (18.6)	1129 (21.5)	2922 (19.6)
65-69	None	1984 (40.4)	4279 (36.1)	6263 (37.3)
	Either	2011 (40.9)	5274 (44.5)	7285 (43.4)
	Both	916 (18.7)	2310 (19.5)	3226 (19.2)
70-74	None	948 (42.2)	4585 (39.2)	5533 (39.7)
	Either	912 (40.6)	5089 (43.5)	6001 (43)
	Both	386 (17.2)	2025 (17.3)	2411 (17.3)
75-79	None	400 (40.7)	3302 (38.7)	3702 (38.9)
	Either	413 (42)	3791 (44.5)	4204 (44.2)
	Both	170 (17.3)	1434 (16.8)	1604 (16.9)
≥ 80	None	203 (40.3)	4507 (44.2)	4710 (44)
	Either	192 (38.1)	4211 (41.3)	4403 (41.1)
	Both	109 (21.6)	1486 (14.6)	1595 (14.9)
Total	None	11734 (39.4)	18955 (38.7)	30689 (39)
	Either	12392 (41.6)	21319 (43.5)	33711 (42.8)
	Both	5641 (19)	8697 (17.8)	14338 (18.2)

Compared with the employed men, the retired men overall had 28% (OR 1.28; 95% CI 1.24-1.33) higher odds of meeting either of the guidelines. Regarding Either vs. None, retired men in the age groups: 55-59 (OR 1.26; 95% CI 1.10-1.44), 60-64 (OR 1.38; 95% CI 1.28-1.5), 65-69 (OR 1.26; 95% CI 1.17-1.36), and 70-74 (OR 1.47; 95% CI 1.33-1.62), had 26%-47% higher odds of meeting either of the guidelines. Regarding Both vs. None, retired men in the 55-59 age group had 29% (OR 1.29; 95% CI 1.12-1.50) higher odds, whereas retired men in the 70-74 age group had 13% (OR 0.87; 95% CI 0.78-0.97) lower odds, of meeting both of the guidelines **(Figure 4A)**.

Retired women, in general, had 7% (OR 1.07; 95% CI 1.03-1.10) higher odds of meeting either of the guidelines and 5% (OR 0.95; 95% CI 0.92-0.99) lower odds of meeting both of the guidelines, compared with the employed women. Regarding Either vs. None, retired women in the age groups 55-59 (OR 1.15; 95% CI 1.01-1.30), 60-64 (OR 1.20; 95% CI 1.11-1.3), 65-69 (OR 1.22; 95% CI 1.13-1.31), and 70-74 (OR 1.15; 95% CI 1.05-1.27), had 15%-22% higher odds of meeting either of the guidelines. Regarding Both vs. None, retired women in the age groups 55-59 (OR 1.23; 95% CI 1.05-1.42), 60-64 (OR 1.33; 95% CI 1.21-1.46), and 65-69 (OR 1.17; 95% CI 1.07-1.28) had 17%-33% higher odds, whereas retired women in the ≥ 80 age group (OR 0.61; 95% CI 0.48-0.78) had 39% lower odds, of meeting both of the guidelines **(Figure 4B)**.


A
Either vs. None
Odds Ratio
0
0.5
1
1.5
2
* 1.26
* 1.38
* 1.26
* 1.47
1.13
1.16
* 1.28
55-59
60-64
65-69
70-74
75-79
≥80
Total
Both vs. None
Odds Ratio
0
0.5
1
1.5
* 1.29
1
0.98
* 0.87
0.96
* 0.98
1.01
55-59
60-64
65-69
70-74
75-79
≥80
Total

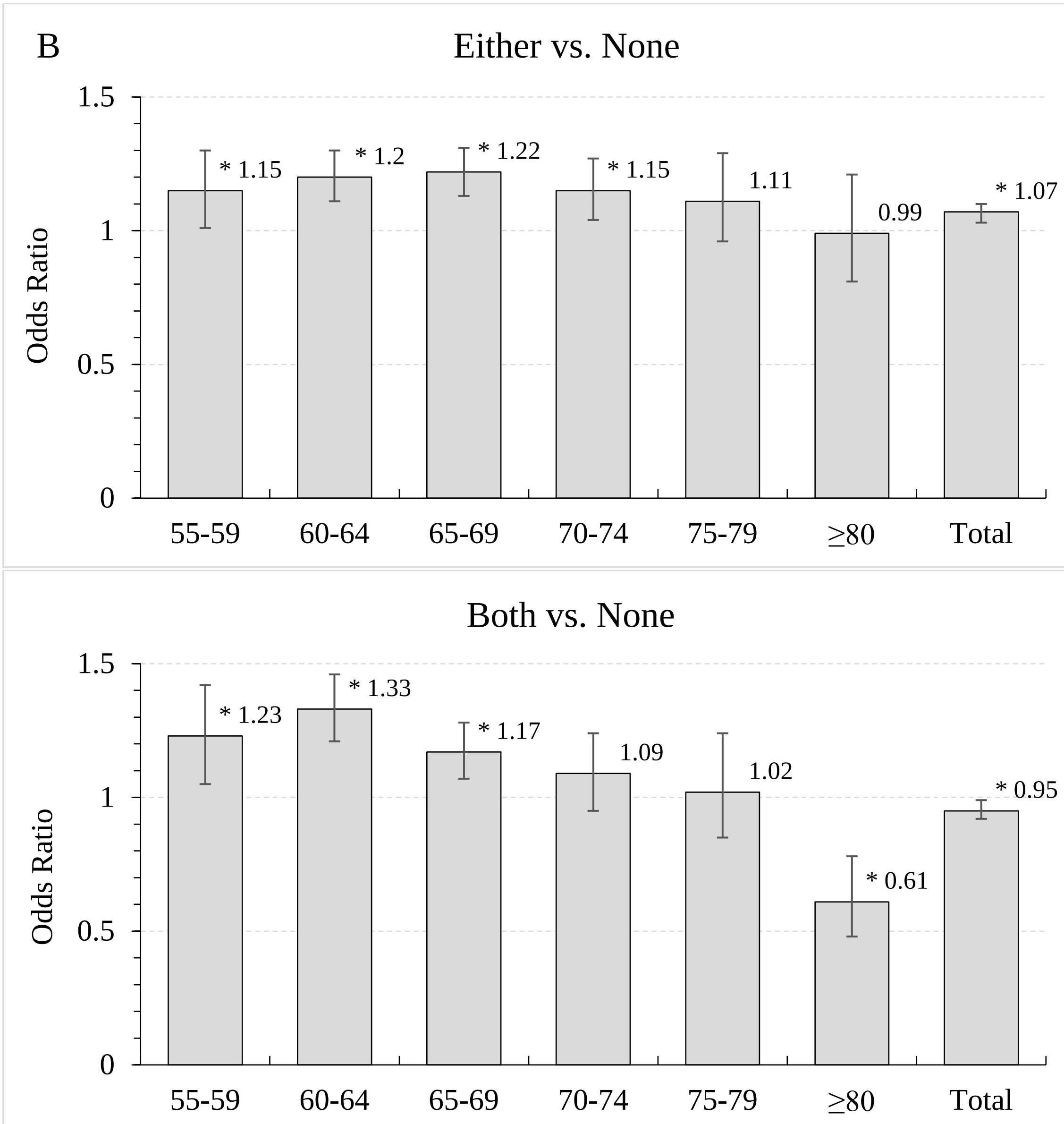


Figure 4. Association between Meet the 2008 Guidelines and Employment Status. (Retired vs. Employed) (A) Male; (B) Female. *P < 0.05.

Intensity for the First Activity

The majority of the first reported activity was classified into moderate or vigorous intensity, and only one-third of the participants (29.2% in men; 31.9% in women) did not have activities or moderate/vigorous-intensity activities **(Table 9.1, Table 9.2)**.

