Trends in muscle-strengthening exercise among a nationally representative sample of U.S. adults between 2011 and 2017

ABSTRACT

Background: Muscle-strengthening exercise (MSE) is a component of the World Health Organization's '2010 Global Recommendations on Physical Activity for Health'. However, its participation trends are seldom examined in physical activity surveillance. This study describes the trends in prevalence and correlates of MSE among a large sample of U.S. adults. *Methods*: Data were analysed from the 2011, 2013, 2015 and 2017 U.S. Behavioral Risk Factor Surveillance System surveys. Self-reported MSE participation was assessed using the same validated survey item. Population-weighted proportions were calculated for: (i) 'insufficient' (0-1 time/week), or (iii) 'sufficient MSE' (≥2 times/week). Prevalence ratios of those reporting sufficient MSE across sociodemographic characteristics were calculated using multivariate Poisson regression. *Results*: Data were available for 1,735,626 participants (≥18 years). Over the 7-year monitoring period, the prevalence of sufficient muscle-strengthening exercise showed a small (1.2%) but statistically significant increase. (2011=29.1%; 2013=29.4%; 2015= 30.2%; 2017=30.3%,$p<0.001$ for linear trend). Consistently older adults, females, those with lower education/income were less likely to report sufficient MSE, compared to their counterparts. *Conclusions*: Between 2011-2017, between 70.9% and 69.7% of U.S. adults did not meet the MSE guidelines. Consistently low participation in MSE highlights the need to provide support for the uptake/adherence of this health behavior at the population level.

Keywords: strength training; exercise; epidemiology, public health

Introduction

Strong epidemiological evidence shows that regular physical activity reduces the risk of all-cause and chronic disease-specific mortality and multiple chronic health conditions, such as cardiovascular disease, diabetes and breast/colon cancer.[1,2] Since the mid-1970's and until recently, physical activity guidelines for public health were exclusively based on promoting moderate-to-vigorous intensity aerobic activity (e.g. walking, jogging, cycling). However, over the last decade, muscle-strengthening exercise (weight/strength training) has since been incorporated into public health guidelines.[3]

Muscle-strengthening exercise was first included in the '*2008 Physical Activity Guidelines for Americans*', [4] and was subsequently adopted in the World Health Organization's (WHO) '*2010 Global Recommendations on Physical Activity for Health*', [5] The WHO guidelines state that adults ≥18 years should "*two or more days per week of muscle strengthening activity involving major muscle groups*".[5] The addition of muscle-strengthening exercise into physical activity guidelines is due to the strong clinical and epidemiological evidence showing that this activity has multiple independent health benefits. In brief, meta-analyses of short duration (typically 6-12 weeks) clinical exercise studies have shown multiple health outcomes including increased skeletal muscle mass/strength, [6], bone mineral density,[7] enhanced ability to perform activities of daily living [8] and improved cardiometabolic health.[9] Importantly, in many of these studies, the benefits of muscle-strengthening exercise occur either independent of, or are more effective than participation in moderate-to-vigorous intensity aerobic activity alone. A recent meta-analysis of 11 prospective cohort studies showed that compared with no exercise, muscle-strengthening exercise was independently associated with 21% lower risk of all-cause mortality.[10]

Despite its multiple health benefits, physical activity surveillance rarely assess population-level trends in muscle-strengthening exercise participation. [11] In the U.S., for example, prevalence estimates from population studies conducted between 2004-2017, show that between 6·0%-30·2% of adults (≥18 years) meet muscle-strengthening exercise guidelines (≥2 times/week).[12-15] However, data on the trends over time of muscle-strengthening exercise levels are limited. One study, analysing the U.S. National Health Interview Survey (NHIS), showed that between 1998 and 2008, the proportion of adults meeting muscle-strengthening exercise guidelines increased from 17·7% to 21·9%.[16] More recently, a technical report from the U.S. '*Healthy People 2020 Midcourse Review*' showed that between 2008 and 2014, the prevalence of those meeting muscle-strengthening exercise guidelines increased from 21·9% to 24·4%.[17]

