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2017

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Factors Associated with Participation in Resistance Training: A Systematic Review

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Word Count: 5982

Abstract

Objective: Regular participation in resistance training is critical to health and recommended in most international physical activity guidelines. Few people, however, participate in resistance training. The purpose of this review was assess the demographic, behavioural, intra-personal, inter-personal and environmental factors associated with participating in resistance training.

Data Sources: Eligible studies were from English, peer-reviewed published articles that examined correlates or determinants of RT in adult samples. Searches were performed from August 2015 to April 2016 in six databases.

Results: We identified 51 independent data-sets, from nine countries, primarily of moderate to high quality, and 23 factors related to participating in RT. Education, perceived health status, quality of life, affective judgments, self-efficacy, intention, self-regulation behaviors, subjective norm, and program leadership were associated with RT.

Conclusion: Low education levels and poor health status were associated with low participation rates in resistance training. Intra-personal factors including affective judgements, self-efficacy, and self-regulation behaviours, and inter-personal factors including subjective norms and program leadership are important for promoting resistance training behaviours.

Summary

What is already known?

-Resistance training is critical to public health and recommended in international guidelines

-The prevalence of resistance training participation is low

What are the new findings?

- Participation in resistance training was low among individuals with low education levels and poor health status.

- Intra-personal factors including affective judgements, self-efficacy, and self-regulation behaviours, and inter-personal factors including subjective norms and program leadership are important for promoting resistance training behaviours.

-Few studies have explored the potential environmental factors associated with resistance training participation.

Physical inactivity is now the fourth leading cause of death worldwide, and this has important health, economic, environmental and social consequences [1]. Although originally limited to the promotion of aerobic exercise and cardio-respiratory fitness, physical activity recommendations have evolved to now include resistance training [2]. There are important musculoskeletal (e.g., improvements in posture, mobility and balance)[3] and metabolic (e.g., reductions in blood sugar levels and increases in lean muscle mass) [4, 5] health benefits of participating in resistance training (RT). Participation is also associated with decreased mortality rates[6]. International [7] guidelines [8] [9] [10] now recommend that adults participate in RT activities involving major muscle groups on two or more days a week.

Resistance training can involve a variety of training modalities, including free weights, weight machines, medicine balls, elastic tubing devices and an individual's body weight. Although the majority of RT studies have involved supervised programs held in clinics or gymnasiums overseen by exercise health professionals [3, 11], there is growing interest in the evaluation of home-based programs [12-14]. These programs have the potential to overcome common barriers to participation, such as accessibility and affordability [15, 16].While the benefits of RT are now well established, the prevalence of participation RT in nationally representative samples is low, ranging from 10.4 [17] to 30% [18, 19] of adults meeting RT guidelines . Clearly RT promotion is needed to reap the established health benefits of participation.

Successful physical activity promotion is founded on a clear understanding of the factors influencing whether people participate [20]. We have sound understanding of the factors that influence participation in aerobic physical activity [21], there is only one narrative review of the factors that influence participation in RT [22]. Given that RT is a unique behaviour with a far

lower participation rate compared to aerobic exercise, and because it requires specific knowledge, efficacy and equipment, there may be different factors that influence participation in RT compared to aerobic physical activity [23]. Therefore, we aimed to investigate the demographic, behavioral, intra-personal, inter-personal, and environmental factors associated with participation in RT, using a socio-ecological framework [22-24].

METHODS

We followed the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) guidelines when conducting and reporting this systematic review (see Supplementary Appendix for completed PRISMA checklist).

Eligibility criteria

For a study to be considered for this review, it had to report a variable with a test of association with RT and be published in English language in a peer-reviewed journal. We included all study designs.

Search strategy and screening

Two independent reviewers searched the Web of Science, PubMed, Medline, SCOPUS, Google Scholar and SPORTDiscus online databases from database inception to April 2016. The search strategy (Appendix A) was constructed around the themes resistance training, strength training, weightlifting, correlates, determinants, attitudes, environment, social support, self-efficacy and demographics. We also conducted forward citation tracking to identify any articles that may have been missed in the electronic database search.

