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Bachelor's thesis in Human Movement Science
Supervisor: Stine Øverengen Trollebø
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Kunnskap for en bedre verden

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Abstract

Purpose: Anxiety symptoms can be characterized by excessive worrying or fear, often combined with unpleasant physical reactions. Psychiatric treatment for anxiety can be costly, waiting lists can be long, and medication can have unfortunate side-effects. This motivates the focus of this study, which is to examine the effect of aerobic exercise on anxiety symptoms. **Method:** The studies that are included were found through the databases PubMed and ScienceDirect 17.02.22. Only randomized controlled trials from the last 10 years that examined the effect of aerobic exercise on anxiety symptoms in healthy adults were included. Anxiety symptoms were measured by Anxiety sensitivity index (ASI), State-trait anxiety inventory (STAI) or Depression-anxiety stress scale (DASS-21). Eight trials were included in this literature review. **Result:** Seven of the eight trials indicated that aerobic exercise had a significant effect on reduction of anxiety symptoms**. Conclusion:** Based on the result there is reason to suggest that aerobic exercise in moderate intensity can produce positive acute effects on anxiety symptoms and may therefore be recommended as an expedient treatment for anxiety. More research is needed that involves a larger sample with different types of anxiety disorders, and that further examines the relationship with aerobic exercise and symptoms of anxiety.

Abstrakt

Bakgrunn: Symptomer på angst kan kjennetegnes av overdreven bekymring og frykt, ofte kombinert med ubehagelige fysiske reaksjoner. Behandling av angst kan ha høye kostnader og lange ventelister, og medisiner kan ha uheldige bivirkninger. Dette motiverer fokuset til denne studien, som er å undersøke effekten av aerob trening på angstsymptomer. **Metode:** Studiene som er inkludert ble funnet gjennom databasene PubMed og ScienceDirect 17.02.22. Kun randomiserte kontrollerte studier fra siste 10 år som studerte effekten av aerob trening på angstsymptomer hos friske voksne ble inkludert. Angstsymptomer ble målt med Anxiety sensitivity index (ASI), State-trait anxiety inventory (STAI) eller Depression-anxiety stress scale (DASS-21). Åtte studier ble inkludert i denne litteraturstudien. **Resultat:** Sju av de åtte studiene kunne vise til at aerob trening hadde signifikante effekter på reduksjon av angstsymptomer. **Konklusjon:** Basert på resultatet kan man anta at aerob trening i moderat intensitet gir gode akutte effekter på angstsymptomer og kan anbefales som en hensiktsmessig behandlingsform for angst. Det er behov for mer forskning som tar for seg et større utvalg med flere typer av angstlidelser, og som utforsker nærmere forholdet mellom aerob trening og symptomer på angst.

1. Introduction

Anxiety disorders are the most prevalent psychiatric conditions. According to epidemiological surveys, one- third of the population is affected by an anxiety disorder during their lifetime. They are more common in women. These disorders are associated with a considerable degree of impairment, high healthcare costs, and an enormous burden on society (1). Anxiety symptoms can be characterized by excessive worrying or fear, often combined with unpleasant physical reactions such as rapid heart rate, sweating, nausea, chills, trembling, and hyperventilating (2). Most studies show a high overlap among the anxiety disorders and between the anxiety disorders and other mental conditions, respectively (1).

Anxiety sensitivity (AS) refers to the tendency to fear body sensations associated with anxious arousal because of their perceived physical, psychological, or social consequences. AS has been identified as a risk factor for the development of anxiety-related psychopathology, particularly in panic disorders. AS intensifies the symptoms of anxiety disorders and appears to relate to many different anxiety symptoms and disorders. Research has also identified elevated AS as a risk factor for exercise avoidance (3,4). The Anxiety sensitivity index (ASI) is an assessment tool that measure AS (3). Other widely used assessment tools for measuring anxiety symptoms are the Stait-trait anxiety inventory (STAI) and the Depression anxiety stress scale (DASS-21) (5,6).

Anxiety disorders vary in degree of severity, from periods of mild discomfort to panic disorder. Depression is common for those with anxiety disorders. Pharmacological agents such as selective serotonin reuptake inhibitors (SSRIs) and various forms of cognitive behavioral therapy (CBT) are the frontline treatments for people with anxiety disorders and depression. Some of the side effects that accompany SSRIs are weight gain, sexual dysfunction, sleep disturbances, and elevated blood pressure (1,7).