Table 9.1 Intensity for the First Activity and Employment Status among Males at Each Age Group

Age group	Intensity	Employed	Retired	Total
		n (%)	n (%)	n (%)
55-59	No	3412 (30.3)	325 (25.6)	3737 (29.8)
	Moderate	5629 (50)	701 (55.2)	6330 (50.5)
	Vigorous	2217 (19.7)	245 (19.3)	2462 (19.7)
60-64	No	2797 (29)	1072 (24.4)	3869 (27.6)
	Moderate	4561 (47.3)	2301 (52.4)	6862 (48.9)
	Vigorous	2292 (23.8)	1017 (23.2)	3309 (23.6)
65-69	No	1578 (29.1)	2540 (25.8)	4118 (27)
	Moderate	2441 (45.1)	4833 (49.1)	7274 (47.7)
	Vigorous	1398 (25.8)	2464 (25)	3862 (25.3)
70-74	No	854 (32.6)	2566 (26.7)	3420 (28)
	Moderate	535 (20.4)	2078 (21.6)	2613 (21.4)
	Vigorous	1232 (47)	4966 (51.7)	6198 (50.7)
75-79	No	386 (33.1)	2127 (31.5)	2513 (31.7)
	Moderate	1 (0.1)	3 (0)	4 (0.1)
	Vigorous	779 (66.8)	4630 (68.5)	5409 (68.2)

Table 9.1 (continued)

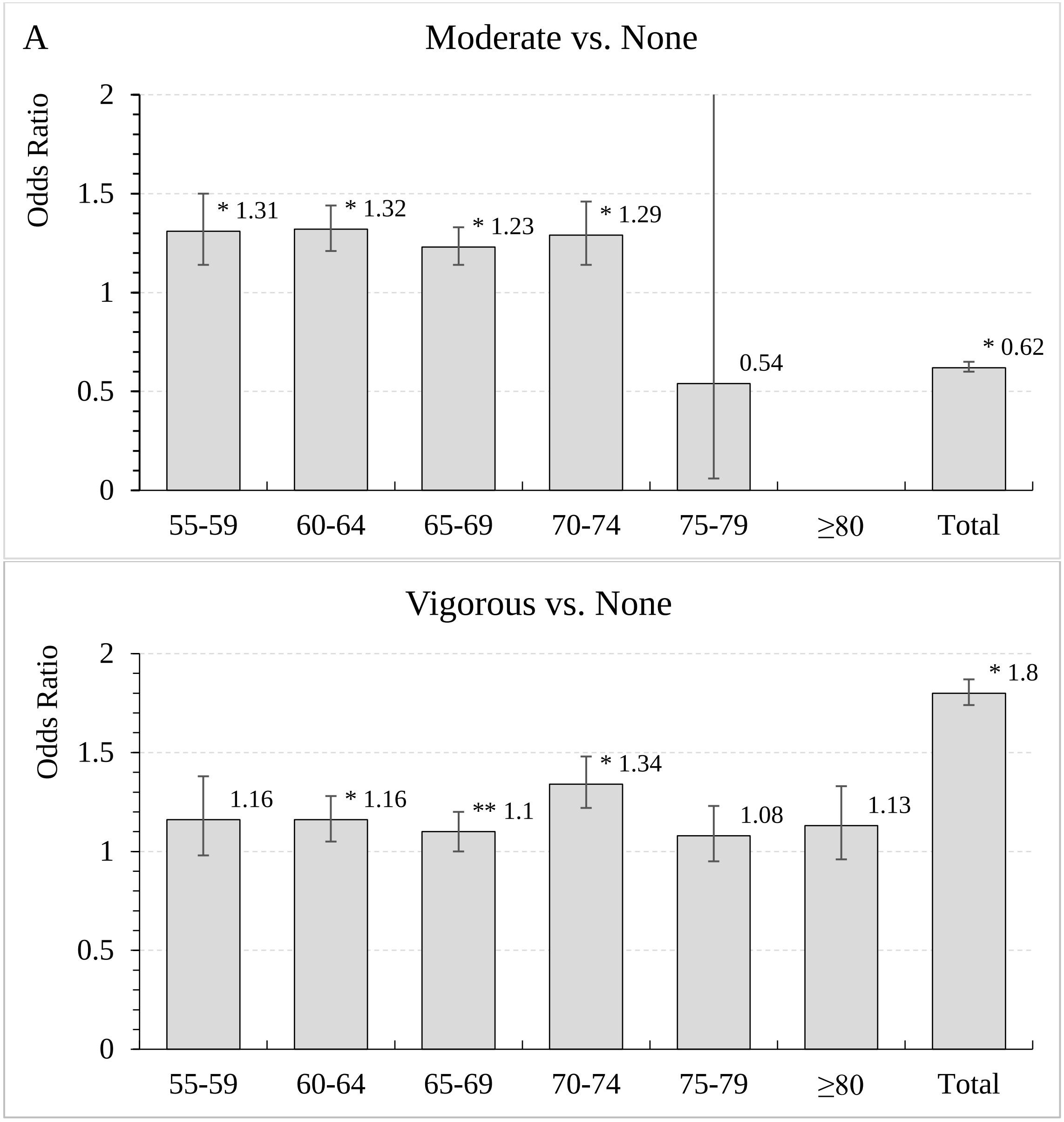
≥ 80	No	255 (37.7)	2594 (34.8)	2849 (35)
	Moderate	/	/	/
	Vigorous	422 (62.3)	4860 (65.2)	5282 (65)
Total	No	9282 (30.1)	11224 (28.5)	20506 (29.2)
	Moderate	13167 (42.8)	9916 (25.2)	23083 (32.9)
	Vigorous	8340 (27.1)	18182 (46.2)	26522 (37.8)

Table 9.2 Intensity for the First Activity and Employment Status among Females at Each Age Group

Age group	Intensity	Employed	Retired	Total
		n (%)	n (%)	n (%)
55-59	No	3160 (27.6)	365 (25.5)	3525 (27.4)
	Moderate	6031 (52.6)	779 (54.5)	6810 (52.8)
	Vigorous	2267 (19.8)	285 (19.9)	2552 (19.8)
60-64	No	2729 (28.2)	1390 (26.5)	4119 (27.6)
	Moderate	4889 (50.6)	2702 (51.5)	7591 (50.9)
	Vigorous	2047 (21.2)	1157 (22)	3204 (21.5)
65-69	No	1477 (30.1)	3442 (29)	4919 (29.3)
	Moderate	2421 (49.3)	5761 (48.6)	8182 (48.8)
	Vigorous	1013 (20.6)	2660 (22.4)	3673 (21.9)
70-74	No	748 (33.3)	3745 (32)	4493 (32.2)
	Moderate	979 (43.6)	5171 (44.2)	6150 (44.1)
	Vigorous	519 (23.1)	2783 (23.8)	3302 (23.7)
75-79	No	359 (36.5)	3132 (36.7)	3491 (36.7)
	Moderate	6 (0.6)	36 (0.4)	42 (0.4)
	Vigorous	618 (62.9)	5359 (62.8)	5977 (62.8)
≥ 80	No	192 (38.1)	4380 (42.9)	4572 (42.7)
	Moderate	0 (0)	1 (0)	1 (0)
	Vigorous	312 (61.9)	5823 (57.1)	6135 (57.3)
Total	No	8665 (29.1)	16454 (33.6)	25119 (31.9)
	Moderate	14326 (48.1)	14450 (29.5)	28776 (36.5)
	Vigorous	6776 (22.8)	18067 (36.9)	24843 (31.6)

Compared with the employed men, the retired men had a 38% (OR 0.62; 95% CI 0.6-0.65) lower probability of participating in moderate-intensity PA (MPA), and a 80% (OR 1.8; 95% CI 1.74-1.87) higher probability of participating in vigorous-intensity PA (VPA). Regarding Moderate vs. No, in the age groups: 55-59 (OR 1.31; 95% CI 1.14-1.5), 60-64 (OR 1.32; 95% CI 1.21-1.44), 65-69 (OR 1.23; 95% CI 1.14-1.33), and 70-74 (OR 1.29; 95% CI 1.14-1.46), retired men had 23%-32% higher odds of participating in MPA, compared with the employed men in the same age group. Regarding Vigorous vs. No, in the age groups: 60-64 (OR 1.16; 95% CI 1.05-1.28), 65-69 (OR 1.10; 95% CI 1.00-1.20), and 70-74 (OR 1.34; 95% CI 1.22-1.48), retired men had 10%-34% higher odds of participating in VPA, compared with the employed men in the same age group **(Figure 5A)**.