Data extraction

Data extraction was performed independently by two reviewers. The extracted data included the theory and constructs underlying RT participation, country of origin, sample size, average age of participants, clinical status of participants, study design, length of the study, intervention description (including interview and focus groups), RT component of intervention (including interview and focus groups), and RT measure. All data extracted were checked for accuracy and consistency by a third reviewer.

We identified 77 articles, which were classified into three categories: “include” (58 articles), “potential for inclusion” (7 articles), and “not relevant” (12 articles). The abstracts of these articles (all three categories) were than scrutinized by RR and a tentative decision was made to include 58 articles. The full text articles of all these studies were then carefully scrutinized to make a final decision regarding the inclusion of articles (for example, to assess whether analyses conducted in the article separated RT and aerobic exercise, whether only intention to participate was measured in the article instead of RT behaviour, etc.). Any additional questions relating to the inclusion of articles was directed to all authors (e.g. whether or not to include the one youth study that was located).

Risk of bias assessment

The criteria for assessing risk of bias were adapted from the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [25] and the Consolidated Standards of Reporting Trials (CONSORT) statement[26]. Two reviewers independently assessed each study. Disagreements were resolved via consensus, and a third reviewer was consulted if consensus could not be reached. Inter-rater reliability was evaluated using a weighted kappa statistic. A study was considered high quality if it scored 5 or above, moderate quality if it

scored 3-4 and low quality if it scored 2 or lower (see Appendix B for scoring and the instrument used). We did not assess risk of bias in the seven qualitative studies included in our review.

Analysis

We read each study, then developed themes and sub-themes. Themes were appraised within a socio-ecological framework and at least three studies investigating a similar factor related to participation in RT were required to establish a theme. This approach has been used previously in reviews [27, 28]. We identified 5 themes: demographics (e.g., age, sex, ethnicity, income, education, employment), health behaviours (e.g., smoking, alcohol consumption), intra-personal factors (e.g., attitude/outcome expectation, affective judgement, perceived behavioural control/self-efficacy, intention), inter-personal factors (e.g., marriage/cohabitation, social support, subjective norm), and environment (e.g., accessibility and convenience/connectivity, safety, and aesthetics).

Based on Sallis et al.'s [29] rubric for determining an association among studies, we considered it a positive association if there was a positive association between a factor and participating in RT in greater than 59% of studies; a negative association if there was a negative association between a factor and participating in RT in greater than 59% of studies; inconclusive if 34-59% of studies found an association between a factor and participating in RT, and no association if less than 34% of studies showed an association between a factor and participating in RT. When analysing the variables, both statistical significance ($p < .05$) and a clinically meaningful effect size [30, 31] ($d > 0.19$; $r > 0.09$; odds ratio (OR) > 1.49) needed to be present to conclude that any given factor had a positive or negative association with participating in RT.

Meta-analysis was precluded because there was extensive heterogeneity in the RT measures (e.g. format of measurement, mode), statistical tests employed, definitions of predictors (e.g. baseline, change), and study designs (e.g. cross-sectional, experimental).

RESULTS

Study Characteristics

We included 51 studies in the final analyses (Figure 1). Supplementary Table 1 highlights the study characteristics of the studies included and Table 1 provides an overview of the results by theme.

The length of studies ranged from one visit to six years with an average length of 7.3 months. The 51 independent data sets represented a total of 164,378 participants with the sample sizes ranging from 9 [32] to 96,191 [33]. Thirty-eight studies included males and females. Four studies did not report the sex distribution [33-36]. One study included males [37] only and 12 studies included females only. The highest proportion of studies came from the U.S. (n=22), and the remainder from Canada (n=14), Australia (n=7), Japan (n=3), Finland (n=2), Switzerland (n=1), Belgium (n=1), and South Africa (n=1).

The studies varied greatly in how they assessed participation in RT. Only four studies used an objective measure of RT (including attendance rolls) [37-40]. Most studies used self-report questionnaires to assess RT behavior (n= 47). There was also heterogeneity in the way RT was performed within interventions (i.e. dumbbells, Thera bands, multi-gym equipment) and the locations (i.e. within fitness centres, home-based).