To live with anxiety symptoms can be exhausting and have consequences on the quality of life of the ones affected. With the side effects of medications and long waitlists for treatment, aerobic exercise can be a feasible choice that can produce acute effects after only a single session (4,8). A growing body of literature has shown positive effects of aerobic exercise on anxiety symptoms (9). Some research has found that low cardiorespiratory fitness (CRF) predicts greater improvements in anxiety symptoms (10).

An acute bout of exercise is a physical stressor that activates the hypothalamic-pituitary-adrenal (HPA) axis. This causes an allostatic response that consists of a rapid increase in stress hormones that gradually returns to resting-state levels when the exercise ceases (11). Aerobic exercise is an easily accessible and efficient form of intervention for most individuals and requires minimal or no clinical contact.

Additionally, aerobic exercise may constitute a type of interoceptive exposure, evoking physiological changes such as elevations in heart rate (HR), muscle tension, shortness of breath and sweating, that mimic the anxiety responses of those with significant anxiety. Like other interoceptive exposure strategies, exposure to exercise-induced bodily sensations may facilitate learning that the sensations are discomforting but not catastrophic (9). Exercise can also affect the underlying factors of anxiety, like the risk of cardiovascular disease, sleep disturbances, and the sense of mastery (9). Exercise may reinforce adaptive beliefs that one has the power to influence his or her environment and bring out desired outcomes (9).

One previous trial has found evidence that aerobic exercise facilitates the effectiveness of CBT in panic disorder. The improvements in symptoms of anxiety due to a combination of CBT and aerobic exercise were not only held stable but even increased over time. The results from this trial confirmed an anxiolytic effect of regular aerobic exercise in moderate intensities, in contrast to light exercises without cardiovascular activation (12).

The American College of Sports Medicine (ACSM) defines aerobic exercise as "any activity that uses large muscle groups, can be maintained continuously, and is rhythmic in nature" (13). As the name implies, muscle groups activated by this type of exercise rely on aerobic metabolism to extract energy in the form of adenosine triphosphate (ATP) from amino acids, carbohydrates, and fatty acids. Examples of aerobic exercise include cycling, dancing, hiking, jogging/long- distance running, swimming, and walking. These activities can be assessed through the aerobic capacity, which is defined by the ACSM as "the product of the capacity of the cardiorespiratory system to supply oxygen and the capacity of the skeletal muscles to utilize oxygen" (13). Optimal aerobic exercise conditions require intensities from 60-90 % of maximum heart rate (13).

Possible implications for assessing aerobic exercise and anxiety symptoms might be regarding self-report bias (14), or timing of the outcome measurements (15). With anxiety being more prevalent in females, research regarding gender differences and menstrual cycle affecting changes in anxiety can be of importance (1,16).

While there is existing literature claiming that CBT and SSRI are efficient strategies in reducing anxiety symptoms (1,7), others claim that aerobic exercise appears to be just as effective, (17). The purpose of this literature review is therefore to determine whether aerobic exercise is an expedient strategy of reducing anxiety symptoms in adults.

2. Methods

2.1 Search strategy and selection criteria

A systematic literature search was conducted on February 17th, 2022, using the databases PubMed and ScienceDirect. The search consisted of combinations of the terms "anxiety", "anxiety sensitivity", "aerobic", "training" and "exercise. These terms were combined with Boolean operations AND/OR which gave a concise and accurate article outcome relevant to the theme. The search was restricted to randomized controlled trials completed within the last 10 years. All included studies had to be published in English and key terms were to be present in title or abstract. To be eligible for inclusion, the trials should examine the effect of moderate intensity aerobic exercise (55-85% of heart rate maximum (HRmax) or maximum heart rate reserve (HRRmax)) on anxiety symptoms in both male and female adults. Exclusion criteria were medical conditions or severe psychopathology, resistance training, high intensity interval training, sprint interval training or exercise combining medication or psychotherapy.

2.2 Trial selection and data extraction

The initial search resulted in 113 original articles, whereas 1 duplicate were removed. This led to 27 articles of interest based on title. After reading abstracts, nine articles were excluded based on exclusion criteria. Additional 18 full-text articles were critically assessed and ten of these were excluded. In conclusion, eight trials were chosen for this literature review *(See figure 1).* The anxiety assessment tools extracted from the trials were the State-trait anxiety inventory (STAI), the Anxiety sensitivity index (ASI) and the Depression anxiety stress scale (DASS-21; Subscale anxiety), excluding secondary and diagnose-specific outcome measurements. DASS-21 anxiety scale assesses autonomic arousal, skeletal muscle effects, situational anxiety, and subjective experience of anxiety affect. The ASI is a measure tapping the fear of anxiety sensations. In the ASI-3 version of the ASI these fears are divided into a physical, cognitive and social dimension. The STAI consists of questions regarding anxious feelings and symptoms you have right now (state), and in general (trait). Examples of what the STAI measures include feelings of apprehension, tension, nervousness, and worry (3,5,6).