To our knowledge, no studies since then have assessed the more recent trends in muscle-strengthening exercise among U.S. adults. Furthermore, there has been limited examination of trends in muscle-strengthening exercise across multiple population sub-groups based on socio-demographics (e.g. age, education level, income, employment status) and U.S. census regions. Importantly, from a public health perspective, existing studies on trends of muscle-strengthening exercise does not typically conduct a multivariate adjusted analysis.[17,18] The development of relevant public health interventions and policies requires regular assessment of physical activity-related behaviors to monitor trends over time and determining the most at-risk populations.[19]

The primary aim of this study, therefore, is to describe the trends in prevalence in muscle-strengthening exercise among a large sample of U.S. adults between 2011 and 2017. The

secondary aim is to describe how trends vary between sociodemographic factors and by U.S. census region.

Methods

We analysed data from the 2011, 2013, 2015 and 2017 U.S. Behavioral Risk Factor Surveillance System (BRFSS) surveys.[1] Initiated in 1984, the BRFSS collects state-specific data on health risk behaviors that are pertinent to public health among an U.S. adult population.[1] Since assessments of muscle-strengthening exercise have only been included since 2011 BRFSS, we analysed data from the 2011 BRFSS across four survey time points until the most recently publically available data in 2017. A description of the background and methodology utilized in the BRFSS is available elsewhere.[1] In brief, the BFRSS collects data from the health departments of all 50 U.S. states and each BRFSS survey was approved by the National Center for Health Statistics Research Ethics Review Board.[1] The median response rate was 49·7%, 45·9%, 47·2% and 45·9%, for the 2011, 2013, 2015 and 2017 telephone interview surveys, respectively.[1]

For the present analysis, participants were excluded if data were missing for muscle-strengthening exercise (n=308,172; 15·5% of the total sample). Consistent with our previous study, [14] to enhance generalizability, we did not use any other exclusion criteria. Furthermore, since the WHO physical activity guidelines recommend muscle-strengthening exercise on two or more days per week for both adults (aged 18-64 years) and older adults (aged ≥65 years),[5] we included adults aged ≥18 years in our analysis.

Detailed information on the physical activity survey items used in the BRFSS is available elsewhere.[20] To assess muscle-strengthening exercise levels, respondents were asked:

"*During the past month, how many times per week or per month did you do physical activities or exercises 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*". These survey items have shown evidence of reliability (Cohen's *k*= 0.85–0.92) and convergent validity (using the ≥2 times/week threshold against all-cause mortality).[10]

Respondents were given the option of reporting their muscle-strengthening exercise frequency as either: [i] 'times per week' or [ii] 'times per month'. Consistent with previous studies,[14,15] for those reporting times per month, this number was divided by four to provide estimates for weekly frequency. As with our previous study,[14] to limit the possibility of unrealistic responses, weekly frequency of muscle-strengthening exercise was truncated at 14 times/week (<1·0% of the sample). These MSE data were reduced in two ways. First, MSE levels were classified into five categories as: [i] 0; [ii] 1; [iii] 2; [iv] 3; and [v] ≥4 times/week. Second, according to the WHO guidelines,[5] the sample was dichotomised as: [i] 'sufficient muscle-strengthening exercise' (≥2 times/week); or [ii] 'insufficient muscle-strengthening exercise' (0-1 times/week).

Sociodemographic characteristics (sex, age, education level, employment status, and income categories) were assessed using standard questions. These sociodemographic characteristics were chosen due to their established association with muscle-strengthening exercise.[12-14] Each sociodemographic characteristic sub-category is consistent with both standardized BRFSS reporting,[1] and previous studies reporting on BRFSS muscle-strengthening exercise.[14,15]

To examine how muscle-strengthening exercise is patterned among the U.S. population at the geographical level, we stratified the sample according to U.S. Census Bureau regions.[21] Using a standardized approach,[21] four regions were defined as: [i] Midwest: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; [ii] Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; [iii] South: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia; and [iv] West: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

All analyses were conducted with the Complex Samples module of SPSS version 22 (SPSS Inc. an IBM Company, Chicago, IL). In the analysis for the primary aim, weighting factors to correct for non-response, stratification and clustering were implemented to enhance population representativeness.[1]