Risk of bias assessment

Reporting of eligibility criteria was adequate in all but 4 of the quantitative studies [34, 41-43]. The sources and details regarding the reliability of physical activity assessment was provided in 41 of the 44 studies, with 43 studies providing the sources and details concerning reliability of potential factors associated with RT. The majority (35/44) of included studies fulfilled 4 criteria or less (of a possible score of 6 criteria), equating to a moderate to high risk of bias. Seven studies had a low risk of bias; 3 studies fulfilled 5 criteria [44-46], and 4 studies fulfilled 6 criteria [33, 47-49]. Inadequate reporting of randomisation method, power calculations, and participant completion rates were common issues identified by assessing risk of bias (see Appendix B). For instance, only 15 studies reported the randomisation method employed, 10 studies reported power calculation details, and 17 studies reported percentages of participants who completed different measures. Inter-rater reliability between the two reviewers for the risk of bias assessment was high (mean Cohen's Kappa values of 0.85).

Table 1. Summary of the correlates of resistance training behavior.

Potential predictive factor	Positive association with participation in RT	Negative association with participation in RT	No association with participation in RT	Overall association with participation in RT
<u>Demographic factors</u>				
Age		[33, 34, 37, 38, 42, 47-51]	[41, 52-59]	?
Sex		[47, 49]	[33, 34, 38, 41, 43, 44, 48, 50, 51, 53, 55]	0
Race		[60]	[33, 43, 47-52, 54]	0
Income	[34, 42, 48, 51]	[53]	[41, 43, 58]	?
Education	[34, 38, 42, 47-51, 53, 54]			+

Occupational status (employed)	[54, 59]		[37, 41, 43, 52, 55, 59] [37, 42, 48, 51, 52, 56, 58]	0
Health condition/medical treatments		[38, 55, 61]	[48, 51, 53, 58]	?
Perceived health status	[34, 38, 41, 48, 49, 51, 62]		[58, 59]	+
Quality of life	[32, 37, 53, 58]		[63]	+
BMI	[48-51, 56]		[38, 41, 53, 58, 59, 64]	?
<u>Behavioral factors</u>				
Smoking		[41, 51, 64]	[37, 53, 59]	?
Alcohol consumption	[51]		[37, 64]	0
Total physical activity	[34, 42, 47, 58, 60]		[37, 53, 56, 59]	?
<u>Intra-personal factors</u>				
Attitudes/outcome expectations	[54, 55, 60, 62, 63, 65-69]		[37, 48, 57-59, 70-73]	?
Affective judgments	[43, 48, 66, 68]		[46]	+
Perceived barriers	[73]	[69]	[63, 70, 72]	?
Self-efficacy/perceived behavioral control	[34, 37, 39, 42, 45, 48, 55, 58, 60, 62, 65-68, 70, 71, 74, 75]		[46, 55-57, 63, 72]	+
Self-regulatory behaviours	[45, 48, 58, 69, 75]		[72]	+
Intention	[37, 48, 60, 62, 65-67]		[45, 57, 68]	+
<u>Inter-personal factors</u>				
Marital status	[42, 51, 56]		[37, 43, 47, 48, 50, 52, 54, 58]	0
Social support	[32, 35, 36, 40, 58, 73, 76, 77]		[39, 45, 50, 56, 61, 78]	?
Subjective norm	[37, 41, 48, 60, 62, 65, 66, 68]		[57]	+

Program leadership	[32, 35, 36, 40, 76, 78]	+

Note: Numbers in parentheses represent study citation. At least three studies were required for a theme and an estimate of strength behavior. + = positive association (>59% of studies), - = negative association (>59% of studies), ? = indeterminate (34-59% of studies showing an association) and 0 = no association (<34% of studies showing any association).

