

From The Department of Global Public Health
Karolinska Institutet, Stockholm, Sweden

EFFECTS OF EXERCISE ON ALCOHOL USE DISORDERS

Victoria Gunillasdotter



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EFFECTS OF EXERCISE ON ALCOHOL USE DISORDERS

THESIS FOR LICENTIATE DEGREE

By

Victoria Gunillasdotter

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Principal Supervisor:

Assistant Professor Mats Hallgren
Karolinska Institutet
Department of Global Public Health

Co-supervisor(s):

Professor Sven Andréasson
Karolinska Institutet
Department of Global Public Health

Professor Maria Jirwe
Swedish Red Cross University
Department of Health Sciences

Examination Board:

Professor Mattias Damberg
Uppsala University
Department of Public Health and Caring Sciences

Professor Kirsten Roessler
University of Southern Denmark
Department of Psychology

Associate Professor Fredrik Spak
Sahlgrenska University Hospital, Göteborg

To my daughter, Iman

POPULAR SCIENCE SUMMARY OF THE THESIS

Do you drink too much and exercise too little? Have you had thoughts of wanting to change your drinking habits, but undergoing alcohol treatment feels distant? Are you still struggling to get started with that exercise routine? Well, you are not alone.

Most individuals with problematic alcohol consumption, referred to as having an alcohol use disorder, are living a socially stable life with permanent employment, housing, and a family. A majority of these individuals are highly aware of excessive drinking being detrimental for their health and well-being. However, many are reluctant to seek the help offered by health care or the municipal social services. Reasons for this may vary but stigma, shame, and a desire to take care of the problem on one's own are common explanations.

Moreover, many individuals with alcohol use disorders are not getting enough exercise. As might be expected, having two unhealthy behaviors increase the risk of bad health, including developing diseases such as diabetes, heart disease and cancer. Unhealthy habits seem to cluster. However, the good news is that healthy behaviors cluster as well. What is even better is that the effects from exercise, besides improving your physical health and fitness in general, may have a positive effect on mood and reduce stress and anxiety, symptoms that often make it difficult to change alcohol habits. Multiple health behavior change is a concept that promote change in more than one behavior at a time and is suggested to have greater impact on health than if an individual only focuses on changing one. What if you could focus on primarily changing your exercise habits while improving you drinking habits?

This thesis suggests that a change of alcohol habits could be easier to accomplish in the form of a lifestyle change with a focus on increased exercise. A randomized controlled trial was set out to investigate if exercise alone can help reduce alcohol consumption in those who do not seek treatment for their alcohol use disorder. In the study, 140 individuals were randomly allocated to perform either aerobic exercise or yoga or were assigned to a control group, receiving telephone counselling about their alcohol habits. At twelve weeks, both exercise groups had decreased their alcohol consumption, from around 20 drinks per week to 13-15 drinks per week. This decrease was more or less equivalent to a bottle of wine, and a result from the participants exercising on average once a week. Although neither aerobic exercise nor yoga were found to be better than the control group, the decrease of consumption in the exercise groups was similar to the decrease for those receiving phone counselling. Furthermore, the study found that exercise did not necessarily have to be high intensity, as yoga tended to reduce alcohol consumption more than aerobic exercise.

By interviewing some of the participants in the exercise groups, the study found that the decrease in alcohol consumption was a result of reduced alcohol craving and better mood states following exercise. In addition, exercise improved the participants fitness, sleep, energy, and physical strength. The study also observed that exercising could be rewarding, making alcohol intake unnecessary. However, these effects were shown to be highly dependent on individual preferences of the type of exercise. Enjoyment seemed to be a key

factor if one experienced exercise as positive or not, and hard-earned efforts from the gym and success of having changed exercise habits could eventually increase the individual's self-esteem and self-confidence to change alcohol habits.

Nevertheless, to develop a new habit can be just as difficult as ending an old one and undertaking a new exercise regimen is in no way different. Results from the study showed that factors making it easier to start new exercise behaviors, besides enjoyment, were weekly planning, easy access to the gym and monitoring of the progress.

Given low treatment rates for alcohol use disorders, these findings are of relevance as it is of importance to find effective, attractive, and easily accessible treatments for those in need. A lifestyle change with a focus on increased exercise may be such a treatment.