Retired women, in general, had 47% (OR 0.53; 95% CI 0.51-0.55) lower odds of participating in MPA, and 40% (OR 1.40; 95% CI 1.35-1.46) higher odds of participating in VPA, compared with the employed women. Regarding Moderate vs. No, retired women in the 60-64 age group had 9% (OR 1.09; 95% CI 1.00-1.18) higher odds of participating in MPA than the employed women in this age group. Regarding Vigorous vs. No, retired women in the age groups 60-64 (OR 1.11; 95% CI 1.01-1.22) and 65-69 (OR 1.13; 95% CI 1.03-1.24) had 11% and 13% higher odds of participating in VPA, whereas in the age group $\geq$ 80 (OR 0.82; 95% CI 0.68-0.98), retired women were 18% less likely to participate in VPA **(Figure 5B)**.


A
Moderate vs. None
Odds Ratio
2
1.5
1
0.5
0
* 1.31
* 1.32
* 1.23
* 1.29
0.54
* 0.62
55-59
60-64
65-69
70-74
75-79
≥80
Total
Vigorous vs. None
Odds Ratio
2
1.5
1
0.5
0
1.16
* 1.16
** 1.1
* 1.34
1.08
1.13
* 1.8
55-59
60-64
65-69
70-74
75-79
≥80
Total

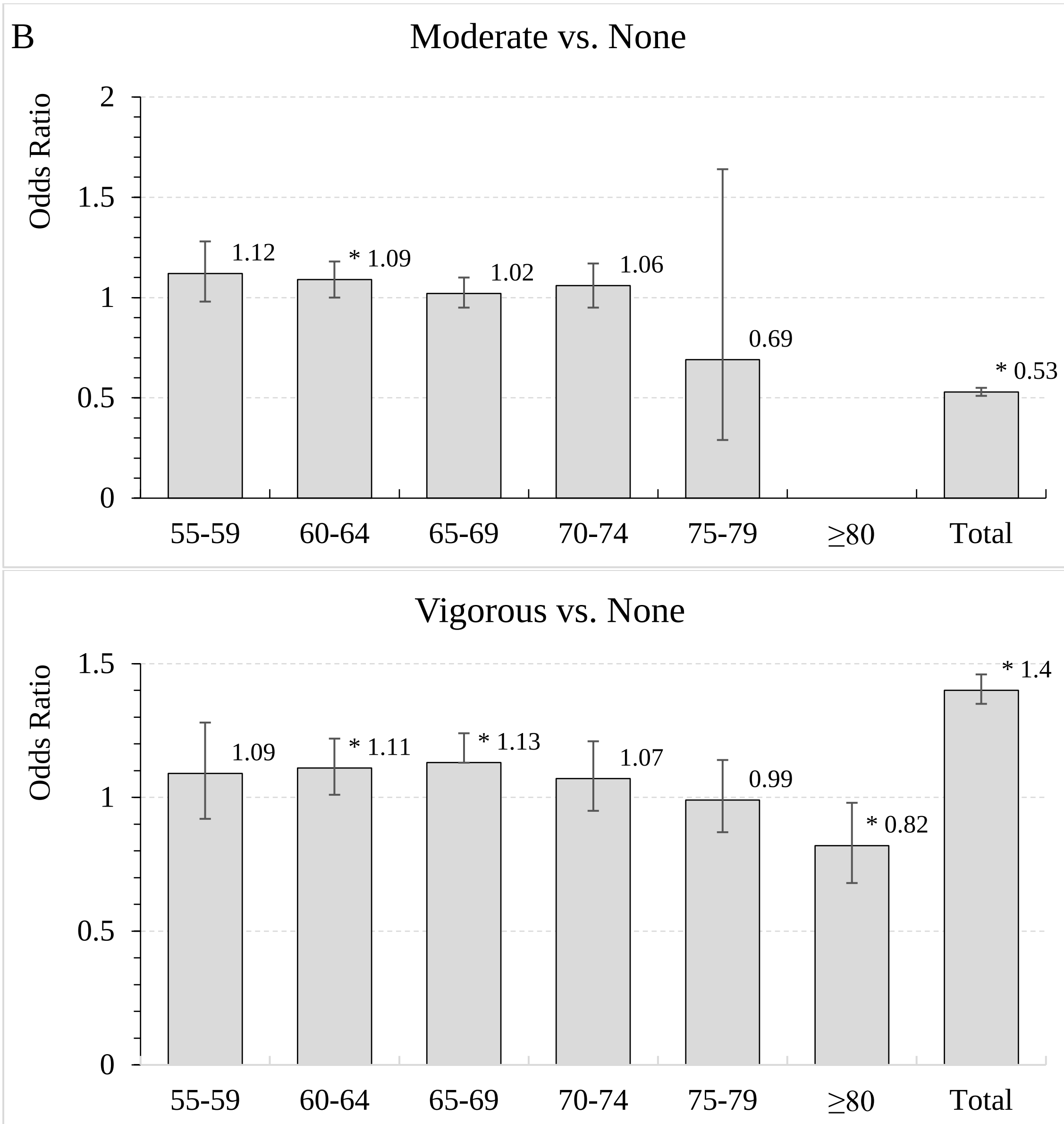


Figure 5. Association between Intensity for the First Activity and Employment Status. (Retired vs. Employed) (A) Male; (B) Female. *P < 0.05, **P = 0.05. *Note.* No data for Aged ≥ 80 on "Moderate vs None"

Intensity for the Second Activity

Approximately, over half of the participants, 55.7% in men and 56.8% in women, did not have the second activity or the activities were not classified as moderate or vigorous intensity **(Table 10.1, Table 10.2)**.

Table 10.1 Intensity for the Second Activity and Employment Status among Males at Each Age Group

Age group	Intensity	Employed	Retired	Total
		n (%)	n (%)	n (%)
55-59	No	6410 (56.9)	706 (55.5)	7116 (56.8)
	Moderate	2967 (26.4)	354 (27.9)	3321 (26.5)
	Vigorous	1881 (16.7)	211 (16.6)	2092 (16.7)
60-64	No	5429 (56.3)	2252 (51.3)	7681 (54.7)
	Moderate	2173 (22.5)	1134 (25.8)	3307 (23.6)
	Vigorous	2048 (21.2)	1004 (22.9)	3052 (21.7)
65-69	No	3038 (56.1)	5111 (52)	8149 (53.4)
	Moderate	1020 (18.8)	1995 (20.3)	3015 (19.8)
	Vigorous	1359 (25.1)	2731 (27.8)	4090 (26.8)
70-74	No	1516 (57.8)	5077 (52.8)	6593 (53.9)
	Moderate	236 (9)	835 (8.7)	1071 (8.8)
	Vigorous	869 (33.2)	3698 (38.5)	4567 (37.3)
75-79	No	711 (61)	3794 (56.1)	4505 (56.8)
	Moderate	3 (0.3)	16 (0.2)	19 (0.2)
	Vigorous	452 (38.8)	2950 (43.6)	3402 (42.9)

Table 10.1 (continued)