Demographic factors with consistent evidence of a relationship with participating in RT

Sixteen studies assessed the relationship between *education* and RT [34, 37, 38, 41-43, 47-55, 58]. There was a meaningful and significant relationship between higher education and more frequent participation in RT in ten studies [34, 38, 42, 47-51, 53, 54]. Four studies that found no relationship between participation in RT had small samples, and therefore may have been underpowered to detect an effect [37, 43, 52, 55]. By contrast, all of the large sample and population-based surveys found a significant relationship between education and participation in RT, with the odds of college graduates engaging in RT over high school graduates ranging from 1.7 times [49] to 2.5 times [47] more likely. *Higher education is reliably linked to more frequent participation in RT.*

The relationship between *perceived health status* and participating in RT was reported in 9 studies [34, 38, 41, 48, 49, 51, 58, 59, 62] and 7 [34, 38, 41, 48, 49, 51, 62] showed a significant and meaningful association between higher ratings of perceived health and more frequent participation in RT. Many of these results were in the medium to large effect size range [34, 41, 48, 49, 51, 62]; for example, people who reported superior perceived health were 13.5 times more likely to be participating in RT as frequently as advised [49]. *There is reliable evidence that positive perceived health is linked to more frequent participation in RT.*

The relationship between *perceived quality of life* and participating in RT was assessed in 6 studies [32, 37, 53, 54, 58, 63]. All the participants were special populations including cancer survivors [37, 58], those with multiple sclerosis [32], and older adults [53, 54, 63]. Four studies

examined health-related quality of life [37, 53, 58, 63], and three explored fatigue [32, 37, 58]. There was a significant positive relationship between quality of life and participating in RT in 3 studies [37, 53, 58] with small to medium effect sizes. Three studies supported a relationship between lower reported fatigue and more frequent participation in RT with small to medium effect sizes [32, 37, 58]. *Perceived quality of life and lower fatigue has a positive association with RT participation*.

Demographic factors with consistent evidence of no relationship with participating in RT

Ten studies examined the relationship between selected *race* demographics and participation in RT [33, 43, 47-52, 54, 60]. There was no relationship between race and participation in RT in 9 studies [33, 43, 47-52, 54]. *There is little evidence that race is reliably related to participation in RT, although the sampling thus far has been predominantly from the United States and focused on comparisons among Caucasian, Black and Hispanic races*.

The relationship between *sex* and participating in RT was examined in 13 studies [33, 34, 38, 41, 43, 44, 47-51, 53, 55]. There was no sex different in participation in RT in 8 studies [38, 41, 43, 48, 50, 51, 53, 55]. In 3 studies, there was a statistically significant relationship between sex and participation in RT but of trivial effect size [33, 34, 44]. In 2 large U.S. national surveys, men participated more frequently in RT compared to women [47, 49]. *There is no reliable sex difference in the frequency of RT participation*.

Nine studies assessed the relationship between *work status* (working vs. not working) and participating in RT [37, 42, 48, 51, 52, 54, 56, 58, 59]. Only two of the nine samples showed a significant relationship between work status and RT [54, 59]. *There is limited evidence to suggest a relationship between work status and frequency of participation in RT*.

Demographic factors with inconsistent evidence of a relationship with participating in RT

Ten [33, 34, 37, 38, 42, 47-51] of the studies had a significant negative correlation between older age and participation in RT, including the highest quality studies [33, 34, 42, 47, 49, 50]. Nine studies [41, 52-59] did not report an association between age and participating in RT, and many of these had small or age-constrained samples (e.g., older adult samples). *There is mixed evidence for the relationship between age and participating in RT, although higher quality studies suggest older adults may participate in less RT than younger people*.

Eleven studies assessed the relationship between *BMI* and participating in RT [38, 41, 48-51, 53, 56, 58, 59, 64]. Five studies supported a positive relationship between normal weight BMI (19-25) and participating in RT compared to obese participants [48-51, 56], all with small effects. In 4 studies that did not find a relationship between BMI and participating in RT there was a risk that the studies were underpowered due to small sample size [38, 53, 59, 64]. *There may be a small effect for people with normal BMI to participate in RT compared to people with obesity*.

Eight studies investigated the relationship between *income* and participating in RT [34, 41-43, 48, 51, 53, 58]. In 4 studies there was a significant positive relationship between higher income and more frequent participation in RT [34, 42, 48, 51]. In three studies there was no relationship between income and participating in RT [41, 43, 58], and in 1 study participants with lower incomes were more likely to join a RT program than those with higher incomes [53]. *The relationship between income and participating in RT is unclear*.

