The effect of resistance exercise training on anxiety symptoms: a systematic review and meta-analysis

The Effect of Resistance Exercise Training on Anxiety Symptoms: A Systematic Review and Meta-Analysis

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Abstract

Purpose: To estimate the population effect size for resistance exercise training (RET) effects on anxiety and to determine whether variables of logical, theoretical, and/or prior empirical relation to anxiety moderate the overall effect.

Methods: Thirty-one effects were derived from 16 articles published before February, 2017, located using Google Scholar, MEDLINE, PsycINFO, PubMed, and Web of Science. Trials involved 922 participants and included both randomization to RET (n=486) or a non-active control condition (n=436), and a validated anxiety outcome measured at baseline, mid- and/or post-intervention. Hedges' *d* effect sizes were computed and random effects models were used for all analyses. Meta-regression quantified the extent to which participant and trial characteristics moderated the mean effect.

Results: RET significantly reduced anxiety symptoms (Δ=0.31, 95%CI: 0.17-0.44; z=4.43; p<0.001). Significant heterogeneity was not indicated (QT(30)=40.5, p>0.09; I²=28.3%, 95%CI: 10.17%-42.81%); sampling error accounted for 77.7% of observed variance. Larger effects were found among healthy participants (Δ=0.50, 95%CI: 0.22-0.78) compared to participants with an illness (Δ=0.19, 95%CI: 0.06-0.31, z=2.16, p<0.04). Effect sizes did not significantly vary according to sex (β=-0.31), age (β=-0.10), control condition (β=0.08), program length (β=0.07), session duration (β=0.08), frequency (β=-0.10), intensity (β=-0.18), anxiety recall time frame (β=0.21), or whether strength significantly improved (β=0.19) (all p≥0.06).

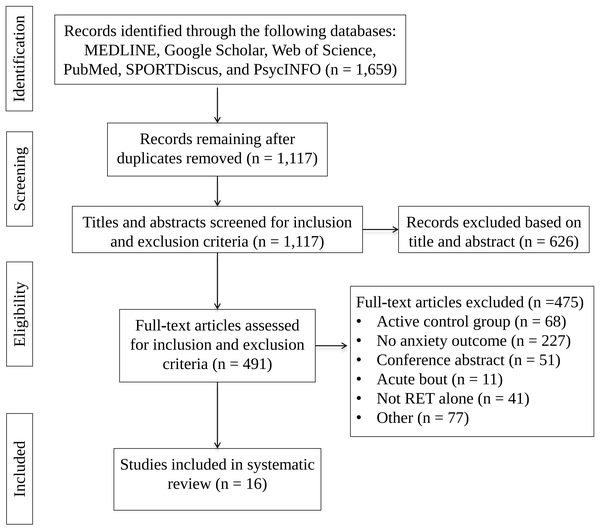
Conclusions: RET significantly improves anxiety symptoms among both healthy participants and participants with a physical or mental illness. Improvements were not moderated by sex, or based on features of RET. Future trials should compare RET to other empirically-supported therapies for anxiety.

Background

- The available evidence supports the anxiolytic effects of acute exercise, and exercise training among otherwise healthy adults, adults with a chronic illness, and anxiety disorder patients.
- Although aerobic exercise training has well-established effects on anxiety that are comparable to other empirically-supported treatments, the anxiolytic effects of RET remain understudied.
- To date there has been no quantitative synthesis of the available empirical evidence, particularly randomized controlled trials.

Methods

- Inclusion criteria were: (1) English language peer-reviewed publications, (2) randomized allocation to either an exercise intervention or a non-active control condition, and (3) an anxiety outcome measured at baseline and at mid- and/or post-intervention.
- Investigations were excluded that (1) included exercise as one part of a multicomponent intervention but did not include the additional component in a comparison condition, and/or (2) compared exercise only with an active treatment.



Data Synthesis and Analysis

- Hedges' *d* effect sizes were calculated by subtracting the mean change in the comparison condition from the mean change in the exercise condition, and dividing this difference by the pooled standard deviation of baseline scores.
- Meta-regression was used as the overall analysis of moderator effects. Random effects models were used with macros (SPSS MeanES, MetaReg; SPSS, Inc) to aggregate mean effect size delta (Δ) and to test variation in effects according to moderator variables.
- Moderators were selected based on theoretical, practical, and/or prior empirical relation with anxiety and/or exercise effects on anxiety.