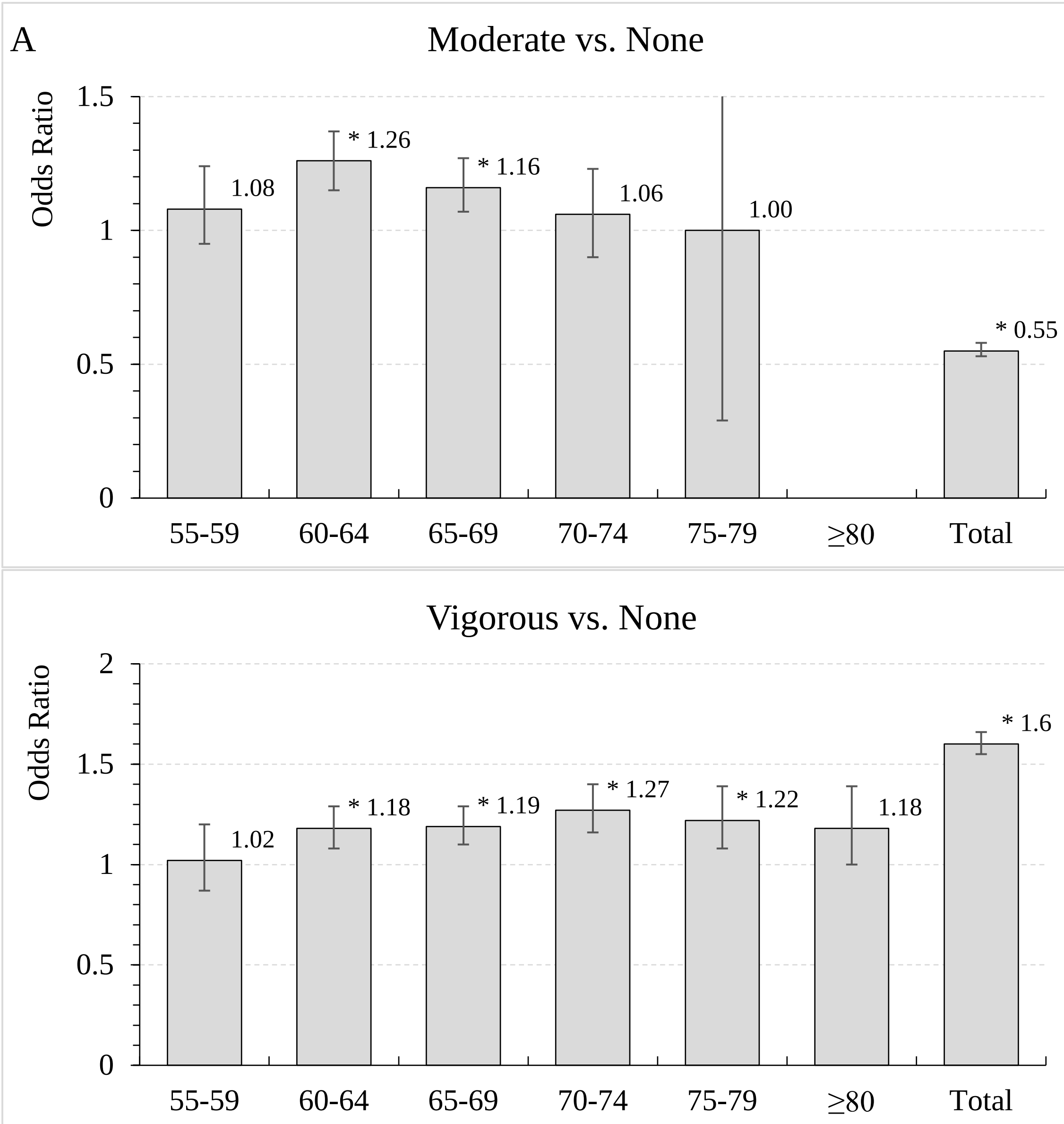
≥ 80	No	442 (65.3)	4587 (61.5)	5029 (61.8)
	Moderate	/	/	/
	Vigorous	235 (34.7)	2867 (38.5)	3102 (38.2)
Total	No	17546 (57)	21527 (54.7)	39073 (55.7)
	Moderate	6399 (20.8)	4334 (11)	10733 (15.3)
	Vigorous	6844 (22.2)	13461 (34.2)	20305 (29)

Table 10.2 Intensity for the Second Activity and Employment Status among Females at Each Age Group

Age group	Intensity	Employed	Retired	Total
		n (%)	n (%)	n (%)
55-59	No	6365 (55.6)	764 (53.5)	7129 (55.3)
	Moderate	2608 (22.8)	380 (26.6)	2988 (23.2)
	Vigorous	2485 (21.7)	285 (19.9)	2770 (21.5)
60-64	No	5342 (55.3)	2725 (51.9)	8067 (54.1)
	Moderate	1918 (19.8)	1138 (21.7)	3056 (20.5)
	Vigorous	2405 (24.9)	1386 (26.4)	3791 (25.4)
65-69	No	2807 (57.2)	6263 (52.8)	9070 (54.1)
	Moderate	949 (19.3)	2619 (22.1)	3568 (21.3)
	Vigorous	1155 (23.5)	2981 (25.1)	4136 (24.7)
70-74	No	1310 (58.3)	6552 (56)	7862 (56.4)
	Moderate	371 (16.5)	2193 (18.7)	2564 (18.4)
	Vigorous	565 (25.2)	2954 (25.3)	3519 (25.2)
75-79	No	607 (61.7)	5017 (58.8)	5624 (59.1)
	Moderate	33 (3.4)	428 (5)	461 (4.8)
	Vigorous	343 (34.9)	3082 (36.1)	3425 (36)
≥ 80	No	313 (62.1)	6685 (65.5)	6998 (65.4)
	Moderate	/	/	/
	Vigorous	191 (37.9)	3519 (34.5)	3710 (34.6)
Total	No	16744 (56.3)	28006 (57.2)	44750 (56.8)
	Moderate	5879 (19.8)	6758 (13.8)	12637 (16)
	Vigorous	7144 (24)	14207 (29)	21351 (27.1)

Compared with the employed men, retired men had 45% (OR 0.55; 95% CI 0.53-0.58) lower probability to participate in MPA, and 60% (OR 1.60; 95% CI 1.55-1.66) higher probability to participate in VPA. Regarding Moderate vs. No, in the age groups: 60-64 (OR 1.26; 95% CI 1.15-1.37), and 65-69 (OR 1.16; 95% CI 1.07-1.27), retired men had 26% and 16%, respectively, higher odds, of participating in MPA, relative to the employed men in the same age group. Regarding Vigorous vs. No, in the age groups: 60-64 (OR 1.18; 95% CI 1.08-1.29), 65-69 (OR 1.19; 95% CI 1.10-1.29), 70-74 (OR 1.27; 95% CI 1.16-1.40), and 75-79 (OR 1.22; 95% CI 1.08-1.39) retired men had 18%-22% higher odds of participating in VPA, relative to the employed men in the same age group **(Figure 6A)**.

Retired women, in general, had a 31% (OR 0.69; 95% CI 0.66-0.72) lower probability of participating in MPA, and a 19% (OR 1.19; 95% CI 1.15-1.23) higher probability of participating VPA, relative to the employed women. Regarding Moderate vs. No, retired women in the age groups: 55-59 (OR 1.21; 95% CI 1.07-1.38), 60-64 (OR 1.16; 95% CI 1.07-1.27), 65-69 (OR 1.24; 95% CI 1.13-1.35), 70-74 (OR 1.18; 95% CI 1.04-1.34), 75-79 (OR 1.57; 95% CI 1.09-2.26), had 16%-57% higher odds of taking MPA than the employed women in this age group. Regarding Vigorous vs. No, retired women in the age groups 60-64 (OR 1.13; 95% CI 1.04-1.23) and 65-69 (OR 1.16; 95% CI 1.07-1.26) had 13% and 16%, respectively, higher odds of participating in VPA, relative to the employed women in the same age group **(Figure 6B)**.


A
Moderate vs. None
Odds Ratio
1.5
1
0.5
0
1.08
* 1.26
* 1.16
1.06
1.00
* 0.55
55-59
60-64
65-69
70-74
75-79
≥80
Total
Vigorous vs. None
Odds Ratio
2
1.5
1
0.5
0
1.02
* 1.18
* 1.19
* 1.27
* 1.22
1.18
* 1.6
55-59
60-64
65-69
70-74
75-79
≥80
Total