Ten studies examined *health condition* (including comorbidities) and participating in RT [37, 38, 48, 51, 53, 55, 56, 58, 59, 61]. In 3 studies, the presence of new health conditions,

particularly type 2 diabetes, was negatively associated with adherence to a RT program [38, 55, 61], while in 4 studies there was no association [48, 51, 53, 58]. In 5 studies of cancer survivors, no cancer-related medical aspect (e.g., cancer site, treatment type, time since treatment, etc.) was related to participating in RT. *The relationship between health condition and participating in RT participation is unclear*.

Health behaviors with inconsistent evidence of a relationship with participating in RT

Three studies investigated the relationship between regular consumption of alcoholic drinks and participating in RT [37, 51, 64]. Two studies had no association between regular alcohol consumption and participating in RT [37, 64], while one study found that regular and social drinkers were more likely to participate in RT compared to non-drinkers [51]. *There is inadequate and mixed evidence for the association between consumption of alcohol and RT participation*.

Six studies assessed the relationship between smoking status and participating in RT [37, 41, 51, 53, 59, 64]. In 3 studies there was a relationship between non-smoking status and higher frequency of RT participation with small effects [41, 51, 64]. In 2 studies there was no relationship between smoking status and participating in RT [37, 53]. In 1 study there was no association between smoking status and participating in RT in men, but women non-smokers were more likely to adhere to RT participation compared to women smokers [59]. *The relationship between smoking status and participating in RT is unclear*.

Nine studies assessed the relationship between general physical activity and participating in RT [34, 37, 42, 47, 53, 56, 58-60]. Five studies found a positive association between general physical activity participation and RT participation with medium to large effects [34, 42, 47, 58,

60]. In 4 studies that did not find a relationship between general physical activity engagement and participation in RT, there was a risk that the studies were underpowered due to small sample size [37, 53, 56, 59]. *The relationship between RT participation and total physical activity is unclear, although higher quality studies suggest there may be a positive association*.

Intra-personal factors with consistent evidence of a relationship with participating in RT

The relationship between *affective judgments* and participating in RT was assessed in 6 qualitative studies [32, 35, 36, 40, 76, 78] and 5 quantitative studies [43, 46, 48, 66, 68]. Affective judgment was measured as intrinsic regulation from self-determination theory [43, 46], affective attitude/beliefs from theory of planned behavior [48], and self-evaluative outcome expectations from social cognitive theory [66]. In 5 of the qualitative studies, affective judgments were highlighted as a key factor in RT participation [32, 35, 36, 76, 78], although 2 of these studies showed that participants did not perceive RT as enjoyable [76, 78]. In 4 of the quantitative studies, affective judgments were positively associated with participating in RT [43, 48, 66, 68]. The discrepant study had a small sample that may have a risk of bias to detect a significant relationship [46]. *There is strong evidence that affective judgments are linked to RT*.

The relationship between *self-efficacy/perceived behavioral control* and participation in RT was assessed in 22 studies [34, 37, 39, 42, 45, 46, 48, 55-58, 60, 62, 63, 65-68, 70-72, 74, 75]. Sixteen studies used measures of self-efficacy from social cognitive theory/transtheoretical model; 11 found a significant positive association with participating in RT [39, 42, 45, 57, 58, 60, 66, 67, 70, 71, 75], while 5 studies found no association [46, 55, 56, 63, 72]. Nine studies used measures of perceived behavioral control from the theory of planned behavior; 8 studies showed a positive association with participating in RT [37, 48, 55, 60, 62, 65, 68, 74], and 1 study

showed no association [57]. The 3 intervention studies reviewed, which represent the highest quality evidence, had mixed results. Fetherman et al. [63] showed changes in RT participation did not track to changes in self-efficacy, while Lubans et al. [45] found that changes in RT participation and self-efficacy were not associated in mediation analyses. By contrast, Millen and Bray [71] showed changes in self-efficacy partially mediated the relationship between the intervention and changes in RT participation. *There is a consistent positive relationship between self-efficacy/perceived behavioral control and participating in RT but the effectiveness of interventions to increase RT participation by promoting self-efficacy is unclear*.