Results

- Twenty-seven of 31 effects (87.1%) were larger than zero.
- The mean effect size Δ was 0.31 (95%CI: 0.17-0.44; z=4.43; p<0.001).
- Significant heterogeneity was not indicated ($Q_T(30)$=40.5, p>0.09; I^2=28.3%, 95%CI: 10.17%-42.81%), and sampling error accounted for 77.7% of observed variance.
- The fail-safe number of effects was 151
- Larger effects were derived from studies in which participants were healthy (Δ=0.50, 95%CI: 0.22-0.78) compared to physically- or mentally-ill participants (Δ=0.19, 95%CI: 0.06-0.31, z=2.16, p<0.04).
- Effect sizes did not significantly vary according to sex (β=-0.31), age (β=-0.10), control condition (β=0.08), program length (β=0.07), session duration (β=0.08), frequency (β=-0.10), intensity (β=-0.18), supervision (β=0.06), primary outcome (β=0.29), recall (β=0.21), or a significant improvement in strength (β=0.19) (all p≥0.07).
- Effects were similar for the RET interventions (Δ=0.13, 95%CI: 0.03-0.29) and AET interventions (Δ=0.18, 95%CI: 0.03-0.33) .
- When directly comparing the effects of RET to AET, with RET serving as the intervention group and AET serving as the control group in Hedges' *d* calculations, no significant differences were found (Δ=-0.07, 95%CI: -0.22 to 0.09).

Univariate Moderator Analysis

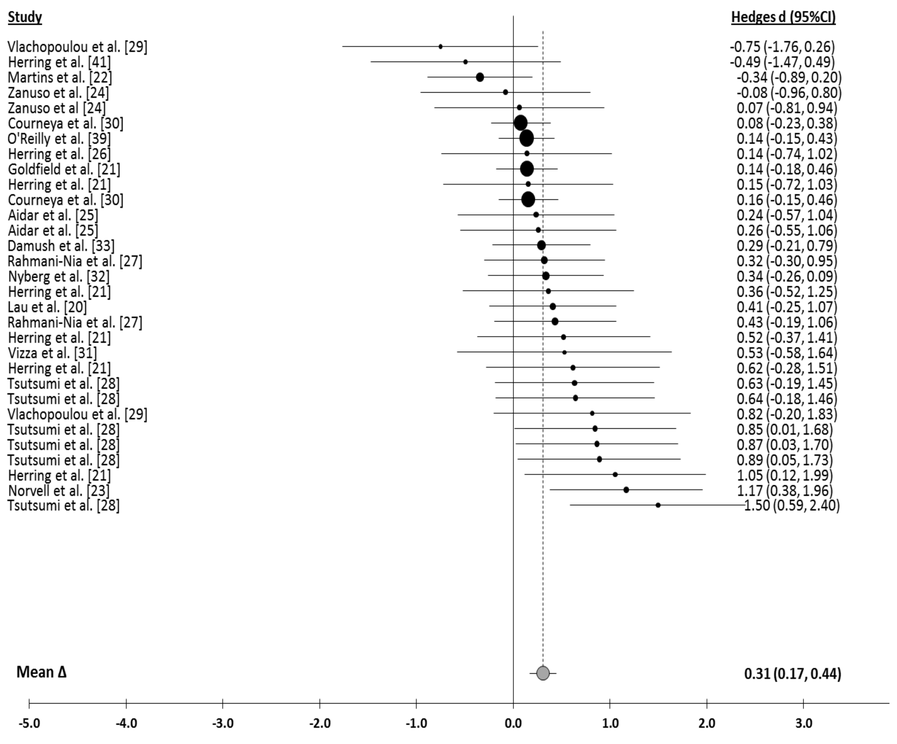
Effect moderator	Contrast weights	Effects (k)	Δ	95% CI	Contrast *p*-value
Sex					
Female	-1	16	0.44	0.24 to 0.63	0.07
Mixed	0.5	10	0.11	-0.06 to 0.27	
Male	0.5	5	0.43	-0.11 to 0.96	
Age(y)					
<25	0.5	10	0.31	0.11 to 0.51	0.56
25-54	0.5	8	0.26	-0.03 to 0.55	
55+	-1	12	0.40	0.13 to 0.66	
Health					
Healthy	1	13	0.50	0.22 to 0.78	0.03
Physical illness	-0.5	10	0.15	0.02 to 0.29	
Mental illness	-0.5	8	0.37	0.01 to 0.73	
Control					
No treatment	1	13	0.40	0.13 to 0.66	0.62
Usual care	-0.5	6	0.12	-0.08 to 0.32	
Wait list	-0.5	10	0.41	0.16 to 0.67	
Program					
<12 weeks	-1	14	0.28	0.18 to 0.50	0.68
12+ weeks	1	15	0.42	0.15 to 0.70	
Session					
<60min	-1	22	0.29	0.15 to 0.42	0.63
60+ min	1	7	0.33	-0.08 to 0.74	
Frequency					
2d/week	-1	8	0.41	0.13 to 0.70	0.56
3d/week	1	21	0.34	0.17 to 0.54	
Intensity					
Moderate	1	24	0.31	0.14 to 0.47	0.27
Vigorous	-1	6	0.47	0.14 to 0.80	
Supervised					
Combination	-1	5	0.10	-0.44 to 0.65	0.77
Yes	1	20	0.20	0.08 to 0.32	
Primary Outcome Anxiety					
No	-1	8	0.16	0.01 to 0.31	0.07
Yes	1	23	0.42	0.22 to 0.61	
State vs. Trait					
State	-1	22	0.27	0.12 to 0.43	0.17
Trait	1	9	0.42	0.16 to 0.69	
Significant Improvement in Strength					
Yes	1	21	0.37	0.20 to 0.54	0.24
No	-0.5	2	0.18	-0.07 to 0.43	
Not reported	-0.5	8	0.20	-0.17 to 0.56	