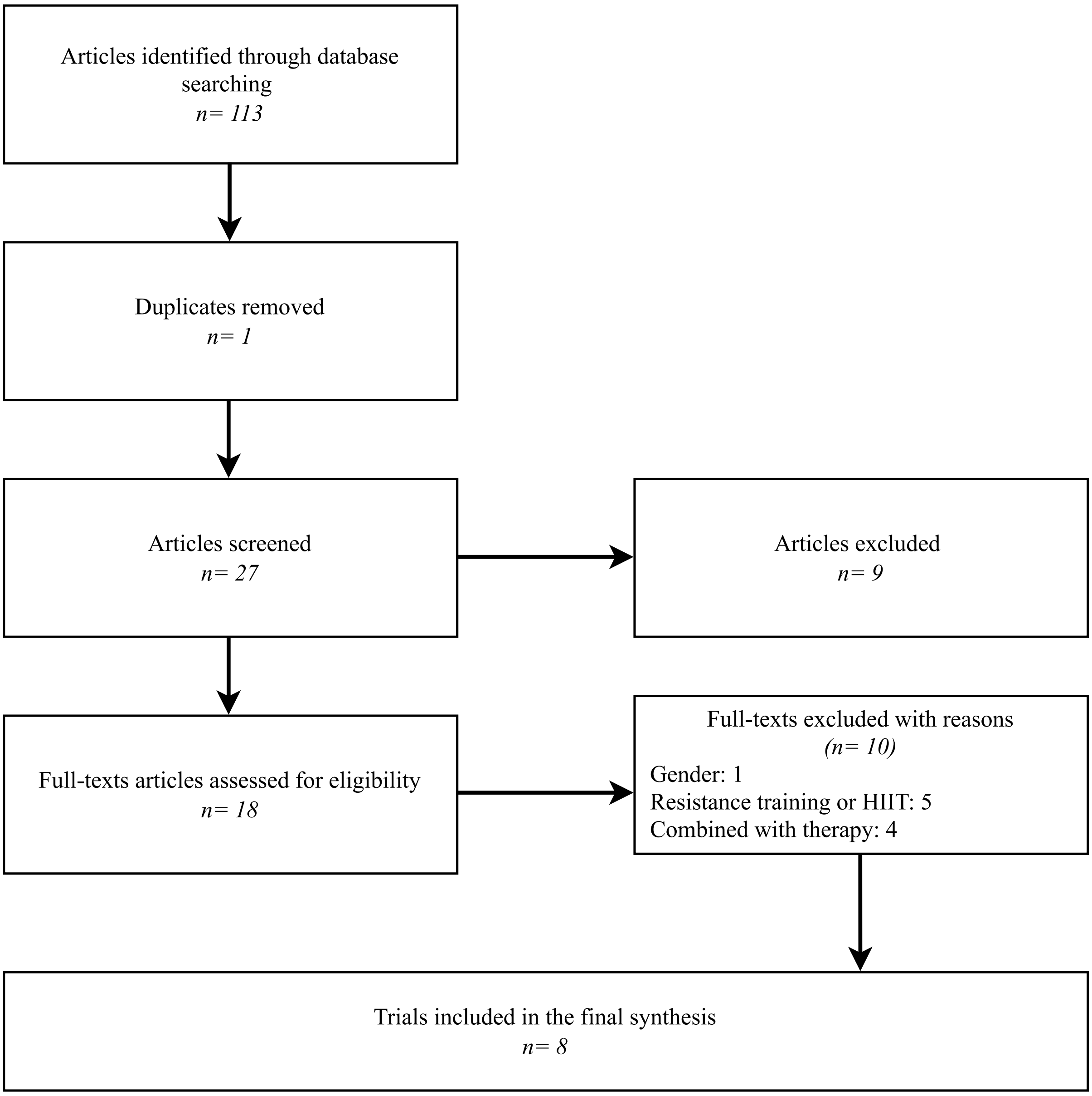

Figure 1: Flow chart of article conduction

3. Results

Eight trials (18–25) were included with a total of 491 participants that were either placed in an intervention group or a control group *(see Table 1).* All participants in the trials were considered as healthy but inactive individuals. Their activity level was evaluated by selfreports or physical tests at baseline. In all the trials there was an abundance of females. All the trials conducted a protocol where the aerobic exercise was performed continuously in moderate intensity, ranging from 20 minutes to 45 minutes respectively. Seven of the eight trials consisted of aerobic exercises performed on a stationary bicycle or treadmill while supervised by a health or training professional.