To examine the primary aim, for the individual 2011, 2103, 2015 and 2017 samples, weighted prevalence levels (in percentage) and their 95% confidence intervals (95% CI) were calculated for weekly muscle-strengthening exercise frequency, first for five categories: [i] 0; [ii] 1; [iii] 2; [iv] 3; and [v] ≥4 times/week, and second for two categories: [i] 'insufficient' (0-1 times/week); and [iii] 'sufficient muscle-strengthening exercise' (≥2 times/week). In addition, the prevalence levels of those reporting sufficient muscle-strengthening exercise for each individual sample are presented across sociodemographic characteristics and by U.S. Census regions. Trends in prevalence of reporting sufficient muscle-strengthening exercise (dependant) over time (independent) were assessed using linear regression analysis. A p-value of <0.05 was used to indicate statistical significance.

To examine the secondary aim, a series of multivariate analyses were performed separately for the 2011, 2013, 2015 and 2017 BRFFS samples. In these analyses, Poisson regression with a robust error variance was applied to calculate prevalence ratios (PR). In cross-sectional epidemiological studies, providing prevalence ratios derived from Poisson regression is considered a more statistically robust method than the generally used logistic regression.[22] In each model, the associations of reporting/not reporting 'sufficient muscle-strengthening exercise' (≥2 times/week: 'yes' vs 'no') with sociodemographic characteristics and U.S. Census region (explanatory variables) were assessed. To adjust for yearly variations, year of study was included as a covariate.

Results

The weighted sample characteristics for each year sample are shown in Supplementary Table 1. Overall, between 2011 and 2017, the mean yearly sample size was 433,907 (range: 393,746-477,663). In brief, over half were aged ≥45 years, just under half earned ≥$50,000/year and over one quarter had graduated from college.

<<Insert figure 1 >>

Figure 1 shows the weighted percentages for MSE for the 2011, 2013, 2015 and 2017 samples. Over the study period, the prevalence decreased among those reporting no muscle-strengthening exercise (2011 = 59.0% vs. 2017 = 57.7%). In contrast, the prevalence increased among those doing muscle-strengthening exercise ≥4 times/week (2011 = 11.9% vs. 2017 = 13.4%). However, across the remaining muscle-strengthening exercise frequencies, the prevalence levels remained stable across each survey (Figure 1).

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Overall, the proportions reporting sufficient muscle-strengthening exercise (≥ 2 times/week) showed a small (1.2%) but significant increased linear trend over time (p <0.001), with 29·1% (95% CI 28·8-29·4), 29·4% (95% CI 29·1-29·7), 30·2% (95% CI 29·9-30·5) and 30·3% (95% CI 30·0-30·6), for 2011, 2013, 2015 and 2017 BFRSS, respectively (Table 1). Significant linear trends were observed across most sociodemographic characteristics and all U.S. Census regions (p <0.001, for most comparisons). However, across specific population sub-groups, there were some patterns observed. First, in 2015, the prevalence of those meeting the MSE guideline peaked among students and those aged 18-24, but declined in 2017. Second, between 2011 and 2017, MSE guideline adherence declined among the lowest income group (< $15,000).

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Table 2 shows the results of the multivariate adjusted analyses of individual BRFSS surveys. Generally, across sociodemographic characteristics and U.S. Census regions, the adjusted prevalence ratios (APR) APRs were similar for all time points. The lowest APRs were among those who were 'unable to work' (APR range: 0·40-0·44). Compared to males, females were less likely to report sufficient muscle-strengthening exercise. Across each individual survey, APRs decreased with age, but increased with income and education level. When compared to students, all other employment categories were less likely to report sufficient muscle-strengthening exercise. When compared to those living in the West U.S. Census region,

according to the 2017 analysis, those living in the South, Midwest and Northeast regions were less likely to report sufficient muscle-strengthening exercise (APR range: 0·80-0·93).

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Discussion

Among a sample of almost 1·8 million U.S adults, between 2011 and 2017, ~70% did not meet the muscle-strengthening exercise guideline. The persistently low recent population prevalence levels, in combination with established independent multiple health benefits associated with this behaviour,[2,6-9] emphasize the need for public health action to support the uptake and adherence of muscle-strengthening exercise among U.S. adults.