The relationship between participating in RT and strategies to regulate behavior, such as plans, monitoring, and goal setting, were assessed in 6 studies [45, 48, 58, 69, 72, 75]. In 5 studies, there was a significant positive association between *self-regulatory behaviors* and participating in RT [45, 48, 58, 69, 75], with medium to large effects. These self-regulation strategies mediated the relationship between their intervention and changes in RT [45]. *Strategies to self-regulate RT participation are related to RT behaviour*.

Ten studies assessed the relationship between *intention* and participating in RT [37, 45, 48, 57, 60, 62, 65-68]. A positive relationship was identified in 7 studies [37, 48, 60, 62, 65-67], with medium to large effects. The highest quality observational trial [57], and the only experimental trial among the 10 studies [45] did not show a significant relationship between intention and participating in RT. *Intention is associated with participating in RT, but higher quality studies are needed to understand whether this relationship extends to RT behaviour change*.

Intra-personal factors with inconsistent evidence of a relationship with participating in RT

The association between *perceived benefits* of RT and participating in RT was assessed in 6 qualitative studies [32, 35, 40, 54, 76, 77], and 21 quantitative studies [37, 45, 48, 54, 55, 57-60, 62, 63, 65-73, 79]. In the 6 qualitative studies, participants reported benefits from participating in RT. The key benefits were increased strength [32, 54, 76, 77] and well-being [35, 40, 76] but participants did not believe RT affected weight loss [40, 76]. In 10 of the quantitative studies there was evidence of a positive association between perceived benefits (measured via outcome expectations, attitudes, and pros/decisional balance) and participating in RT [54, 55, 60, 62, 63, 65-69], and no association in 11 studies [37, 45, 48, 57-59, 70-73, 79]. *There is mixed evidence for whether perceived benefits of RT are associated with participating in RT*.

The association between perceived barriers of RT and participating in RT was assessed in 5 qualitative studies [32, 35, 36, 54, 78] and 5 quantitative studies (measured via cons and negative outcome expectations) [63, 69, 70, 72, 73]. The qualitative studies highlighted lack of time due to other interests and responsibilities as the most common reported barrier to RT participation [32, 35, 36, 54, 78], followed by poor health [35, 54] and financial costs [32, 54]. In 3 of the 5 quantitative studies, there was no association between barriers and RT participation [63, 70, 72]. One study found negative outcome expectations were negatively associated with participating in RT [69], and 1 study found poor weather was negatively associated with participating in RT [73], both with medium effects. *There is inconsistent evidence for a relationship between perceived barriers and participating in RT, but participants in RT trials consistently highlight the time burden that RT may take from other responsibilities and interests*.

Inter-personal factors with consistent evidence of a relationship with participating in RT

The relationship between *subjective norm* and participating in RT was assessed in 9 studies [37, 41, 48, 57, 60, 62, 65, 66, 68]. Eight studies supported a positive association between subjective norm and participating in RT [37, 41, 48, 60, 62, 65, 66, 68], with small effects. In 1 study there was no association between subjective norm and participating in RT [57]. *There is evidence that subjective norm has a small positive relationship with RT participation.*

Six qualitative studies examined the role of *program leadership* and participating in RT [32, 35, 36, 40, 76, 78]. Program leaders were critical to ongoing adherence in RT and one of the key elements of trial participation. *There is strong evidence of a relationship between program leadership and participating in RT*.

Inter-personal factors with consistent evidence of no relationship with participating in RT

The relationship between *marital status* and RT participation was assessed in 11 studies [37, 42, 43, 47, 48, 50-52, 54, 56, 58]. In 8 studies there was no association between marital status and RT participation [37, 43, 47, 48, 50, 52, 54, 58], while 3 studies found a positive association between being married (compared to single) and more frequently participating in RT [42, 51, 56]. *Marital status is not related to participating in RT*.