In the trial of McIntyre et a., (24) the participants performed the exercise on their own, and what type of exercise equipment used were not mentioned. In the trial of LeBouthillier et al., (18) exercise was performed with a pyramid-interval including sprints and active breaks. The trial of Fetzner et al., (20) included participants diagnosed with post-traumatic stress disorder (PTSD) or subsyndromal PTSD. In the trial of LeBouthillier et al., (25) the participants met the criteria for social anxiety or generalized anxiety disorder. The trial of Medina et al., (23) included participants with elevated anxiety, and in the remainder of the trials the participants did not have a diagnosis, or elevated anxiety were not a criterion.

Table 1: *Overview of included trials with descriptives*

Trial	Selection	Age	Outcome measure	Intervention
McIntyre et al., (2020) (18)	Total *(n)* = 119 Intervention *(n)* = 60 Control *(n)* = 59	20-45 years	STAI	**Intervention:** *Aerobic exercise* 55-65% week 1-2, 65-75% week 3-4, 80% HRmax in week 5-12 **Control:** *No exercise*
Lucibello et al., (2019) (22)	Total *(n)* = 42 Intervention (*n)* = 22 Controls *(n)* = 20	18-30 years	STAI-6	**Intervention:** *Aerobic exercise* 27.5 mins at 70-75 % HRmax **Control:** *No exercise*

Mason et al., (2018) (23)	Total *(n)* = 63 Intervention group 1 *(n)* = 21 Intervention group 2 *(n)* = 22 Control *(n)* = 20	18-65 years	ASI-3	**Intervention group 1:** *SIT – sprint interval* 3x20s sprints at 85% HRmax with active recovery of 2 mins **Intervention group 2:** *MICT - aerobic exercise* 45 mins continuous exercise at 70% HRmax **Control:** *No exercise*
LeBoutillier et al., (2017) (21)	Total *(n)* = 56 Intervention group 1 *(n)* =23 Intervention group 2 *(n)* =18 Control *(n)* =15	18-65 years	ASI-3 DASS-21	**Intervention group 1:** *Aerobic exercise* 40 minutes at 60-80 % HRRmax **Intervention group 2:** *Resistance training* 2-3 sets of 10-12 repetitions (legs, shoulders, chest, bicep, tricep and hamstring) **Control:** *No exercise*
LeBoutillier et al., (2015) (19)	Total *(n)* = 41 Intervention (*n*) = 21 Control (*n*) = 20	18-65 years	ASI-3	**Intervention:** *Aerobic exercise* 20 minutes at 60-80 % HRRmax **Control:** *Stretching* <50% HRRmax All participants were asked to avoid exercise for 48 h before participating in the trial
Medina et al., (2015) (24)	Total *(n)* = 60 Intervention (*n*) = 40 Control (*n*) = 20	*Mean age* 20.68 years	ASI	**Intervention:** *Aerobic exercise* 20 minutes at 60-80 % HRmax Verbal instructions to attend physical sensations and rate their level of subjective distress every 3 mins **Control:** *No exercise*

Broman-Fulks et al., (2015) (25)	Total *(n)* = 77 Intervention group 1 *(n)* = 25 Intervention group 2 *(n)* = 26 Control (*n)* = 26	*Mean age* 20.12 years	ASI-3 STAI-S	**Intervention group 1:** *Aerobic exercise* 20 minutes at 65-75% HRmax **Intervention group 2:** *Resistance training* 3 exercises (squats, bench press and lat pulldowns) Intensity and duration comparable to the aerobic exercise **Control:** *No exercise*
Fetzner et al., (2014) (20)	Total *(n)* = 33 Intervention group 1 *(n)* = 11 Intervention group 2 *(n)* = 11 Control *(n)* = 11	*Mean age* 36.9 years	ASI-3	**Intervention group 1:** *Aerobic exercise with cognitive distraction* Watched a nature documentary while exercising and answered questions **Intervention group 2:** *Aerobic exercise with intentional focus* Watched themselves in real-time video while focusing on somatic sensations in legs, upper body and breathing **Control:** *Aerobic exercise only* **All groups:** 20 minutes at 60-80% HRRmax Participants were asked to maintain their pre-treatment activity level throughout the trial