The finding that muscle-strengthening exercise levels were low, but appeared to increase slightly from 29·1% in 2011 to 30·3% in 2017 is consistent with previous studies.[16,17] For example, data from the U.S. NHIS showed that the proportion of American adults meeting muscle-strengthening exercise guidelines increased from 17·7% in 1998 to 21·9% in 2008.[16] However, we urge caution when interpreting these trends as increasing from 21·9% (NHIS) in 2008 to 30·3% in 2017 (BRFSS). These variances in muscle-strengthening exercise prevalence estimates between the BRFSS and NHIS samples are likely due to a combination of factors. Including differences in: [i] data collection methods (e.g. telephone vs. face-to-face interviews); [ii] survey items (e.g. the use of different terminology to define muscle-strengthening exercise); and [iii] sample sizes (e.g. samples of the individual waves of the BRFSS being ~5 fold greater than those from the NHIS).

The marginal increases in meeting the muscle-strengthening exercise guideline (≥2 times/week) observed in the present study are likely to be due to increasing numbers engaging in high levels of this exercise mode. As shown in Figure 1, the prevalence of those reporting the highest muscle-strengthening exercise frequency (≥ 4 times/week) increased by 1.4% from 2011 to 2017. Due to the study design, we are unable to determine the cause(s) of this observation. However, this may be due to the increase in popularity in muscle-strengthening exercise-related fitness trends, such as training with free-weights, body weight training and functional fitness training. [23] Nonetheless, we emphasize that across studies, 70-80% of U.S. adults were not meeting the muscle-strengthening exercise guidelines over the last decades. Notably, compared to the proportion of the pooled BRFSS sample reporting no self-reported moderate-to-vigorous intensity aerobic activity (~30%),[1] almost double reported no muscle-strengthening exercise (~60%).

The key sociodemographic correlates of muscle-strengthening exercise guideline adherence identified in the present study are generally consistent with previous research. Studies from the U.S., [12-14], Australia, [11,24] and U.K.,[25] have also shown that population sub-groups least likely to meet the muscle-strengthening exercise guidelines include females, older adults, and those with low income and education levels. These consistent cross-country findings underscore the importance of establishing the barriers and enablers to muscle-strengthening exercise among these population sub-groups, both within the U.S. and globally. The patterns of muscle-strengthening exercise by U.S. census region showed that compared to those in the West region, populations within the Midwest, South and Northeast regions are less likely to report sufficient muscle-strengthening exercise.

The low prevalence of muscle-strengthening exercise presented in this study suggests that this behaviour warrants immediate public health action. However, compared to aerobic

activity, muscle-strengthening exercise has been of limited focus in public health approaches to chronic disease prevention.[25] This may be due to, first, muscle-strengthening exercise having been a component of the physical activity guidelines only within the last decade, and second, the process in getting large proportions of the population to become engaged in this behaviour is likely to be more challenging than moderate-to-vigorous intensity aerobic activity.[26,27] Synchronized and multilevel health promotion strategies are required to increase population-level muscle-strengthening exercise engagement. Potential future concurrent approaches may include providing physical environmental support (e.g. equipment in open spaces and subsidised community health centre memberships), providing equipment (e.g. resistance bands) to promote this activity in the multiple settings (e.g. home/workplace/community), subsidising access to exercise professionals who have capacity to safely instruct those with no previous experience (e.g. strength and conditioning professionals/fitness trainers), and using mass media campaigns to promote this physical activity mode.

Insights may be gained from developing a better understanding of the key factors influencing muscle-strengthening exercise among populations who have high prevalence levels. An example from the present study is that, across BFRSS surveys, student populations regularly had the highest muscle-strengthening exercise prevalence levels. While our study design limits the ability to accurately establish the temporal relationship, these data suggest that once student populations transition into employment, their muscle-strengthening exercise levels subsequently decline. Understanding the key individual (e.g. time allocation, motivation, cost), social (peer support/social modelling), and physical environmental factors (access to facilities/equipment) that cause declines in muscle-strengthening exercise during major events across the lifespan will provide unique insights into the key determinants of this

behaviour. While much research has focused on the tracking of aerobic physical activity though the lifespan, [28] comparative research on muscle-strengthening exercise is non-existent. A lifespan approach to muscle-strengthening exercise is particularly important considering that age-related declines in muscle mass/muscle function are predicted to be among the key 21st century public health challenges.[29,30]

A strength of this study includes the recruitment of large representative samples of U.S. adults. In addition, the use of standardized data collection processes ensure that our results can be compared with findings from future waves of the BRFSS. The analysis of several public surveillance data sets is also a strength, and we are not aware of any epidemiological study on muscle-strengthening exercise with a comparable sample size.