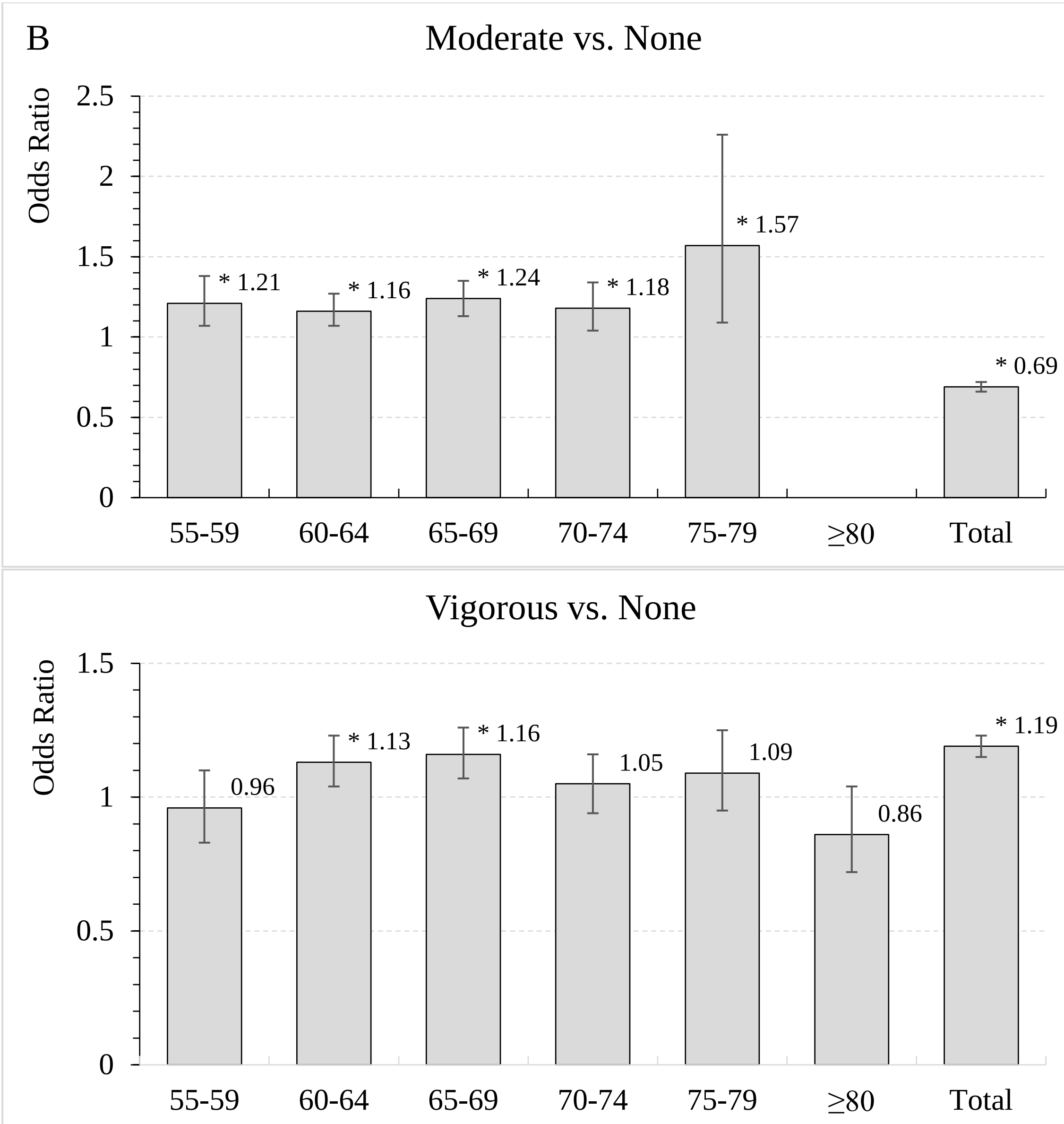


Figure 6. Association between Intensity for the Second Activity and Employment Status. (Retired vs. Employed) (A) Male; (B) Female. *P < 0.05. *Note.* No data for Aged ≥ 80 on "Moderate vs None"

Chapter 5: Discussion

The purpose of this study was to analyze the association of retirement and LTPA among US adults aged 55 years and older, using nationally representative data from the 2017 BRFSS. To examine the association between employment status and LTPA, and capture more characteristics of LTPA, six dependent variables from 3 aspects -- participation, guideline compliance, and intensity -- were used in the study. This study also examined associations for subgroups of gender and age stratifications.

PHYSICAL ACTIVITY PARTICIPATION

Overall, retired men (74.1%) were significantly more likely than employed men (73.3%) to engage in the exercise in the past 30 days, even though the odds was only 4% higher; whereas, retired women (68.8%) were significantly less likely than employed women (74%) to participate in physical activity the past 30 days. Among males, for all age groups, the results consistently indicated that retired people were more likely than employed people to participate in the exercise, although the age groups 75-79 and ≥ 80 had insignificant findings. Among females, only those aged 60-64 found a significant 9% higher odds for retirees to have exercise participation, and for those aged ≥ 80, a significant 22% lower odds for retirees to participate in physical activity in the past 30 days was found.

Most of the previous studies suggest that retirement is associated with increased PA participation for both genders. However, the current study found opposite results for women. One explanation is that we assessed the participation in the past 30 days, while previous studies did not indicate the period, or they measured it with different ranges. Besides, our study sample is comprised of people from 50 to over 80 years old, and 40%

of the individuals are 70 years and older, leading to an older overall sample than previous studies that could result in different findings.

MEETING GUIDELINES

"Meet the 2008 Guidelines" combines the first two recommendation variables, which provides additional information for the analysis. In both genders, retirement is associated with a higher likelihood of meeting either one of the guidelines, and the same results were found in age groups under 75 years old. Even though overall, retired women were slightly less likely to meet both guidelines than employed women, those in younger age groups (55-59, 60-64, and 65-69) were significantly more likely to meet both guidelines. The result showed that the age group ≥ 80 had significantly lower odds, which could be an explanation that causes the lower likelihood of all women. There is no significant association for retirement and meeting both guidelines among men, and only the age group 55-59 found a higher likelihood for retired men. In summary, retirement has different effects on meeting both guidelines for different genders.

Overall, retirement is associated with a higher likelihood of meeting aerobic recommendations in both genders. The same results were shown in most of the age groups for both genders, except for age 75-79, and age ≥ 80 in women. Retired men were also slightly more likely to meet strengthening recommendations, whereas retired women were less likely to meet strengthening recommendations. In contrast to aerobic recommendations, the same results for overall men were only found in the relatively younger age groups (55-59 and 60-64). For women, the 60-64 age group found high odds, while the ≥ 80 group found significantly lower odds. In summary, retirement has more impact on aerobic PA in general and across the age groups, but the effect is not influential for muscle-strengthening PA. Besides, retirement has different effects on men and women.

The current study used a different definition for meeting the 2008 Guidelines. Therefore, the "meeting aerobic recommendations" variable is more appropriate to make the comparisons to the previous literature since none of the previous studies included muscle-strengthening recommendations in the analysis. Our findings are consistent with the previous literature suggesting that retirees are more likely to meet the aerobic recommendations (Kämpfen & Maurer, 2016; Mein et al., 2005).

PA INTENSITY

The 2017 BRFSS asked about the two most frequent LTPA of people. Overall, retired people were less likely to have MPA, but more likely to have VPA, compared to employed people. Taking age into consideration, age groups under 75 years old among men consistently showed significantly higher odds for retirees to do MPA. However, the huge variability in 75-79, and the lack of participants ≥ 80 classified into moderate intensity could be an explanation for the lower odds in the overall sample. Similar patterns for the moderate intensity are found in women, except that only the 60-64 age group showed a significant result. For the vigorous intensity, even though only the results in the age groups 60-64, 65-69, and 70-74 showed significance, in all age groups, retirees were more likely than those employed to do VPA. In women, significantly higher odds were only found in 60-64 and 65-69, and retirees ≥ 80 have significantly lower odds to do VPA.

Previous literature indicated that retirement was associated with an increase in MVPA or MPA, but had either no or a negative effect on VPA (Brown et al., 2009;

Holstila et al., 2017; Lahti et al., 2011; Stenholm et al., 2016). The inconsistent findings in the current study may be due to the different estimation of the intensity. The previous studies used absolute intensities that corresponded to the reported PA, while the current study used relative intensities that were estimated based on the PA type and respondent's age and gender.

STRENGTHS AND LIMITATIONS

There are several strengths of this study. First, our study used a nationally representative sample from the BRFSS, which is one of the largest databases for tracking health conditions and behaviors. Therefore, given the large sample size, instead of only examining the overall study population, we were able to conduct analyses on multiple age subgroups for both genders. The results that were masked or cancelled out in the total sample can be identified. Additionally, participants in the study range in age from 55 to over 80, which provides information for not only middle-aged or young-old population, but also middle-old and even old-old population. To capture more characteristics of physical activity, our study examined LTPA participation, recommendations/guidelines compliance, and LTPA intensity, which makes it possible to compare the results to different previous studies. Apart from examining aerobic guidelines, the study also examined the muscle-strengthening guidelines which are not analyzed in the previous literature. The LTPA intensity variables in the study are relative intensities. Relative intensity is more favorable for older people rather than using absolute intensity for self-reported LTPA since cardiorespiratory fitness is relatively lower among the older population. In this study, 63% of participants are aged 65 and older, 19.5% are 60-64 years; therefore, relative intensity better represents the real efforts for the LTPA done by the study population.

