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Sex Difference in Participation in Muscle-Strengthening Activities

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Background: Previous data from the United States Centers for Disease Control and Prevention indicate men are more likely than women to participate in muscle-strengthening activities (e.g., resistance training). However, a recent review by Rhodes et al. concluded there is no reliable sex difference in participation. The purpose of the current paper was to review population-level surveys of participation in muscle-strengthening activities to clarify if a sex difference in participation exists.

Methods: Keyword searches (e.g., "resistance training participation") were performed in PubMed and Google Scholar to identify papers that surveyed a general adult population (N > 1,000) and reported an outcome of the proportion of the population meeting recommendations for "muscle-strengthening activities" (i.e., ≥ 2 times/wk) or participating in resistance training.

Results: Sixteen studies from 6 countries met the inclusion criteria. Irrespective of the measure of participation, population-levels of participation were typically higher in men than women. More men than women met recommendations for muscle-strengthening activities in England (men: 34%; women: 24%), Finland (men: 18.1%; women: 16.4%), Northern Ireland (men: 25%; women: 14%), Scotland (men: 30%; women: 25%), and the United States (men: 34.8%; women: 25.8%). For Australia, some studies showed no sex difference in participation, whereas other studies showed greater participation among men.

Conclusion: A sex difference exists in participation in muscle-strengthening activities. Low participation rates in both sexes indicate efforts to encourage participation in men and women are warranted. The results also highlight the need for rigorous definitions of "participation," as the lack of such definitions explains the mixed results reported previously.

Key Words: Gender, Muscle strength, Physical activity, Resistance training, Sex, Strength training

INTRODUCTION

Resistance training is a mode of physical exercise that involves repeated muscle contractions against external resistance to improve muscle strength. When performed for several weeks or months, resistance training causes benefits in health and function such as improved muscle size and strength, improved performance on tasks associated with daily living and athletic performance, increased bone mineral density, and improvements in cardiovascular risk factors [1-5]. Consequently, resistance training is part of exercise

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prescription guidelines across the lifespan for healthy and clinical populations [1,2,6,7]. Also, some researchers have argued that resistance training should play a more prominent role in discussions on physical activity for public health [8].

Resistance training is safe, and it is effective at improving health and function. Yet, most individuals do not meet guidelines for participation [9]. Thus, researchers often test for correlates or determinants of resistance training participation. In a recent review, Rhodes et al. summarized data on 23 demographic, behavioral, intrapersonal, and interpersonal factors and their association with resistance training participation [10]. Example factors included age, sex, race, income, education, smoking, alcohol consumption, attitudes, self-efficacy, marital status, and social support. Based on results from 13 studies [11-23], the authors concluded there is "no reliable sex difference in the frequency of [resistance training] participation" [10]. The results were somewhat surprising, given that in 2013 the Centers for Disease Control and Prevention (CDC) in the United States reported a large sex difference in participation in "muscle-strengthening activities" (≥ 2 times/wk) [9]. The CDC's report revealed 34.4% of male adults and 24.5% of female adults from the general population (N = 469,312) met recommended guidelines for muscle-strengthening activities [9]. Rhodes et al. acknowledged the sex difference in participation in the United States, but they suggested it was not generalizable to other countries [10]. However, no explanation was offered for why a sex difference in participation would exist in the United States but not in other countries.

Closer examination of the 13 papers [11-23] in the sex difference analysis by Rhodes et al. reveals a number of issues [10]. First, in epidemiological research on physical activity, "participation" typically refers to the proportion or percentage of individuals in a population who report (yes or no) if they partake in an activity, with specific criteria for participation defined by the investigators. One of the main issues with the analysis by Rhodes et al. was that not all of the studies in their analysis reported participation or were designed to measure participation. Some of the studies were *intervention* studies that measured other constructs [11,20]. For example, Aartolahtia et al. measured *adherence* to a 2-year, supervised strength and balance training program [11]. Jette et al. measured the total number of exercise sessions completed as part of a home-based strength training program [20]. Baker et al. measured *adoption* of a strength training program, with adoption defined as the number of individuals who enrolled in a randomized-controlled trial (RCT) after completing a survey about strength training [12].

Other issues also exist with the analysis by Rhodes et al. [10]. For example, whereas participation rates are typically acquired from surveys of a large number of individuals within the general population, Rhodes et al. included papers with relatively small sample sizes. Four of the papers included samples sizes less than 300 [11,17,20,21]. Moreover, some of the papers were conducted in specific patient groups. For example, 6 of the 13 papers included *only* older adults [11,12,15,17,18,20]. Finally, some of the papers had a disproportionate number of men and women. For example, of the 102 older adults in the study by Jette et al., 75% were women [20]. Of the 182 older adults in the study by Aartolahti, 71% were women [11].

In their paper, Rhodes et al. briefly acknowledged the studies in their analysis "varied greatly in how they assessed participation in [resistance training]" [10]. Yet, more rigorous inclusion criteria could have been established to prevent such heterogeneity. Given this heterogeneity, it remains unclear if a sex difference exists in participation in resistance training or other muscle-strengthening activities. Clarification of this issue might help to understand what demographic groups are less likely to participate in muscle-strengthening activities and thus less likely to receive the benefits of participation in such activities.