Inter-personal factors with inconsistent evidence of a relationship with participating in RT

The association between *social support* and participating in RT was investigated in 7 qualitative studies [32, 35, 36, 40, 76-78] and 7 quantitative studies [39, 45, 54, 56, 58, 61, 73]. Six qualitative studies identified social support as a key theme [32, 35, 36, 40, 76, 77] while one study did not [78]. A positive relationship between social support and RT participation was found in 2 quantitative studies [58, 73], and 5 studies showed no association [39, 45, 54, 56, 61]. Two studies reported a positive association between family support and participating in RT, with small

effects [54, 58], while 1 study [39] reported a similar positive relationship in the first 3 months of RT participation but no relationship at 6 months. In 1 study there was a small positive association between friend support and participating in RT [58], while 1 study showed no association [54]. Six qualitative studies found that peer support was a key factor for participating in RT, and 1 quantitative study [39] showed no association. *The relationship between social support and participating in RT is unclear*.

DISCUSSION

Overall, we included 51 studies (17 cross-sectional, 10 longitudinal, seven qualitative, 16 experimental, and one quasi-experimental) in our review. This advances the synthesis of RT research from a prior overview of 16 studies [22] and demonstrates that considerable research has accumulated on participation in RT. Overall, the research literature includes a high level of self-reported participation in RT (92% used self-report), studies mainly of moderate-level quality and considerable variability in sample size (ranging from 9 to 29,783). We have sound understanding of how basic demographic, inter- and intra-personal variables may relate with participation in RT, but a paucity of information on the influence of environmental factors. Our review had excellent heterogeneity of sampling across the population with a considerable proportion of studies involving clinical samples, older adults, and women. Variables related to sampling (e.g., age, sex, and health condition) were not moderators of inter- and intra-personal factors and participating in RT, supporting the generalisability and robustness of our findings.

Educational level, perceived health status, and quality of life were positively associated with participating in RT. These results mirror those of reviews of general physical activity [21] suggesting that educated and healthy adults are more likely to engage in RT than less educated

and healthy adults. This suggests that RT promotion efforts must target more vulnerable populations, particularly when the effects of regular RT (e.g. reduction of sarcopenia, maintenance of bone density) may be particularly important for quality of life and activities of daily living [80]. There was mixed evidence that participating in RT was associated with age and total physical activity, and limited evidence that participating in RT was associated with sex, race, and occupational status. This contrasts reviews in general physical activity [21, 27] and might be explained by the fact that fewer people in general participate in RT compared to aerobic activities [18, 19]. It is also possible that current research on RT is underpowered. In support of this, larger studies with broad sampling did show effects for younger adults participating in more RT than older adults [33, 34, 42, 47, 49, 50]. Further, there were some small effects favoring males participating in RT more than females [47, 49] and Caucasian women participating in RT more frequently than Black women [33, 60]. Although these findings are from the U.S., so the generalisability to other populations is unknown.

Most research has focused on investigating the relationship between intra- and inter-personal variables and participating in RT. Self-efficacy, affective judgments, intention, subjective norm, program leadership and self-regulation behaviors were all associated with participating in RT. Self-efficacy [81-83], intention [84], affective judgments [85] and self-regulation behaviors [86, 87] are arguably the most reliable intra-personal correlates of general physical activity behaviour, so it is probably not surprising that these factors are also related to participating in RT. Therefore, RT interventions should include strategies to target these key variables. Task (i.e., perceived capability to perform RT actions) and barrier (perceived capability to overcome barriers to adhering to RT) self-efficacy [45, 58], might be especially important considerations. People need to feel confident to do RT behaviours (task self-efficacy) [74].

Therefore, to improve adherence to RT interventions it may be important to assess an individual's skills and support him or her to learn appropriate skills if this is required [88, 89]. Future experimental studies that examine skill-training and RT adherence are now needed to validate these correlational findings.

For interpersonal factors, subjective norm showed a small effect size relationship with participating in RT. This is similar to effects present in general physical activity research [90]. In contrast, there is strong evidence that program leadership affects participation in general physical activity [91], and may be especially important for participating in RT since RT may require new skills and attendance at a community recreation facility. Therefore, we recommend promotion efforts that train personnel in effective motivational leadership skills [92].