ABSTRACT

Background: Alcohol use disorders are common, yet highly undertreated. Major barriers for not seeking treatment are stigma, lack of problem awareness, and the desire to self-manage the problem. In addition to health consequences resulting from harmful alcohol consumption, there are reports that individuals with alcohol use disorders are physically inactive. Exercise is a non-stigmatizing treatment option associated with positive health outcomes, both in terms of physical health and mental health. The aim of this thesis is to evaluate if exercise can help reduce alcohol consumption in non-treatment seeking adults with alcohol use disorders.

Method: Study I was a randomized controlled trial (n=140) evaluating the change in weekly alcohol consumption at the end of a 12-week intervention, comparing aerobic exercise, yoga, and treatment as usual (phone counselling). In Study II, the aim was to narratively describe the experiences of yoga and aerobic exercise among non-treatment seeking adults with alcohol use disorder. Data was collected through individual semi-structured interviews with twelve participants from Study I.

Results: In Study I, the within-group reductions in weekly consumption were statistically significant in all three groups, but no group differences were found at follow-up. Compared to treatment as usual the per-protocol analyses favored yoga compared to aerobic exercise. Study II identified one main category; Motivating and maintaining a lifestyle change including four generic categories: (a) Initiating factors for lifestyle change, (b) Influencing lifestyle change, (c) Influencing physical and mental health and (d) Influencing alcohol consumption.

Conclusion: Exercise is an attractive treatment option for non-treatment seeking individuals with alcohol use disorders. Changing alcohol habits may be easier to accomplish when presented as part of a larger lifestyle change, with focus on increased exercise. A 12-week exercise program has effects on alcohol consumption comparable to usual care, and yoga-based exercise tends to reduce consumption more than aerobic exercise. Self-selected exercise may increase compliance, strengthen the mood-enhancing effects of exercise, and as a result reduce alcohol cravings and the need to drink. The success of changing exercise habits may reinforce the individual's self-esteem and self-efficacy and consequently increase the individual's motivation to change the drinking habits.

LIST OF SCIENTIFIC PAPERS

- I. **Gunillasdotter V**, Andréasson S, Jirwe M, Ekblom Ö, Hallgren M. Effects of exercise in non-treatment seeking adults with alcohol use disorder: a three-armed randomized controlled trial (FitForChange). *Drug and Alcohol Dependence*. 2022:109266.

- II. **Gunillasdotter V**, Andréasson S, Hallgren M, Jirwe M. Exercise as treatment for alcohol use disorder: a qualitative study. *Drug and Alcohol Review*. 2022 (accepted manuscript).

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LIST OF ABBREVIATIONS

ANCOVA	Analysis Of Covariance
ANOVA	Analysis Of Variance
AUD	Alcohol Use Disorders
AUDIT	Alcohol Use Disorders Identification Test
CBT	Cognitive Behavior Treatment
CI	Confidence Interval
DALY	Disability-Adjusted Life Years
DSM	Diagnostic and Statistical Manual of Mental Disorders
GGT	Gamma-Glutamyl Transferase
HPA-axis	Hypothalamic Pituitary Adrenal axis
ICD	International Classification of Disease
IPAQ	International Physical Activity Questionnaire
ITT	Intention-To-Treat
MDD	Major Depression Disorder
MET	Motivational Enhancement Therapy
MetS	Metabolic Syndrome
MHBC	Multiple Health Behavior Change
PA	Physical Activity
PAP	Physical Activity on Prescription
PEth	Phosphatidylethanol
PP	Per-Protocol
PT	Personal Trainer
RCT	Randomized Controlled Trial
SATS	Sport Aerobic Training Center
SD	Standard Deviation
SUD	Substance Use Disorders
TAU	Treatment As Usual
TLFB	Time-Line-Follow Back
T2D	Type 2 Diabetes
WHO	World Health Organization

1 PREFACE

As a nurse working with treatment of alcohol dependence, I have always had a salutogenic approach to the patient's health. Despite illness, I find it important to also pay attention to factors that can help maintain health despite stressful conditions. Therefore, I was very glad when given the opportunity to be part of a project that evaluated exercise as treatment for alcohol use disorders. Health benefits of regular exercise are known to be synergetic; exercise is therefore a fundamental factor for health.