Therefore, the purpose of the current paper was to clarify if there is a sex difference in participation in muscle-strengthening activities when participation is measured at a population level. Moreover, the accumulated data can serve as a central source for sex- and country-specific data on rates of participation in muscle-strengthening activities.

MATERIALS AND METHODS

The current paper is a narrative review of literature on participation rates in muscle-strengthening activities in men

and women. The independent variables were country and sex. The dependent variable was participation rates in muscle-strengthening activities. Approval from an ethics board was unnecessary given the current paper is a review of existing literature.

Papers were discovered with relevant keyword searches in PubMed and Google Scholar. Example search terms included "resistance training participation," "muscle-strengthening activities", and "sex and resistance training participation." Some papers on the topic were already familiar to the author; others were discovered via cross-referencing and citation tracking; and others were cited in the review by Rhodes et al. [10].

To be included in the current paper, a study needed to (a) be a population-level survey of the general adult population (N > 1,000; not a specific group of adults); and (b) have reported an outcome of the proportion of the population meeting recommendations for "muscle-strengthening activities" (i.e., ≥ 2 times/wk) or the proportion of the population participating specifically in resistance or weight training.

No statistical analyses were performed. However, the data are presented in a way that indicates if the original studies reported a statistically significant association between sex

Table 1. Population levels of participation in muscle-strengthening activities in men and women

Country	Sample size (N)	Age (yr)	Survey name (year)	Participation outcome	Men	Women	Ref
AUS	21,603	≥15	Exercise, Recreation, Sport Survey (2010)	MSE ≥ 2 times/wk	11.8%	12.1%	[26]
AUS*	9,434	≥18	National Nutrition and Physical Activity Survey (2011-12)	MSE ≥ 2 times/wk	20.7%	16.6%	[24]
AUS	1,230	≥18	Central Queensland Social Survey (2006)	Any gym-based resistance training in past wk	12.6%	14.8%	[19]
AUS*	1,237	≥18	Central Queensland Social Survey (2006)	Currently performing (a) sufficient or (b) some resistance training	a:6.5% b:16%	a:3.6% b:14.1%	[25]
ENG†	8,291	≥16	Health Survey of England (2012)	MSE ≥ 2 times/wk	34%	24%	[29]
FIN*	64,380	≥18	Regional Health and Well-Being Study (2013-14)	MSE ≥ 2 times/wk	18.1%	16.4%	[31]
IRE†	4,509	≥16	Health Survey Northern Ireland (2013-14)	MSE ≥ 2 times/wk	25%	14%	[30]
SCOT*	14,366	≥16	Scottish Health Survey (2012-14)	≥ 1 gym workout (weight training or exercise bike) in past 4 wk	18%	12%	[33]
SCOT†	5,000	≥16	Scottish Health Survey (2015)	MSE ≥ 2 times/wk	30%	25%	[27]
USA†	469,312	≥18	BRFSS (2011)	MSE ≥ 2 times/wk	34.4%	24.5%	[9]
USA*	397,423	≥18	BRFSS (2015)	MSE ≥ 2 times/wk	34.8%	25.8%	[32]
USA†	-35,000	≥18	NHIS (1991)	Weight lifting or other exercise to increase strength in past 2 wk	20%	14.1%	[28]
USA*	29,783	≥18	NHIS (2003)	MSE ≥ 2 times/wk	22.3%‡	17.4%‡	[14]
USA*	-30,000	≥18	NHIS (2004)	MSE ≥ 2 times/wk	21.9%	17.5%	[13]
USA*	16,697	≥17	NHANES III (1988-94)	Lifted weights (a) ≥ 1 time in past month; (b) ≥ 2 times/wk in past month	a:19.5% b:12.7%	a:7.7% b:5%	[16]
USA	4,271	≥18	HealthStyles (2009)	MSE ≥ 2 times/wk	34%	29.5%	[22]

*Statistically significant association between sex and participation in muscle-strengthening activities or a statistically significant difference in participation rates between men and women.
†No test for statistical significance was performed. Studies without an asterisk or cross symbol did not find a statistically significant association between sex and participation in muscle-strengthening activities or did not find a statistically significant difference in participation rates between men and women.
‡These values were computed based on the information presented in the paper.
AUS: Australia, BRFSS: Behavioral Risk Factor Surveillance System, ENG: England, FIN: Finland, IRE: Ireland, MSE: muscle-strengthening exercise/activities, NHIS: National Health Interview Survey, NHNES: National Health and Nutrition Examination Survey, NR: not reported, SCOT: Scotland, USA: United States of America.

and participation or a statistically significant difference in participation rates between men and women.

RESULTS

Table 1 summarizes results from population-level studies that have reported participation rates in muscle-strengthening activities in adult men and women. A total of 16 studies from 6 countries were discovered. The total sample was 1,112,536 individuals.