However, several limitations should be considered for this study. The BRFSS is based on the telephone survey, and all the information is self-reported by respondents. The reliability of the data depends on respondents and interviewers. Recall bias and social desirability bias inevitably affect the quality and reliability of the data. People tend to overestimate physical activity, resulting in some extremely high physical activity volume and intensity. For the questions about chronic diseases and health behaviors, respondents may have the tendency to report the answers that seem more socially acceptable, which mask their real conditions. Additionally, the study only measured LTPA, other domains such as occupational, transport, household PA, and total PA were not taken into account. The majority of the participants were Caucasian (85.7%), which may not cover some of the characteristics of other races or ethnicities.

FUTURE RESEARCH

The cross-sectional design of the study made it impossible to track the behavior change before and after retirement, and we were not able to consider the effects of retirement duration. Future research should consider using a longitudinal design to compare the change of behavior before and after the retirement transition, and consider the duration and the exact time point of the retirement. Second, the influence of retirement on PA should also be further explored on different genders and ages. Third, total PA and domain-specific PA should be measured to represent different aspects of PA patterns. Combining objective measures with subjective measures can provide more details about daily PA. The definition and the measures of retirement are crucial for including and categorizing participants in a study. Previous studies largely depended on self-reporting, and only considered retirement in general. Future studies can use other measures such as the pension data, or occupational PA to indicate the retirement status, and consider different retirement statuses and the reasons for retirement, such as semi-retirement or disability retirement.

CONCLUSION

The purpose of the present study was to examine the association of retirement and LTPA among the middle-aged and older US population with cross-sectional data. The results of the current study indicate that retired men are more likely than employed men, while retired women are less likely than employed women, to participate in physical activity. Retirees have a higher probability of meeting the aerobic recommendations. However, for the muscle-strengthening recommendations, retired men are more likely to meet the recommendations while the retired women are less likely to meet the recommendations, relative to the employed individuals, respectively. Further, results suggest that a lower likelihood of the 2008 Guidelines (both recommendations) compliance is associated with retired women, and no significant association with retired men. Regarding the intensity, retirees are associated with a higher likelihood of practicing VPA and a lower likelihood of practicing MPA, which is probably due to the relative intensity measurement.

The current study suggests that retirement is associated with an increase in LTPA for both genders. Aerobic activities are the major contributor to the LTPA with retirement, whereas muscle-strengthening activities are less influenced by the retirement status, indicating the need for emphasizing and promoting muscle-strengthening activities. The gender differences in the results suggest different preferences and patterns of LTPA between men and women. Future studies should also consider the age and retirement interaction to understand the PA changes among middle-aged and older adults.

Appendix A

Appendix A. Variables List

Variable	Measure	Note
Employment Status	0*= Employed (Not Retired), 1 = Retired	*include: Employed for wages and Self-employed
Age Group (years)	1 = 55-59, 2 = 60-64, 3 = 65-69, 4 = 70-74, 5 = 75-79, 6 = ≥ 80	
Gender	1 = Male, 2 = Female	
Race/Ethnicity	1 = White, 2 = Black, 3 = Asian, 4 = American Indian/Alaskan, 5 = Hispanic, 6 = Other	
Income ($)	1 = ≤ 15,000 2 = 15,000~ < 25,000 3 = 25,000~ < 35,000 4 = 35,000~ < 50,000 5= ≥ 50,000	
Education	1 = Did not graduate High School, 2 = Graduated from High School 3 = Attended College or Technical School 4 = Graduated from College or Technical School	
Marital Status	0*=Not Married, 1=Married,	*include: Divorced, Widowed, Separated, Never married, A member of an unmarried couple
BMI	1 = Underweight 2 = Normal 3 = Overweight 4 = Obese	Underweight (BMI < 18.5) Normal (18.5 ≤ BMI < 25.0) Overweight (25.0 ≤ BMI < 30.0) Obese BMI (BMI ≥ 30.0)
Current Smoking	0 = No, 1 = Yes	
Heavy Alcohol Consumption	0 = No, 1 = Yes	

Chronic Diseases	0 = None, 1 = Yes	Participants will be considered as "Yes" if they have reported one of the following chronic diseases: 1) CHD or MI, 2) High Blood Pressure, 3) Diagnosed with Arthritis, 4) Current Asthma.
Exercise in the Past 30 Days	0 = No, 1 = Yes	
Meeting Aerobic Recommendations	0 = No, 1 = Yes	
Meeting Muscle-Strengthening Recommendations	0 = No, 1 = Yes	
Meet Guidelines	0 = Neither, 1 = Either, 2 = Both	Based on "Aerobic" and "Muscle-strengthening" Recommendations
Intensity for the First Activity	0 = No Moderate or Vigorous Activity, or no Activity 1 = Moderate 2 = Vigorous	
Intensity for the Second Activity	0 = No Moderate or Vigorous Activity, or no Activity 1 = Moderate 2 = Vigorous	

Appendix B

Appendix B. Literature Review: Retirement and Physical Activity

Author	Data Source	Sample	Exposure	Outcome	Main findings
1. LTPA					
1.1 Participation					
Henning et al. (2020)	Swedish HEARTS longitudinal study	1,033 (W = 56.81%) Swedish individuals 60-66 y	Retirement: transition and duration 1-year pre-retirement 1year and 2-year post retirement	Leisure PA engagement trajectory	Leisure PA engagement increased after retirement. Trajectory of leisure PA engagement shows that PA increase from 1- year pre-retirement to the transition and post-retirement years.
Aggio et al. (2019)	British Regional Heart Study: longitudinal prospective cohort study (12, 16, and 20 years follow-ups)	Analysis 1: 5,116 Analysis 2: 5,085 Analysis 3: 5,106 UK men 45-59 y at baseline	Retirement (leaving employment)	LTPA trajectories Analysis 1: Sport participation Analysis 2: Recreational activity Analysis 3: walking	Retirement is associated with increased PA which is largely due to increased sport/exercise participation. Retirement is associated with an increase in sport participation only in those who already play sports but a decrease in those who rarely participate.

					Changes in PA following retirement are specific to the type of PA
Biernat et al. (2019)	Social Diagnosis longitudinal study data (2011, 2013, 2015) in Poland	M = 2,880, W = 2,730	Retirement duration: short term (up to 2 years) and medium term (2-4 years).	Sports or exercise activity (S/EA) participation. Binary variables: 1) Sport Activity 2) Member of Sports Club	Retirement doesn't have an effect for S/EA participation in the short term. Retirement reducing S/EA participation in men in the medium term.
Oshio et al. (2017)	The Longitudinal Survey of Middle-Aged and Older Adults in Japan. 10-year panel survey data (2005-2014)	M = 4,441, W = 4,842 50-59 y in the first wave Participants who had been working continuously and retired during the second and tenth waves.	Retirement	LTPA engagement trajectories <u>Binary variable:</u> MPA or VPA at least 2 days/wk	Retirement immediately promoted LTPA for both genders.
Schönbach et al.	German Socio-	Foreigners and	Transition to retirement	Sports participation	Transition to retirement led to an increase in the sports

(2017)	Economic Panel Study Waves 1994—2005 (10 years before and 10 years after retirement)	immigrants in Germany. (non-migrant persons and persons with migrant background) Individuals were not retired when they entered the panel, but retired at follow-up 55-75 y		<u>Binary variable:</u> Active (participate in sports at least every week) or Inactive	participation of non-migrant persons during post-retirement period. Migration status modified the changes in sports participation: persons with migrant background have less increase in post-retirement sport participation compared with non-migrant persons,
Celidoni et al. (2017)	The SHARE survey from 2004-2012 (1st, 2nd, and 4th waves)	45-85 y	Self-reported being retired from work or employed/self-employed	PA participation <u>Binary variables:</u> 1) No any activity 2) No vigorous activity	The probability of not practicing any activity or vigorous activity decreases significantly after retirement.
Skogen et al. (2016) **Cross-sectiona l**	The population-based Nord-Trøndelag Health Study wave 3 (HUNT3; 2006–2008)	N = 2,197 (W = 46.5%) Mean age = 64.9 y	Retirement Participants were categorized into 8 groups based on the distance in time between age retirement, and 1	The frequency of exercise was assessed. <u>Binary variable:</u> Weekly physical activity (Y/N)	No differences in PA defined by time before or after age retirement were identified.