Abbreviations: *STAI(STAI-6, STAI-S) = State Trait Anxiety Inventory (Short form, Subscale), ASI (ASI-3)= Anxiety Sensitivity Index (3-dimensions of AS), DASS-21= Depression Anxiety Stress Scales-21, HRRmax = Heart rate reserve maximum, HRmax = Heart rate maximum*

Table 2: *Results from trials with reported outcome measure*

Trial	Intervention	Measure procedure	Difference between groups
McIntyre et al., (2020) (18)	**Intervention group:** *Aerobic exercise* 12-week exercise period 4 sessions per week 4 weeks deconditioning **Control:** *No exercise* Instructions to remain inactive for the full 16-weeks	STAI Baseline, post-intervention (week 12) and follow-up (week 16)	Treatment effect at post-intervention *Aerobic exercise vs control* 0.99 [0.93, 1.06] Treatment effect at follow-up *Aerobic exercise vs control* 0.94 [0.88, 1.01] *Results presented with beta coefficient [95% Cl]*
Lucibello et al., (2019) (19)	**Intervention group:** 9-week exercise period 3 sessions per week **Control:** *No exercise* Instructions to remain inactive for the full 9-weeks	STAI-6 Baseline, weekly at pre- and 10 mins post-exercise on the last training of the week *No follow up*	Pre-intervention vs weekly measures *Main effect of group* 19.72** *Group by week* 4.05** *Subgroup high anxiety* 3.60* *Subgroup low anxiety* 1.31 *Results presented with F value*

Mason et al., (2018) (20)	**Intervention group 1:** *SIT* Single session **Intervention group 2:** *MICT* Single session **Control:** *No exercise*	ASI-3 Baseline, post-exercise, 3-day and 7-day follow-up	SIT/MICT -5.20*/-6.70* SIT baseline to post-session *Social Cognitive Physical* -1.81 -1.31 -2.09* MICT baseline to post-session *Social Cognitive Physical* -2.10* -2.30* -2.30 SIT/MICT post-session to follow-ups *3-day* *Total:* 4.46 / 5.53 *7-day* *Total:* 1.06 / 1.34 *Results presented with Beta coefficient*
LeBouthillier et al., (2017) (21)	**Intervention group 1:** *Aerobic exercise* 4-week exercise period 3 sessions per week **Intervention group 2:** *Resistance training* 4-week exercise period 3 sessions per week **Control:** *No exercise*	ASI-3 DASS-21 Baseline, weekly every third session, 1-week and 1-month follow-up	ASI-3 *Aerobic exercise / Resistance training vs control* Pre- to post-intervention -3.78 / -13.10** *Results presented with Beta coefficient* DASS-21 anxiety *Aerobic exercise / Resistance training vs control* Pre- to post-intervention -4.75**/-2.41 *Aerobic exercise 1-week/1-month* -1.70/0.89 *Results presented with Beta coefficient*

LeBouthillier et al., (2015) (22)	**Intervention group:** *Aerobic exercise* Single session **Control:** *Stretching* Single session	ASI-3 Baseline, post-intervention, 3-day and 7-day follow-up	*Aerobic exercise vs control* Change from baseline to 7-day follow up *Total* *Cognitive* *Physical* *Social* -2.82* -0.37* -0.26* -0.52** Main effect of group *Total* *Cognitive* *Physical* *Social* 3.28* 0.05 1.53** 0.62 *Results presented with Beta coefficient*
Medina et al., (2015) (23)	**Intervention group:** *Aerobic exercise* 2-week exercise period 3 times per week **Control:** *No exercise*	ASI Baseline, mid-treatment, post-treatment and 3-week follow-up	*Aerobic exercise (treatment) vs control* Pre-treatment to follow-up Time Treatment Time*Treatment 50.21** 46.19** 20.67** *Results presented with F value*

Broman-Fulks et al., (2015) (24)	**Intervention group 1:** *Aerobic exercise* Single session **Intervention group 2:** *Resistance training* Single session **Control:** *No exercise* ***Post CO2:*** Both intervention groups performed a CO2 task after exercising	ASI-3 Baseline, 5-min post-exercise, post-CO2 STAI-S Baseline, 5-min post-exercise	*Aerobic exercise vs control* Baseline to post-CO2 Main effect for time: 56.84** Group by time: 5.88** Simple effect of time *Aerobic exercise:* 26.35** *Resistance training:* 25.81** *Rest (control):* 5.65 *Results presented with F value* No significant time or interaction effects for STAI-S
Fetzner et al., (2014) (25)	**Intervention group 1:** *Aerobic exercise with cognitive distraction* **Intervention group 2:** *Aerobic exercise with intentional focus* **Control:** *Aerobic exercise only* 2-week exercise period 3 session per week for all groups	ASI-3 Baseline, post-exercise, 1-week and 1-month follow-up	*Intentional focus vs cognitive distraction* Pre-treatment to follow-ups Total *Physical* -4.39** -4.39** *Intentional focus vs aerobic exercise* *Total Physical* -2.26** -2.26** *Presented with t value* *Cognitive distraction* ASI-3 total: 2.53 *Intentional focus* ASI-3 total: 0.69 *Aerobic exercise only* ASI-3 total: 0.96 *Presented with cohen effect size*