Alcohol use is unproblematic for most individuals and can be enjoyable on special occasions. However, for some the use becomes problematic and harmful, not only on an individual level but also for the person's surroundings and society at large. The reduction of harmful use of alcohol is, as a consequence, of great public health concern and the aim of a global strategy from the World Health Organization's (WHO) (1). One main concern is that the vast majority of individuals with problematic alcohol use do not seek available treatments provided by the municipal social services or the regional health care. Thus, other forms of effective, attractive, and easily accessible treatments are required for those in need.

This thesis aims to investigate if exercise can help reduce alcohol consumption in non-treatment seeking adults with alcohol use disorders.

2 LITERATURE REVIEW

2.1 THE HARMFUL USE OF ALCOHOL

Harmful use of alcohol is, in its comprehensive definition by the WHO, defined as alcohol consumption that either increases the risk or, causes detrimental health and/or social consequences for the individual, the people around the individual, and for society at large. In 2016, the harmful use of alcohol led to an estimated three million deaths worldwide and accounted for five percent of the total global disability-adjusted life years (i.e., years lost to premature mortality and years lived with disability, DALYs) (2).

The medical condition alcohol use disorder (AUD) is one of the most common mental disorders, with a global prevalence estimated at five percent (3). In Sweden, recent estimates are higher with 11% of the adult population fulfilling the criteria for alcohol use disorders. More men (13%) than women (9%) are affected, and a clear majority have a mild-to-moderate dependence (4). The total annual cost in Sweden for socio-economic consequences due to alcohol consumption has been estimated to SEK 101 billion (5).

2.1.1 Dimensions of harmful use

Depending on a person's drinking pattern and the volume of intake there is a spectrum of alcohol related health- and social consequences. Problematic consumption can be defined as follows:

Hazardous consumption is defined as alcohol consumption that *increases the risk* of negative health or social outcomes. Although there is no 100% risk-free level of consumption, and no international consensus regarding guidelines (6), Sweden has recommendations not to exceed a weekly consumption of 14 standard drinks for men and nine for women, or more than four respectively three drinks per drinking occasion. One standard drink contains 12 grams of pure ethanol (7).

Harmful use is when the consumption is *already causing* negative physical, mental and/or social and occupational consequences. Harmful use of alcohol does not have to be the result of daily consumption, it can also be due to drinking too much on one occasion (i.e., heavy drinking) (2).

Dependence is a condition with behavioral, cognitive, and physiological consequences. In health care and research, the International Classification of Diseases (ICD version 10; soon to be replaced by version 11) and the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) are used to set the diagnosis. In this thesis the medical condition alcohol use disorder from the DSM-5 is used. Key features include drinking more than intended, the need to increase intake to obtain desired effect (tolerance) and alcohol craving. The latter criterion was introduced in the updated DSM-5 version from 2013. To get the diagnosis AUD, one must fulfill minimum two of 11 criteria during the past 12-months. The condition is described as a continuum with mild, moderate or severe dependence (8).

*Table. 1 DSM-5 diagnostic criteria for alcohol use disorder**

Drinking more than intended regarding amounts or period
Unsuccessful in cutting down or control the use of alcohol
Spending a lot of time to obtain, use or recover from alcohol
Craving, or strong urge for alcohol
Alcohol use causing a negative impact on obligations at work, school, or home
Intake despite negative social consequences
Alcohol intake causing a neglect of other activities
Drinking in hazardous situations
Drinking despite physical or psychological health problems
Tolerance: the need to increase the amount to achieve desired effect or, a decreased effect when using the same amount
Withdrawal when reducing alcohol or, the use of alcohol to avoid withdrawal

**At least two symptoms in the past one year. Mild disorder; 2-3, Moderate disorder 4-5; Severe disorder ≥ 6 .*

2.1.2 Consequences for health

Alcohol consumption has been linked to more than 200 diseases, most of them with a dose-response relationship with higher risks the more consumed (9). Harms of alcohol use can be divided into acute and chronic harms. Acute harms can be accidents or self-inflicted harm leading to injuries or death, or as acute toxic effects caused by alcohol poisoning. Chronic harms include noncommunicable diseases such as cardiovascular diseases, diabetes, and cancers. As a consequence of both acute and chronic harms, men with AUD identified in the general population have a mortality rate two times higher compared to those without AUD (10). In a meta-analysis, assessing cause specific mortality risks in AUD patients compared with the general population, the excess mortality rates for those with AUD were more than ten-fold for liver cirrhosis, seven-fold for dying due to injury, and two-fold for cardiovascular and cancer deaths (11). Also of concern, is that available evidence suggests that one in five (22%) has metabolic syndrome (MetS), and one in ten (10%) has type 2 diabetes (T2D), reflecting a generally poor health status among those with AUD compared with the general population (12, 13).