Participant & Trial Characteristics

Study	Measure	Intensity	Duration(wk)	Participant characteristics	Control	Sex	Age(y)	Hedges' d (ES ± 95%CI)
Aidar et al. [25]	STAI-S	Moderate	12	Ischemic stroke	Usual care	Mixed	43-60	0.26 (-0.55 to 1.06)
Aidar et al. [25]	STAI-T	Moderate	12	Ischemic stroke	Usual care	Mixed	43-60	0.24 (-0.57 to 1.04)
Courneya et al. [30]	STAI-S	Moderate	Mid-treatment	Breast-cancer	Usual care	Female	25-78	0.16 (-0.15 to 0.46)
Courneya et al. [30]	STAI-S	Moderate	Post-treatment	Breast-cancer	Usual care	Female	25-78	0.08 (-0.23 to 0.38)
Damush et al. [33]	MHFI-A	Moderate	8	Elderly	Wait list	Female	62-74	0.29 (-0.21 to 0.79)
Goldfield et al. [21]	BRUMS-T	Moderate	22	Obese adolescents	No treatment	Mixed	14-18	0.14 (-0.18 to 0.46)
Herring et al. [26]	POMS-T	Moderate	2	GAD	Wait list	Female	18-37	0.62 (-0.28 to 1.51)
Herring et al. [26]	STAI-T	Moderate	2	GAD	Wait list	Female	18-37	0.14 (-0.74 to 1.02)
Herring et al. [26]	POMS-T	Moderate	4	GAD	Wait list	Female	18-37	0.15 (-0.72 to 1.03)
Herring et al. [26]	STAI-T	Moderate	4	GAD	Wait list	Female	18-37	0.36 (-0.52 to 1.25)
Herring et al. [26]	POMS-T	Moderate	6	GAD	Wait list	Female	18-37	1.05 (0.12 to 1.99)
Herring et al. [26]	STAI-T	Moderate	6	GAD	Wait list	Female	18-37	0.52 (-0.37 to 1.41)
Herring et al. [41]	HADS-A	Moderate	12	Morbidly obese	Usual care	Mixed	24-68	-0.49 (-1.47 to 0.49)
Lau et al. [20]	HADS-A	Vigorous	6	Obese adolescents	Usual care	Mixed	10-17	0.41 (-0.25 to 1.07)
Martins et al. [22]	POMS-T	Moderate	16	Elderly	No treatment	Mixed	65-95	-0.34 (-0.89 to 0.20)
Norvell et al. [23]	SCL-90	Moderate	16	Law enforcement personnel	Wait list	Male	25-40	1.17 (0.38 to 1.96)
Nyberg et al. [32]	HADS-A	Moderate	8	COPD	Other	Mixed	61-74	0.34 (-0.26 to 0.09)
O'Reilly et al. [39]	HADS-A	Low	36	People with knee pain	No treatment	Mixed	40-80	0.14 (-0.15 to 0.43)
Rahmani-Nia et al. [39]	STAI-S	Moderate	8	Untrained college students	No treatment	Not reported	20-23	0.43 (-0.19 to 1.06)
Rahmani-Nia et al. [39]	STAI-T	Moderate	8	Untrained college students	No treatment	Not reported	20-23	0.32 (-0.30 to 0.95)
Tsutsumi et al. [28]	STAI-T	Moderate	12	Elderly	No treatment	Female	60-86	1.50 (0.59 to 2.40)
Tsutsumi et al. [28]	STAI-S	Moderate	12	Elderly	No treatment	Female	60-86	0.87 (0.03 to 1.70)
Tsutsumi et al. [28]	POMS-T	Moderate	12	Elderly	No treatment	Female	60-86	0.63 (-0.19 to 1.45)