<u>*Abbreviations:*</u> *STAI(STAI-6, STAI-S) = State Trait Anxiety Inventory (Short form, Subscale), ASI (ASI-3)= Anxiety Sensitivity Index (3-dimensions of AS), DASS-21= Depression Anxiety Stress Scales-21, *p=<0.05, **p=<0.01*

12-weeks exercise period

McIntyre et al., (18) examined the effect of aerobic exercise on subclinical negative affect on healthy but sedentary adults. After the 12-week exercise period, participants were instructed to refrain from any type of exercise for four weeks. The participants randomized to the control group were asked to remain physically inactive for the full 16-weeks of the trial. The change in STAI-scores from baseline to post-exercise (week 12) and follow-up (week 16) were not significant for the aerobic exercise or the control group *(see Table 2).*

9-weeks exercise period

Lucibello et al., (19) examined the training effect on state anxiety response to an acute bout of exercise in low and high anxious individuals. Beck anxiety inventory was assessed at the onset of the trial to divide the participants into a high or low anxious subgroup. The control group was told to continue their current level of physical inactivity for the nine-week intervention, and they were not informed about how changes in activity can affect anxiety symptoms. STAI-6 was measured each week during the intervention, right before and ten minutes after the last exercise of the week. Two STAI-6 questionnaires were administered to the control group via email, 40 min apart every Friday. The differences between the groups were significant [p=<0.01], and STAI-scores significantly reduced in the subgroup with high anxiety [p=<0.05]. There was no effect of exercise in the low anxiety group *(see Table 2).*

4-weeks exercise period

LeBouthillier et al., (21) examined the efficacy of aerobic exercise as a transdiagnostic intervention for anxiety- related disorders and constructs. ASI-3 and DASS-21 assessments were completed weekly (i.e., approximately every third session), and participants in the control group completed the assessments from home for the duration of the trial phase. At one-week follow-up, participants met with the personal trainer and completed the same assessments. Participants were told to complete the same set of questionnaires at the one-month follow-up. There were no significant changes in ASI-3-scores for the aerobic exercise group compared to resistance training or the control group. For the DASS-21 (anxiety subscale) the results from the aerobic exercise group were associated with a significant reduction relative to the waitlist from pre- to post-intervention [p=<0.01]. No significant changes compared to post-intervention were observed at one-week or one-month follow-up for aerobic exercise *(see Table 2).* There was found an association between low physical fitness and larger reduction in anxiety scores [p=<0.05] for DASS-21.

2-weeks exercise period

Medina et al., (23) examined the effect of moderate aerobic exercise on anxiety sensitivity. During the exercise intervention the participants got verbal instructions to be attentive to the sensations experienced, and they were asked by the protocol therapist to rate their level of subjective distress every three minutes during exercise. The ASI was handed out to all participants at four separate time points: pre-treatment, mid-treatment, post-treatment, and at three-week follow-up. Participants assigned to the control group completed assessments at the same time intervals but did not participate in the exercise. There was observed a significant main effect for time and aerobic exercise [p=<0.01], indicating a general improvement over time and lower scores in the exercise group versus control, respectively (*see Table 2).*

Fetzner et al., (25) examined how aerobic exercise can reduce symptoms of posttraumatic stress disorder (PTSD). Participants were asked to maintain their usual physical activity level throughout the study. The intervention groups consisted of two groups. The aim of group one (CD) was to direct attention away from the uncomfortable and potentially distressing somatic sensations engendered by aerobic exercise. The aim of group two (IP) was to increase attention to somatic sensations brought on by aerobic exercise. The exercise-only (EO) group served as a control group. Following the training sessions, outcome measures were completed. Participants were contacted one-week and one-month post treatment to complete follow-up measures. Anxiety sensitivity (AS) significantly decreased more in CD and EO groups [p=<0.01]. The effect sizes for change in AS during treatment for the EO group were large implying that this finding have a practical significance *(see Table 2).*