	The Norwegian national insurance database (FD-trygd)		group was at the retirement transition		
Zhu (2016)	The Household, Income and Labor Dynamics in Australia Survey (2001-2011, first 11 waves)	3,771 Australian women 50-75 y	Retirement status and duration.	Exercise participation. <u>Binary variables:</u> Take physical exercise Regular exercise: At least 3 times/wk	Women are as likely to take physical exercise before and after retirement. Women are 38.9 percentage points more likely to participate in regular exercise after retirement. The effect of retirement duration on exercising follows the same pattern as with retirement status.
Sjösten et al. (2012)	French national gas and electricity company (GAZEL cohort) 2002-2009	Analysis 1: 2,711 (M = 63%) 50-66 y Analysis 2: 3,812 (M = 75%)	Statutory retirement	Analysis 1: LTPA Trajectories from 4 years before to 4 years after retirement. Measurement: (dichotomized) Annual prevalence of higher LTPA (walking ≥ 5km) Analysis 2:	Analysis 1 Higher LTPA increased by 36% in men and 61% in women during the transition to retirement. Analysis 2 The likelihood of sport activities participation and

				Changes in PA pre- to post-retirement Measurement Changes in leisure-time sport activities: engagement, frequency, and manner	frequency increased during post-retirement on both genders. Participants were more likely to engage in group activities than alone.
Koeneman et al. (2012)	The Longitudinal Aging Study Amsterdam (LASA) First wave (1992-93) and second wave (1995-96)	186 Dutch adults (M = 67%) ≥ 55 y	Change in employment status (Participants had a paid job at baseline but did not have a paid job at follow-up, and reported being in full retirement were classified as retired)	Sports participation: binary variable MVPA duration	Retired participants significantly increased the MVPA duration, but not sports participation, compared to participants who continued to be employed.
Evenson et al. (2002)	The U.S. Atherosclerosis Risk in communities Study (ARIC) (baseline: 1986-1989, follow-up: 1993-1995)	1,825 African-American 5,957 White 45-64 y	Retired or working on follow-up.	Sports and exercise participation. Variables: [Binary] PA prevalence (%) Any exercise or sport participation (%) Any vigorous activity (%) Any regular activity (%) Walk during leisure often or very often (%)	Retirement was associated with increase in sports and exercise participation.

				Bike during leisure often or very often (%) [Estimated based on frequency, duration and subjective intensity] Sport scores Leisure scores Sport + leisure scores	
1.2 Guideline Compliance					
King et al. (2017) **Cross-sectiona l**	The National Health and Nutrition Examination survey (NHANES) 2009-2012	Retirees (N = 359), Non-retirees (N = 597) U.S. population 55-70 y	Retirement status	PA level: total minutes on moderate or vigorous recreational PA <u>3 categories:</u> Ideal (Meet aerobic guidelines) Intermediate (Do not meet aerobic guidelines) Poor (None PA)	Retirees were more likely to be physically active than non-retirees (OR: 1.85; 95% CI: 1.11-3.09) after adjusting for age, sex, race, health insurance status, and poverty level. There were no differences on the prevalence for PA level between retirees and non-retirees.
Kämpfe n and Maurer (2016)	The U.S. Health and Retirement Study (HRS) (2004-2010,	13,491 50-80 y	Retirement status: retired and not retired.	Probability of meeting the 2008 Physical Activity Guideline for Americans. Computing the combination of the reported frequency of	Retirement increases the probability of meeting the US governments' 2008 Physical Activity Guidelines for Americans by 20-40 percentage points.

	wave 7-10)			vigorous- and moderate-intensity activities into a single binary indicator measuring guideline compliance.	
Murtagh et al. (2015)	The Irish Longitudinal Study on Ageing (TILDA) Wave 1	4,892 Irish adults (W = 53.4%) ≥ 60 y	Employment status: Employed or Retired	Physical inactivity <u>Binary variable:</u> Inactive (not meeting aerobic guidelines) or Active (meeting or exceeding aerobic guidelines)	Female: Retirement was associated with higher odd of being physical inactivity. Male: Retirement was associated with a lower odd of being physical inactivity.
Mein et al. (2005)	Phase 5 of the Whitehall II longitudinal study	6,224 UK civil servants (M = 4,500; W = 1,724) 45-69 y	Retirement status (Retired or Not retired) and Working status (≥30 or < 30 h/wk)	Meet PA recommendations (% and Odds ratio) Different types of MVPA (mins/wk)	Retirement is associated with higher rates of meeting PA recommendations for both genders. The benefit is most evident among those who work part time, or not at all, during their retirement. Retirement and lower working hours have additive effect on rates of PA.
1.3 Intensity/FrequencyDuration					

Kats et al. (2020)	The U.S. Atherosclerosis Risk in Communities (ARIC) Study	African American and White adults (M = 3,224, W = 4,371) 45-75 y	Retirement status across 5-years age groups: Retired and Not retired	Mean differences in the average weekly LTPA: Intensity (MET) Duration (hours)	Difference in intensity and duration were observed across sex, but not race. Retirement is associated with greater engagement in PA among older adults. Retired men engaged in 2.5 (0.2-4.8) more h/week of LTPA on average compared to men who remained employed at ages 70-75. Retired women reported 1.5 (0.3, 2.7) more weekly MET compared to women who remained employed at ages 70-75.
Holstila et al. (2017)	Helsinki Health Study cohort data (2000-2012, phase 1, 2, 3)	2,902 (W = 79.6%) 50+ y	Retirement status: 1) continuously employed 2) retired between phase 1 and 2 3) retired between phase 2 and 3	Time (min/wk) spent in moderate to vigorous LTPA (including commuting). Variables: PA min/wk (mean; SD) % of Low activity: < 14 MET-hours/week	The transition to retirement was associated with immediate increase in LTPA, which nevertheless diminished during post-retirement years.
Syse et al. (2017)	The Norwegian study on Life	Gainfully employed individuals	Retirement status	Sport/LTPA: At least weekly or Less than weekly	Retirees were more likely to increase outdoor PA (OR: 2.01; 95% CI: 1.16-3.47)

	course, Ageing and Generation (NorLAG)	57-66 y at baseline			compared with workers.
Stenholm et al. (2016)	Finnish Public Sector study (2000/2002, 2004/2005, 2008/2009, 2012/2013)	9,488 (W = 80%)	Retirement type based on the pension data.	Weekly hours of LTPA (including commuting). <u>Variables:</u> Total weekly PA (MET-hrs.) Moderate PA (h/wk) Vigorous PA (h/wk) % of physically inactive	Retirement increased MPA during 4 years transition, but decreased during the subsequent post-retirement period. Older retirement age, higher occupational status, and fewer chronic disease were associated with greater increase in PA among transition.
Lahti et al. (2011)	Helsinki Health Study questionnaire surveys (baseline: 2000, 2001, and 2002; Follow-up: 2007)	Employees of the City of Helsinki who reached the ages of 40, 45, 50, 55 and 60 years during 2000, 2001, and 2002	Employment status	Moderate- or vigorous LTPA: 1) Time spent (min/week) 2) change in time spent for total MVPA, MPA &VPA	Transition to old-age retirement (> 60y) was associated with an increase in moderate-intensity LTPA, and a decrease in the proportion of inactivity. There were no changes in vigorous activity.