Limitations are also recognized. Foremost is the use of self-report assessments of muscle-strengthening exercise. This assessment method may have resulted in recall bias issues, such as social desirability and over and/or under reporting. However, at present, unlike aerobic physical activity, there is no accepted device-based method (e.g. accelerometery) to assess muscle-strengthening exercise. Consequently, muscle-strengthening exercise is routinely assessed by self-report in public health surveillance.[14] A further limitation was the use of a single self-report item assessing weekly/monthly frequency only, and not the 'intensity' or 'type' of muscle-strengthening exercise. Last, given that 15.5% of the BRFSS sample did not report on their muscle-strengthening exercise levels, our prevalence estimates should be viewed with caution. It is probable that non-responders to the muscle-strengthening exercise item are the most physically inactive. Which, in turn, despite the data being weighted for non-response, is likely to affect prevalence estimates in ways that are not straightforward to

predict. Consequently, the muscle-strengthening exercise prevalence estimates presented here are likely to be conservative.

Conclusion

Among nearly 1·8 million American adults, between 2011 and 2017, ~70% do not report sufficient muscle-strengthening exercise. Consistently low muscle-strengthening exercise levels accentuate the need for public health action to support the uptake/adherence of this important health behavior at the population level. U.S. populations most at-risk of not engaging in sufficient muscle-strengthening exercise include older adults, females, those with low income/education levels, and living in the Midwest and Northeast regions. There was a time trend for the prevalence of reporting sufficient muscle-strengthening exercise to steadily increase between 2011 and 2017.

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Table 1: Proportions (weighted[a]) reporting sufficient muscle strengthening exercise (≥2 times/week) among Behavioral Risk Factor Surveillance System respondents (2011-17): by sociodemographic characteristics and U.S. Census region[b].