The higher importance of affective judgments (i.e., expected pleasure, enjoyment) over more instrumental attitudes/outcome expectations (i.e., expected benefit, utility) was evident in our review. While this finding replicates past research in general physical activity [85], most of our models applied to physical activity from the cognitive tradition do not separate the affective and instrumental components of attitude/outcome expectation. Our review suggests that theories with an emphasis on this distinction such as self-determination theory [93], and extended reasoned action models [94] would be worthwhile to pursue for future intervention research. The largest effect sizes in this review, however, were observed with self-regulation behaviors and this also had the most support among the present experimental research. Thus, models that use self-regulation behavior constructs [95, 96] should be given consideration in RT promotion.

Practitioners who wish to promote RT participation might consider 4 key points:

(1) The very low prevalence of RT participation across the population suggests that most people are unlikely to be already engaging in this activity. It may be especially important to target those who have low formal education and those with compromised health in RT promotion efforts.

(2) Supporting people to start RT may require referral to a supportive program that includes leadership that is focused on making the experience enjoyable and helping to build RT self-efficacy. Programs that include instructions on how to perform RT exercises and provide safe practice are recommended.

(3) Soliciting the encouragement of important family and friends may improve the likelihood of participating in RT by creating strong normative support.

(4) Self-regulation behaviors such as planning and self-monitoring are important for people to start participating in RT.

Only one study in our review [41] explored the relationship between environmental factors and participating in RT. This is a rather glaring omission in this literature, given the massive amount of research attention that environmental correlates of general physical activity has received [97]. Built environment factors such as access to transport, access to shops, access to recreation facilities and having a vehicle were all related to participating in RT [41]. In addition, people with home RT equipment were 4.5 times more likely to participate in RT [41]. The home environment is also an important factor associated with participation in general physical activity [98], and clearly more research (employing objective and subjective assessments of the built environment) is needed to assess the relationship between environmental factors and participating in RT [99].

Most studies have assessed the relationship between single factors and participating in RT, or employed simple multivariable models (with few independent variables). While this is a sensible first step, an examination of how factors may interact to predict participation in RT is needed. In one study, age and socioeconomic status interacted when explaining participation in RT [17], and it is likely there are other relevant interactions. Modelling participation in RT beyond the traditional social-cognitive paradigm may also be useful [100], for example, assessing RT habits since building routines around participation was a frequently reported aspect of successful adoption of RT [35]. The discordance between intention and participating in RT has also been examined in only one study [101]. Most of our models used to understand physical activity participation place intention as the proximal determinant of behaviour and have little explanation for this gap. Action-control models aim to explain how people translate intentions into physical activity [102], and may be a worthy line of exploration in future research. We only identified two studies that had examined factors associated with RT participation among youth [103, 104]. Public health guidelines generally include RT for youth [105-107] so this seems like an underserved population that requires considerable future research.

When using the results of our review, it is important to consider that overall, the studies included were at moderate risk of bias. Therefore, it is possible that some of the relationships between demographic, behavioral, intra-personal, inter-personal, and environmental factors may have been over- or underestimated. Since we only included research published in English language, there is a risk for publication bias and language bias in our review. In addition, the heterogeneity among included studies precluded meta-analysis, so it was not possible to calculate summary estimates. In some areas (e.g.) the conclusions we could draw were limited by few

studies, high risk of bias and small sample sizes. Therefore, publication of new research in these areas might change the findings of our review.

Conclusion

Education, perceived health status, quality of life, affective judgments, self-efficacy, intention, self-regulation behaviors, subjective norm, and program leadership were reliably related to participating in RT. When promoting RT, focus on making the experience enjoyable and building self-efficacy, planning and self-monitoring behaviours. A program with specific RT instruction, and soliciting the encouragement of important family and friends is important for adherence.

Conflict of Interest: All Authors report no conflict of interest for the paper.

Acknowledgement

RER is supported by funds from the Canadian Institutes for Health Research, the Social Sciences and Humanities Research Council of Canada and the Heart and Stroke Foundation of Canada. DRL is supported by an Australian Research Council Future Fellowship. RCP is supported by a National Health and Medical Research Council Senior Research Fellowship.

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