		M = 1253; W = 5,453			
Brown et al. (2009)	The Australian Longitudinal Study on Women's Health (ALSWH) Baseline: 2001 (T1) Follow-up: 2004 (T2)	Mid-age (N = 8,762): 45-50 y	Retirement status (Yes/No)	Moderate- or vigorous intensity LTPA categorized into: None, low, or active PA pattern based on PA at T1 & T2: None at both time Low at both time Decreasing (Move from higher PA category to lower PA category) Increasing (Move from lower PA category to higher PA category)	Retirement was associated with higher odds of increasing PA over a 3-year period (2001-2004).
2. Domain-specific PA					
Jones et al. (2018)	The U.S. Multi-Ethnic Study of Atherosclerosis (MESA) (2000-2012)	4, 091 Average aged 57 y at baseline.	Employment status.	Overall MVPA and domain-specific PA and TV watching. Variables: MVPA (MET-min/wk) Non-walking leisure PA (min/wk) Recreation walking (min/wk)	Retirement was associated with a 10% decrease in MVPA and a 48% decrease in occupational/volunteer MVPA. Retirement was associated with an increase of 9% in non-walking, 13% in recreational walking, 29% in

				Transport walking (min/wk) Household/yard (min/wk) Caregiving (min/wk) Occupational/volunteer MVPA (MET-min/wk) TV watching (h/wk)	household/yard activity.
Van Dyck et al. (2016)	Ghent, Flanders, Belgium (baseline: 2012/2013, follow-up: 2014/2015)	446 (M = 52.6%) 62.4 (2.2) y at baseline	Retirement status: 1) retired at baseline 2) retiring during follow-up	PA (min/wk). Variables: Transport: walking Transport: cycling Garden: MVPA Household: moderate PA Voluntary/work-related: walking Voluntary/work-related: MVPA leisure-time: walking leisure-time: cycling leisure-time: MVPA	Leisure time cycling increased in retiring people, but decreased in retired people. Work-related walking and MV PA decreased in retiring people, while slightly increased in retired people.
Menai et al. (2014)	''Supple´ment ation en VItamines et Mine´raux AntioXydants '' (SU.VI.MAX) cohort. Baseline:	2,841 participants (M = 1,453, W = 1,388) 45 years or older	Retirement status Not retired in 2001 and 2007 Retirement between 2001 and 2007 Retired in 2001 and 2007	PA (h/wk) at baseline and changes during follow-up: Total LTPA Moderate LTPA Vigorous LTPA Walking Gardening Swimming	Participants who retired between 2001 and 2007 had the greatest increase in time spent in LTPA (except for swimming and biking) than the other groups. Participants who not retired in 2001 and 2007 had a higher increase in total and

	2001 Follow-up:2007			Biking Occupational Domestic	moderate LTPA, compared to participants retired in 2001 and 2007.
Barnett et al. (2014)	EPIC (European Prospective Investigation into Cancer)-Norfolk cohort Baseline: 1997-2000 Follow-up: 2006-07	3,334 participants (W = 52%) 45-79 y	Retirement status (complete withdrawal from work)	PA (MET h/wk) Total PA Recreational PA Household PA Transport PA Occupational PA	Retirement was associated with a decrease in total PA and occupational PA. From baseline to follow-up, a mean decrease in overall, transport and occupational PA were shown in all subgroups. The observed decline was greater for retirees than those who remained employed. From baseline to follow-up, a mean increase in recreational and household PA were shown in all subgroups, with consistently greater increases among retirees.
Touvier et al. (2010)	France SU.VI.MAX study (1998-2001)	M = 698 W = 691 45-64 y	Retired or continued to work between 1998-2001.	LTPA & occupational PA. Variables: LTPA: Duration (h/wk) & Score (MET-h/wk) Occupational PA:	LTPA increased among those who had retired, while no change in employed persons

				Duration (h/wk) &Score (MET-h/wk) LTPA by intensity (h/wk) Low (< 3 METs) Moderate (3-6 METs) Vigorous (> 6 METs) Leisure-time walking (h/wk) Ranking of the five most frequently LTPA	
Slingerland et al. (2007)	The GLOBE Study Baseline: 1991 Follow-up: 2004	N = 971 40-65 y and employed at baseline	Employment status at follow-up (employed or retired)	PA (h/wk) Work-related transportation Sports participation Non-sports LTPA	Retirement was associated with higher odds (OR:3.03; 95% CI: 1.97, 4.65) for a decline in work-related transportation PA. Retirement was associated with lower odds for a decline in non-sports LTPA (OR:0.36; 95%CI: 0.19,0.68). But retirement was not associated with an increase in sports participation or non-sports LTPA. Retirement results in a reduction in total PA.
3. Total PA					

Richards et al. (2019)	The Americans' Changing Lives (ACL) survey longitudinal panel study	N = 3,617 (W = 62%) Mean age = 54 y	Change in employment status Becoming retired Involuntarily losing a job within the past 3 years	Three questions were used to measured overall PA: frequency of active sports or exercise, frequency of walking, and frequency of working in garden and yard. Each question had 4 response: often, sometimes, rarely, and never, with higher values indicating more frequent PA.	Overall, retired was associated with greater PA at baseline, while as participants aged, entering into retirement was associated with decreased PA.
Tan et al. (2017)	The Well-being of the Singapore Elderly (WiSE) cross-sectional survey study	N = 2,565 Singapore residents ≥ 60 y	Employment status Paid (part-time or full-time) workers Unemployed Homemakers Retirees	PA level was assessed through a single question that includes both work and leisure PA. Participants were categorized into being physically active or not being physically active.	Retirees had significantly lower levels of PA, compared to those working full-time.
Feng et al. (2016)	The US Health and Retirement Survey (HRS)	N = 5,754 (24,224 person-years) 50-70 y	Transition out of full-time employment. Participants mentioned being retired, who were not employed and	The frequency of light, moderate, and vigorous PA. <u>Binary variables for each measure:</u> 2 times/wk Fewer than 2 times/wk	Individuals who were transition to fully retired were the least active on all intensity PA regardless of intensity at baseline, compared with people who worked full-time.

			not looking for work were defined as fully retired. Participants mentioned being retired, who had part-time job along with were defined as semi-retired.		From baseline to follow-up, transition to fully retirement was associated with an increase in PA regardless of intensity, compared with people who worked full-time.
Ding et al. (2016)	The Social, Economic, and Environmental Factor study (SEEF)	N = 27,257 Participants were recruited from the state of New South Wales, Australia ≥ 45 y	Retirement status Retired: completely retired/pensioner; or not in paid work, self-employed or unemployed.	Total time spent on walking and m-v PA (in bouts of ≥10 mins) in the past week. Participants will be considered as being insufficient PA if < 150 min/wk of MVPA. Binary variable: Insufficient PA (Y/N)	Retirement was associated with lower odds of insufficient PA., compared with individuals who remain working.
Najdi et al. (2011) **Cross-sectional**	A national cross-sectional survey in Morocco.	N = 2,613 (W = 48.1%) Mean age = 41.4 y	Employment status: Employed, Retired, Unemployed, Student.	IPAQ short form PA was categorized into low, moderate, high level based on the estimated total PA energy expenditure.	Retirement was associated with higher odds of low PA, compared with people who remain employed.

Chung et al. (2009)	The Health and Retirement Study (HRS) Data: 1996-2002 (Waves 3-6)	N = 11,469 (W = 52.9%) Mean age = 60.3 y	Working status (dichotomized): retired or working Retired included those who were currently not working for pay and defined themselves as retired. Reversible retirement status	Regular physical activity was the primary outcome. PA was assessed by asking whether participants have participated in vigorous PA or exercise at least 3 times/week on average over the past 12 months.	Overall, the prevalence of retired people participate in regular PA was less than those still working. PA decreased with retirement from a physically demanding job, while increased with retirement from a sedentary job. Wealth level was interacted with occupation type, leading to different impact for the retirement on PA.
Nekuda (2009)	The Health and Retirement Study (HRS) Baseline (T1): 1998 Follow-up (T2): 2000	N = 5,351 (W = 48.3%) Mean age = 59 y All participants were employed at baseline.	Retirement status (whether they were still in the workforce at follow-up)	VPA (activities from all domains at least 3 times per week over the last 12 months	No significance difference for VPA participation between T1 and T2 for entire sample and for those who had retired between T1 and T2. No relationship between retirement status and participation in VPA. Greater pre-retirement VPA was significantly related to participation in VPA.

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