Single session of exercise

Broman-Fulks et al., (24) examined the effects of a single session of aerobic exercise versus resistance training on cognitive vulnerabilities for anxiety disorders. Five minutes after completion of their respective exercise/rest condition, participants completed the baseline series of assessments a second time and were given instructions regarding a CO2 inhalation task. After finishing the task participants rested quietly until any lingering anxiety symptoms subsided, and then completed the ASI-3 a third time. STAI-scores were measured at baseline and once post-exercise. Results indicated that participants in the aerobic exercise group reported greater reductions in ASI-3 scores from baseline to post-exercise compared to control [p=<0.01], and the difference between groups over time were also significant [p=<0.01]. The change in ASI-scores from post-exercise to post-CO2 was not significant. There were no significant findings for STAI-scores *(see Table 2).*

LeBouthillier et al., (22) examined the effect of a single session of aerobic exercise on anxiety sensitivity. ASI-3 scores were assessed immediately after the intervention, and then again at a three-day and seven-day follow-up. Participants were asked to avoid exercise for 48 h before participating in the trial and, if possible, to avoid exercise until they completed both follow-up questionnaires. Participants in the control group performed a stretching routine for the same duration as the aerobic exercise. Results showed that the reductions in ASI-3 total and subscale scores was significant for the aerobic exercise group [p=<0.05] *(see Table 2).*

Mason et al., (20) examined how a single session of either sprint interval training (SIT) or moderate intensity continuous training (MICT) reduces anxiety sensitivity. Participants assigned to one of the exercise groups completed their exercise paradigm and then completed post-session measures of the ASI. Participants assigned in the control group completed the post-session measures right away. Finally, all participants were instructed to complete follow-up surveys that were emailed to them at three- and seven-days following the in-lab session. Compared to the control group, ASI-3 scores were significantly reduced following the MICT exercise [p=<0.05]. For the AS dimensions, the MICT exercise showed significant findings for the cognitive and social concerns [p=<0.05], not for the physical concerns. Results indicated that ASI-3-scores at both follow-ups were not significantly different from post-in-lab session scores *(see Table 2).*

4. Discussion

4.1 Main findings

The purpose of this literature review was to determine whether aerobic exercise is an expedient strategy in reducing anxiety symptoms in adults. In all the included trials except for the trial of McIntyre et al., (18), both single-session and longer interventions of aerobic exercise significantly reduced anxiety symptoms. There is evidence to suggest that the effects of exercise are not sustained nor increased if the aerobic exercise is not maintained. The acute positive effects of at least 20-minutes of aerobic exercise on anxiety symptoms corresponds well with previous research (4,8,9).

4.2 Outcome measures and acute effects

Most of the trials measured anxiety symptoms using the ASI-3 or STAI assessment tools. Two of the eight trials conducted the ASI-3 and STAI, or ASI-3 and DASS-21 simultaneously. Broman et al., (24) found contradicting results where significant results occurred for the ASI-3 there were no significant findings for the STAI. In the same manner, LeBouthillier et al., (21) found significant results for DASS-21 anxiety subscale whereas no significant results for the ASI-3. Consequently, this can raise doubts if the measurements are comparable across trials when the results within the same trial indicate inconsistent findings. All assessment tools target a variety of anxiety symptoms but differ in the symptoms and fears they cover. For instance, the ASI consists of questions related to the "fear of fear" and physical sensations, while the STAI addresses how you feel right now (state) and how you feel in general (trait). The DASS-21 anxiety subscale share similarities with both STAI and the ASI (3,5,6). That the participants in most of the trials were not pre-selected based on high anxiety scores could be another explanation for inconsistent findings.

Frequency and timing of measurement can affect the results. Only two of the trials reported how long after the exercise the measurement took place. First, Lucibello et al., (19) reported conducting the measurement at ten minutes post-exercise at the last training of the week in a nine-week intervention. Measures weekly could be a strength, since this will show how the aerobic exercise effect symptoms over time. Besides, measures more frequently can take more account of day-to-day changes in anxiety. Sleep or menstrual cycle is shown to have an effect at increasing anxiety symptoms (9,16). Secondly, Broman et al., (24) conducted the measurement five minutes post-exercise in a single session intervention. Because of the arousal effects and physiological mechanism arising from exercise, five minutes might be too short of a time period. This is consistent with other research findings (15) suggesting that reductions in state anxiety were observable at 30 minutes post-exercise, but not five minutes after exercise. Since the physical sensations from exercise and anxiety symptoms have similarities, it is important to have in mind that participants might misinterpret the signals.