As expected, not all papers defined participation in the same way. A total of 11 of the 16 papers measured participation as the proportion of respondents meeting recommendations for muscle-strengthening activities (≥ 2 times/wk). Irrespective of the specific measure of participation, population-levels of participation were typically higher in men than women. For example, more men than women met recommendations for muscle-strengthening activities in England (men: 34%; women: 24%), Finland (men: 18.1%; women: 16.4%), Northern Ireland (men: 25%; women: 14%), Scotland (men: 30%; women: 25%), and the United States (men: 34.8%; women: 25.8%). Results from Australia were conflicting. Two papers reported men participate at a higher rate [24,25], whereas two other papers reported no difference in participation [19,26]. Notably, 12 of the 16 papers in Table 1 were not included in the analysis by Rhodes et al. [10], some due to later publication dates.

Not all of the papers in Table 1 included statistical analyses of the data. Five of the 16 papers did not include such analyses [9,27-30]. Of the 11 papers that included statistical analyses, 8 reported significantly higher rates in men [13,14,16,24,25,31-33] and 3 reported no sex difference [19,22,26]. No studies reported statistically higher participation in women.

DISCUSSION

Previous studies have reported conflicting results on whether sex is associated with participation in muscle-strengthening activities. Namely, Rhodes et al., in their recent review, concluded there is "no reliable sex difference in the frequency of [resistance training] participation" [10]. As pointed out in the Introduction of the current paper, the methods used by Rhodes et al. were unsound. Data in the current paper illustrate that when participation is defined as the proportion of the general adult population meeting recommendations for muscle-strengthening activities, men participate at higher rates than women. This finding has been observed in England, Finland, Northern Ireland, Scotland, and the United States.

Australia is an exception to the finding of a sex difference in participation in muscle-strengthening activities. Mixed results have been reported, with two studies reporting men participate at a higher rate [24,25], whereas two other studies reported no sex difference in participation [19,26]. The mixed results from Australia might be due to the specific questions asked in the surveys or the way the original data were processed. Humphries et al. [25] and Humphries et al. [19] reported data from the Central Queensland Social Survey (2006), but the findings from the two studies were different. In the study where a sex difference in participation was reported [25], participation was defined as whether or not respondents were currently performing sufficient "strength-based training" (barbells, dumbbells, weight machines, hand weights). "Sufficient" was determined by strict criterion for training frequency, duration, intensity, and exercise number. However, in the study where there was *not* a significant association between sex and participation [19], participation was defined as whether or not respondents had participated in any "gym-based resistance training" in the past week. Thus, the mixed results from Australia might be due, in part, to the definition of participation.

Confusion about what "participation" is and how to best measure is at the core of the difference between the results reported in the current report and the review by Rhodes et al. [10] Rhodes et al. used a broad definition of participation which allowed for studies that measured different constructs – "adherence" and "adoption" – to be included in their analysis [10]. Participation typically refers to the proportion of individuals in a population who report (yes or no) if they are engaging in an activity at a frequency which is defined by the investigators before the survey is administered. As seen in Table 1, even when the definition of participation is changed slightly, rates of participation change. For example, for both men and women in the

United States, participation in “lifting weights” [16,28] is less than participation in “muscle-strengthening activities” [9,13,14,22,32]. This is because “lifting weights” is a specific type of muscle-strengthening activity. Thus, when constructs such as adherence and adoption are added into analyses of participation, data become unnecessarily heterogenous and thus less informative.

The current paper should also be cause for reflection on the different constructs measured in physical activity surveys and the nomenclature used to refer to these constructs. For example, in the Health Survey for England, “muscle-strengthening activities” include the following: canoeing, climbing, field athletics, horse riding, kayaking, rowing, sailing, skiing/snowboarding, Tai-chi, water skiing, wind surfing, aqua aerobics/aquafit, aerobics, basketball, body boarding, bowls, exercise (press-ups, sit-ups etc), cricket, curling, golf, hillwalking, hockey, ice skating, martial arts other than Tai-chi, netball, pilates, rambling, surfing, tenpin bowling, volleyball, workout at a gym (e.g. exercise bike, weight training), yoga, badminton, cycling, dancing, football, rugby, running/jogging, squash, swimming, tennis [29]. Thus, results from the Health Survey for England should not be used as evidence of participation in “resistance training” or “weight training,” as the survey measures the broader construct of “muscle-strengthening activities.” Rhodes el al. [10] misused the term “resistance training,” because some of the papers in their analysis measured participation in muscle-strengthening activities, not participation in resistance or weight training.

In conclusion, results from the current paper reveal men are more likely than women to participate in muscle-strengthening activities and meet recommended guidelines for participation. This updated evidence can inform initiatives aimed at increasing population-levels of participation in muscle-strengthening activities. Low participation is evident in both sexes and indicates efforts to encourage increased participation in both sexes are warranted. The reasons women participate in muscle-strengthening activities at lower rates than men could also be investigated to inform sex-specific initiatives to increase participation.

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