	Sufficient muscle-strengthening exercise (≥ 2 times/week)				
	2011	**2013**	**2015**	**2017**	***trend p*[c]**
	%[a] (95% CI)	**%[a] (95% CI)**	**%[a] (95% CI)**	**%[a] (95% CI)**	
Total	29.1 (28.8-29.4)	29.4 (29.1-29.7)	30.2 (29.9-30.5)	30.3 (30.0-30.6)	*<0.001*
Sex					
Male	34.2 (33.8-34.7)	34.6 (34.1-35.0)	34.8 (34.4-35.3)	34.4 (34.0-34.9)	*<0.001*
Female	24.3 (23.9-24.6)	24.5 (24.1-24.8)	25.8 (25.5-26.2)	26.4 (25.9-26.8)	*<0.001*
Age					
18-24	43.8 (42.7-45.0)	46.2 (45.1-47.2)	46.3 (45.2-47.4)	45.3 (44.2-46.5)	*<0.001*
25-34	34.3 (33.5-35.1)	35.0 (34.3-35.8)	36.8 (36.0-35.1)	36.9 (36.0-37.7)	*<0.001*
35-44	29.1 (28.4-29.8)	29.3 (28.6-30.0)	29.1 (28.4-29.8)	30.8 (30.0-31.7)	*<0.001*
45-54	25.9 (25.4-26.5)	25.9 (25.4-26.5)	26.6 (25.9-27.2)	26.6 (25.9-27.3)	*<0.001*
55-64	23.7 (23.2-24.2)	23.7 (23.2-24.3)	23.8 (23.3-24.4)	24.1 (23.5-24.7)	*<0.001*
65-74	23.0 (22.4-23.5)	22.9 (22.3-23.5)	24.3 (23.7-24.9)	24.8 (24.1-25.5)	*<0.001*
≥75	19.8 (19.2-20.3)	19.8 (19.2-20.4)	21.0 (20.3-21.8)	21.4 (20.6-22.2)	*<0.001*
Education level[b]					
Not graduate High School	19.7 (18.8-20.5)	18.9 (18.0-19.7)	19.9 (19.0-20.9)	18.3 (17.4-19.3)	*0.600*
Graduated High School	25.0 (24.5-25.5)	25.5 (25.0-30.0)	25.8 (25.3-26.3)	26.0 (25.4-26.6)	*0.010*
Attended College	31.6 (31.0-32.1)	31.7 (31.2-32.2)	32.1 (31.5-32.6)	32.2 (31.6-32.8)	*<0.001*
Graduated College	36.4 (35.9-36.8)	36.7 (36.3-37.2)	37.7 (37.3-38.2)	37.9 (37.4-38.4)	*<0.001*
Employment status					
Student	45.2 (43.5-46.9)	47.4 (45.7-49.0)	48.3 (46.6-49.9)	45.9 (44.2-47.7)	*<0.001*
Employed	31.2 (30.8-31.6)	31.7 (31.3-32.0)	32.8 (32.4-33.2)	33.2 (32.7-36.6)	*<0.001*
Unemployed	29.5 (28.5-30.6)	29.3 (28.1-30.4)	28.2 (26.9-29.5)	26.7 (25.4-28.0)	*0.170*
Homemaker	22.1 (21.3-23.0)	22.0 (21.0-23.0)	22.5 (21.5-23.5)	22.1 (20.9-23.4)	*0.014*
Retired	23.5 (23.0-23.9)	23.3 (22.8-23.8)	24.4 (23.9-24.9)	24.6 (24.1-25.2)	*<0.001*
Unable to work	17.7 (16.8-18.6)	17.6 (16.8-18.5)	18.0 (17.1-18.9)	18.4 (17.5-19.4)	*0.013*
Income categories[b]					
<$15,000	23.1 (22.2-24.0)	23.3 (21.5-23.1)	21.7 (20.8-22.6)	21.7 (20.7-22.7)	*<0.001*
$15,000-$24,999	24.0 (23.3-24.7)	24.7 (24.0-25.4)	24.6 (23.8-25.4)	25.0 (24.2-25.9)	*<0.001*
$25,000-$34,999	26.6 (25.7-27.4)	26.1 (25.2-27.0)	27.4 (26.4-28.4)	25.9 (24.9-27.0)	*<0.001*
$35,000-$44,999	27.8 (27.0-28.5)	29.4 (28.6-30.2)	29.9 (29.0-30.7)	29.5 (28.6-30.4)	*<0.001*
≥$50,000	34.8 (34.3-35.2)	34..9 (34.4-35.4)	35.7 (35.2-36.1)	35.6 (35.1-36.1)	*<0.001*
U.S. Census region[b]					
Midwest	28.8 (28.2-29.4)	28.6 (28.0-29.1)	29.7 (29.1-30.3)	29.6 (29.1-30.2)	*<0.001*
South	29.7 (29.1-30.3)	30.1 (29.6-30.7)	30.3 (29.7-30.9)	30.5 (29.9-31.2)	*<0.001*
Northeast	27.9 (27.4-28.4)	28.1 (27.6-28.6)	27.9 (27.4-28.4)	29.2 (28.7-29.8)	*<0.001*

West	32.0 (31.4-32.6)	32.8 (32.1-33.6)	32.0 (32.4-33.1)	33.5 (32.7-34.3)	*<0.001*

[a] Data weighted using stratum weight provided by the Centers for Disease Control and Prevention (CDC) [31]. [b] U.S. Census Bureau regions are defined as Midwest: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; South: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia; West: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.
[c] p-value for linear regression analysis of the proportion over time (2011 to 2017).

Table 2: Adjusted[a] prevalence ratios[b] (APR) and 95% confidence intervals for reporting sufficient muscle-strengthening exercise (≥ 2 times/week) for the 2011, 2013, 2015 and 2017 Behavioral Risk Factor Surveillance System samples.