The longest intervention of the included trials were McIntyre et al., (18) for 16-weeks total. This trial did not find any significant reduction in anxiety symptoms at post-exercise or follow-up. Anxiety symptoms were measured only post-intervention (week 12) and follow-up (week 16). As there were no measurements of anxiety conducted in between the sessions in the intervention this could be one of the reasons there was no significant findings. Besides, this trial had a deconditioning period after the intervention, which means that the participants were asked to stay sedentary during these weeks. The absence of exercise might contribute to an increase in anxiety symptoms. All the other trials included exercise sessions of at least 20 minutes, (19–25) and found significant reductions at post-exercise after a single-session and over time in the intervention. Only two trials (23,25) found improvements over time when follow-up measures were included. One explanation for the results from the follow-up measures might be the participants change in exercise habits. If the participants stopped exercising after the interventions, this could explain that most of the trials did not find significant changes or improvements at follow-up.

4.3 Anxiety and inactivity

In one of the trials (25) participants placed in the intervention group were instructed to maintain their pre-treatment activity level, one (22) where to refrain from activity 48h before and in others this was not stated (18–21,24). Most of the participants in the trials included in this literature review were considered inactive. This gives reason to assume that they did not perform any exercise in their free time that could have interfered with the results, at least not during the intervention. The trial of LeBouthillier et al., (21) found a significant association between lower cardiorespiratory fitness (CRF) and larger reductions in anxiety scores. It is possible that individuals with lower levels of CRF were more avoidant of certain activities (e.g., physical exertion). Engaging in aerobic exercise may have increased exposure to interoceptive cues and therefore were able to benefit more greatly in these trials. This is supported by previous research where lower CRF were associated with greater reductions in anxiety sensitivity (10).

The trial of Lucibello et al., (19) found significant reduction in anxiety symptoms for the high anxious group, but not in the low anxious group. These results suggest that higher anxiety at baseline can predict greater reductions in anxiety scores. One possible explanation for this is how the stress system (HPA axis) of highly anxious individuals may have adapted to provide a faster rebound from the physical exercise stressor and therefore greater psychological symptom relief (11). One possible factor contributing to this could also be the association with low physical fitness. It is reason to suggest that as most of the participants were inactive, they would have greater potential for reductions in anxiety symptoms.

4.4 Strength and limitations

All trials were RCTs that included both men and women. This review included both single sessions and longer intervention which presents an overview of the acute-effects and long-term effects of aerobic exercise on anxiety symptoms. All trials except for the trial of McIntyre et al., (18) were supervised interventions to ensure correct intensities while exercising. In this trial the aerobic exercise and heart rates were self-reported which can affect the validity of the results (14). A majority of the trials measured anxiety symptoms with the ASI or ASI-3. A study of Wheaton et al., (3) studied the dimensions of ASI scales and found it broadly acceptable to a variety of anxiety disorders. A review of the STAI concludes that it has numerous strengths to use as a significant measure of anxiety (5), and research has also supported the validity of the DASS-21 (6).

Since most of the participants were inactive, mastery and self-efficacy might also be factors contributing positively for those not engaging regularly in exercise. Mastery stemming from exercise-related successes appears to counteract catastrophic thinking characteristics of anxious individuals, further increasing feelings of mastery and self-efficacy that can reduce psychological distress (9).

There were two trials with an active control group (22,25). Previous research comparing moderate aerobic exercise with a lower intensity control group on anxiety sensitivity found improvements in the control group (8). Although the moderate aerobic exercise showed greater improvements, it could be a strength that most of the trials in this review used inactive controls.

In all included trials there was a small sample size where most of the participants were females. Females are more prone to anxiety than men from a genetic and physiological perspective (1). There is also research to support an association between the menstrual cycle and increased anxiety (16). Only two trials examined the effect of aerobic exercise on anxiety symptoms on individuals diagnosed with an anxiety disorder (21,25). Future research should aspire to examine a less homogenous group. It could be interesting to look closer into the dose-response relationship between aerobic exercise and anxiety symptoms, including a variety of anxiety disorders and activity levels.

5. Conclusion

This literature review provides strong evidence that aerobic exercise is an expedient strategy in reducing anxiety symptoms in adults, both healthy and diagnosed. The acute positive effects of aerobic exercise on reducing anxiety symptoms makes it a suitable treatment option. There is reason to suggest that exercise must be maintained for the effects to extend.

Further knowledge about aerobic exercise and exercise adherence in relation to reducing anxiety symptoms can be valuable for therapists and health-care professionals, as aerobic exercise is without any negative side-effects and can be performed at once without any excessive costs.

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