In addition to co-existing somatic diseases, AUD can co-occur with other mental disorders. According to epidemiological studies in the USA, the lifetime prevalence of AUD and major depression disorder (MDD) ranges from 30% to 40% (14). A meta-analysis examining the

co-morbidity between substance use, mood, and anxiety disorders in non-clinical populations found that the odds for developing MDD or anxiety disorder was 2.4 and 2.1 times higher respectively for individuals with AUD (15).

2.2 TREATMENT FOR ALCOHOL USE DISORDERS

In Sweden, treatment of alcohol use disorders is available in specialist care, primary health care, occupational health care and is also offered by the municipal social services. Current recommended treatment options include pharmacological treatment (naltrexone, acamprostate, disulfiram), motivational enhancement therapy (MET), cognitive behavior treatments (CBT) and 12-step programs (Alcoholics Anonymous) (16). However, none of these treatments directly targets poor somatic health or low physical fitness.

A challenging problem is that the demand for treatment is low. Epidemiological studies have exposed a large gap between the number of individuals with the disorder and those receiving treatment (17). Estimates from a national survey in the USA show that the prevalence of alcohol treatment is 25% among those with a lifetime diagnosis of AUD (18). In Sweden, treatment seeking has been found to be even lower, with estimates of seven percent (19). Those treated have shown to have a more severe AUD, with higher consumption, more co-morbidity and more unstable social situations (20).

2.2.1 Barriers to treatment

Several factors have been associated with non-treatment seeking. Such as stigma related to diagnosis and treatment, lack of problem awareness, privacy concerns, and the desire to autonomously manage the problem (21, 22). A Swedish study interviewing individuals with AUD from the general population showed that there was also a strong wish to handle the alcohol problem by making a lifestyle change. The authors concluded that one way to increase treatment seeking would be to offer treatment options that allow autonomy (23). Furthermore, there are reports that spontaneous recover from AUD often occur with concomitant health behavior changes, such as changes in diet and exercise habits (24, 25). This supports the concept of lifestyle change as treatment.

2.3 EXERCISE AND HEALTH

Exercise is, by definition, a sub-category of physical activity (PA) that is planned, structured and repetitive, with the purpose to improve or maintain physical fitness or health (26). The Public Health Agency of Sweden follows the recommended guidelines by WHO that adults, 18 years and over, should be physically active a minimum of 150-300 minutes per week of at least moderate intensity (increased heart rate and respiration). For high intensity activities (marked increased heart rate and respiration) the recommended time is 75-150 minutes (26). For rates of exercise intensity (exertion), see table 2.

There is strong evidence supporting that regular exercise reduces the risk of many diseases and premature death (27). Exercise is also effective as treatment for mental disorders, including depression (28) and anxiety (29). Recently, sedentary behavior (sitting or lying

down while awake) has been associated with detrimental health consequences, increasing the risk for cardiovascular disease, cancer, and diabetes (26). Health benefits associated with exercise seem to have a dose response relationship. However, any type of physical activity is better than none, and it appears that the greatest improvements in health status are seen in those who previously have been sedentary (27).

Table 2. Scale for rating perceived exertion (RPE scale, Borg 1962) (30).