Tsutsumi et al. [28]	STAI-T	Vigorous	12	Elderly	No treatment	Female	60-86	0.89 (0.05 to 1.73)
Tsutsumi et al. [28]	STAI-S	Vigorous	12	Elderly	No treatment	Female	60-86	0.64 (-0.18 to 1.46)
Tsutsumi et al. [28]	POMS-T	Vigorous	12	Elderly	No treatment	Female	60-86	0.85 (0.01 to 1.68)
Vizza et al. [31]	DASS-21	Moderate	12	Polycystic ovarian syndrome	Usual care	Female	21-32	0.53 (-0.58 to 1.64)
Vlachopoulou et al. [29]	STAI-S	Moderate	8	Chemically dependent	No treatment	Male	22-43	-0.75 (-1.76 to 0.26)
Vlachopoulou et al. [29]	STAI-T	Moderate	8	Chemically dependent	No treatment	Male	22-43	0.82 (-0.20 to 1.83)
Zanuso et al. [24]	POMS-T	Vigorous	12	Elderly	Wait list	Mixed	65-78	0.07 (-0.81 to 0.94)
Zanuso et al. [24]	STAI-T	Vigorous	12	Elderly	Wait list	Mixed	65-78	-0.08 (-0.96 to 0.80)

Abbreviations: POMS-T, Profile of Mood States – Tension; SCL-90, Hopkins Symptom Checklist; STAI-T, State-Trait Anxiety Inventory – Trait; STAI-S, State-Trait Anxiety Inventory – State; MHFI-A, Mental Health Functioning Index – Anxiety; HADS-A, Hospital Anxiety and Depression Scales – Anxiety; DASS-21, Depression, Anxiety, and Stress Scale – 21; BRUMS-T, Brunel Mood Scale – Tension; GAD, generalized anxiety disorder; COPD, chronic obstructive pulmonary disease; ES, effect size; CI, confidence intervals

Forest Plot of Unweighted Distribution of Hedges' *d*



Future Research

- Clear and complete information regarding adherence, compliance, attendance, session duration, and intensity is needed.
- There is a critical lack of studies comparing RET and AET within the same study sample.
- Researchers should attempt to match RET with AET as best as possible on multiple relevant features of the exercise stimulus (e.g., intensity/load, time spent actively engaged in exercise, muscle groups exercised).
- The evidence regarding the effects of RET among individuals with an anxiety disorder and in those with subclinical levels of anxiety is limited. RCTs of RET effects on anxiety in those with subclinical or prodromal levels of anxiety are needed.

Conclusions

- The empirical evidence reviewed herein supports RET as a potential low-risk, alternative or adjuvant therapy for anxiety symptoms.
- Future trials should compare RET to other empirically-supported therapies for anxiety, examine plausible neurobiological mechanisms of the anxiolytic effects of RET, and more rigorously examine the optimal total resistance exercise dose required to improve anxiety.