	Sufficient muscle-strengthening exercise (≥ 2 times/week)			
	2011 (n=474,463)	**2013** (n= 448,075)	**2015** (n=393,746)	**2017** (n=405,212)
	APR[a] (95% CI)	**APR[a] (95% CI)**	**APR[a] (95% CI)**	**APR[a] (95% CI)**
Sex (ref: male)				
Female	0.80 (0.79-0.81)	0.78 (0.77-0.79)	0.82 (0.81-0.83)	0.81 (0.80-0.82)
Age (ref:18-24 years)				
25-34	0.76 (0.73-0.78)	0.77 (0.75-0.79)	0.77 (0.75-0.80)	0.79 (0.77-0.82)
35-44	0.68 (0.66-0.70)	0.65 (0.63-0.66)	0.65 (0.63-0.67)	0.66 (0.65-0.68)
45-54	0.61 (0.59-0.63)	0.58 (0.56-0.59)	0.58 (0.56-0.60)	0.58 (0.57-0.60)
55-64	0.57 (0.55-0.58)	0.53 (0.51-0.54)	0.53 (0.52-0.55)	0.53 (0.52-0.55)
65-74	0.55 (0.53-0.56)	0.52 (0.50-0.53)	0.54 (0.52-0.55)	0.54 (0.53-0.56)
>75	0.47 (0.46-0.48)	0.45 (0.44-0.47)	0.47 (0.46-0.49)	0.49 (0.48-0.50)
Education level (ref: Graduated College)				
Attended College	0.77 (0.76-0.78)	0.78 (0.77-0.79)	0.78 (0.77-0.80)	0.77 (0.76-0.78)
Graduated High School	0.58 (0.57-0.59)	0.60 (0.59-0.61)	0.60 (0.59-0.62)	0.61 (0.60-0.62)
Not graduate High School	0.47 (0.45-0.48)	0.47 (0.45-0.48)	0.48 (0.46-0.49)	0.45 (0.44-0.47)
Employment status (ref: Student)				
Employed	0.70 (0.68-0.73)	0.67 (0.65-0.69)	0.66 (0.64-0.68)	0.67 (0.66-0.70)
Unemployed	0.62 (0.59-0.65)	0.59 (0.57-0.62)	0.57 (0.55-0.60)	0.57 (0.54-0.59)
Homemaker	0.58 (0.55-0.60)	0.53 (0.51-0.56)	0.54 (0.52-0.56)	0.52 (0.49-0.54)
Retired	0.57 (0.55-0.60)	0.54 (0.52-0.56)	0.55 (0.53-0.60)	0.55 (0.53-0.57)
Unable to work	0.44 (0.42-0.46)	0.40 (0.38-0.42)	0.40 (0.38-0.42)	0.40 (0.38-0.42)
Income categories (ref: ≥$50,000)				
$35,000-$44,999	0.77 (0.76-0.79)	0.80 (0.78-0.81)	0.79 (0.78-0.81)	0.80 (0.78-0.81)
$25,000-$34,999	0.71 (0.69-0.72)	0.72 (0.70-0.73)	0.73 (0.72-0.75)	0.70 (0.69-0.72)
$15,000-$24,999	0.63 (0.62-0.65)	0.66 (0.64-0.67)	0.66 (0.65-0.68)	0.66 (0.65-0.68)
<$15,000	0.59 (0.57-0.60)	0.62 (0.60-0.65)	0.62 (0.60-0.64)	0.61 (0.60-0.63)
U.S. Census region[c] (ref: West)				
Midwest	0.84 (0.82-0.85)	0.84 (0.82-0.85)	0.87 (0.86-0.89)	0.84 (0.83-0.86)
South	0.92 (0.91-0.94)	0.90 (0.89-0.92)	0.92 (0.91-0.94)	0.93 (0.91-0.95)
Northeast	0.80 (0.79-0.82)	0.81 (0.80-0.82)	0.85 (0.83-0.86)	0.84 (0.83-0.86)

[a] Adjusted for year of study, and all explanatory variables in the table.

[b] Prevalence ratio calculated using Poisson regression with a robust error variance.

[c] U.S. Census Bureau regions are defined as Midwest: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin; Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont; South: Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South

Carolina, Tennessee, Texas, Virginia, and West Virginia; West: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.