6	No exertion at all	
7	Extremely light	
8		
9	Very light	
10		Light intensity exercise
11	Light	
12		Moderate intensity exercise
13	Somewhat hard	
14		High intensity exercise
15	Hard (heavy)	
16		
17	Very hard	
18		
19	Extremely hard	
20	Maximal exertion	

2.3.1 Exercise and substance use disorders

Exercise has for the past three decades been proposed as a coping strategy for preventing relapse in substance use disorders (SUD) including AUD (31), and as a meaningful activity together with others (32, 33). However, evidence is now growing suggesting exercise to have positive effects on craving, cognitive functioning, depression and mood (33) which highlights its potential to improve somatic and psychiatric health in individuals with SUD. Exercise has, for example, demonstrated reductions in craving, mood and withdrawal symptoms during smoking cessation (34). Furthermore, a large randomized controlled trial (RCT) (n=309) evaluating exercise or health education as an adjunct treatment to regular care for substance use (alcohol, cocaine, methamphetamine, amphetamine, marijuana, or other stimulant), showed that those in exercise group had significant higher abstinence rates than those

receiving health education when controlling for treatment adherence and baseline stimulant use (35).

2.3.2 Exercise and alcohol use disorders

Research of exercise levels in individuals with AUD has given a quite complex picture. Some studies have indicated a positive association between alcohol intake and exercise levels (36). While others show an inverted J-shaped curve, where the odds of being physically active peaks at moderate drinking and then decrease with heavier consumption (37). A Swedish general population study examining the fitness levels for adults based on alcohol consumption found that hazardous drinkers are a heterogenous group in relation to exercise behaviors. The study showed that low-hazardous drinkers exercised more compared to non-hazardous drinkers. However, hazardous drinkers were less physically active and engaged less in exercise than low-risk drinkers and the odds of doing no exercise at all was found to be 1.22 higher among male high-hazardous drinkers compared to non-hazardous drinkers (40 to 65 years). For women in the same category the odds were 1.43 higher. Male high-hazardous drinkers in the same age group were also found to be almost twice more sedentary than non-hazardous drinkers (38). The study shows the complexity of exercise behaviors in individuals with AUD.

In terms of evaluating effects of exercise on AUD they can be divided into acute and long-term studies:

2.3.2.1 Acute studies

Three studies have examined the acute effects of exercise in adults. Ussher and colleagues explored the effects of exercise on mood and alcohol craving in a cross-over trial. Twenty participants were randomized to ten minutes of cycling on either moderate or light intensity. Questionnaires were completed before, during, immediately after, as well as five and ten minutes after exercise. Results showed a significant reduction in craving during exercise in the moderate intensity group but only during exercise (39).

In an RCT, Brown and colleagues investigated the acute effects of moderate intensity exercise on craving, mood, and anxiety in 26 outpatients over 12-weeks. After each exercise session participants showed an increase in mood and decreases in anxiety and craving. Results showed that the changes in mood and anxiety remained stable over the 12-weeks while craving diminished (40).

In a nested study embedded in the current RCT, Hallgren and colleagues examined the acute effects of exercise on craving, mood, and anxiety. Participants completed questionnaires 30-minutes before, immediately before and after, and 30-minutes post a 12-minute sub-maximal cycling fitness test. Results showed significant reductions in craving, mood disturbance and state anxiety over time. Between group analyses indicated larger effects in those with severe AUD compared to those with mild AUD. The authors speculate that exercise induced reductions on alcohol craving are mediated by changes in negative mood-states (41).

2.3.2.2 *Long term studies*

Four recent trials have examined the long-term effects of exercise in adults. Brown and colleagues randomized 49 sedentary AUD patients to a 12-week group aerobic exercise (treadmill, elliptical machine, or recumbent bicycle) plus group behavioral treatment intervention for exercise, or brief advice to exercise, as an adjunct to alcohol treatment. Those in the exercise arm had significantly fewer drinking days and heavy drinking days compared to the brief advice condition (42).

Effects of medical yoga was evaluated in a Swedish pilot study. Eighteen outpatients diagnosed with AUD were randomized to treatment as usual (TAU) or TAU plus yoga for ten weeks. At six months the reduction in consumption in the TAU plus yoga group was larger than TAU only. However, the difference was not statistically significant (43).

In a Danish study (n=175), Roessler and colleagues explored the effects of a six-month exercise intervention (brisk walking and running) as adjunct treatment for AUD. Participants were randomized to either TAU, TAU plus supervised group exercise, or TAU plus individual exercise. Alcohol intake did not differ between groups at follow-up, but exercise at moderate intensity was protective against excessive drinking compared to low intensity exercise (44).

In a recent study, Weinstock and colleagues randomized 66 sedentary adults from the general population with AUD to either gym membership only, or a gym membership plus a motivational intervention for exercise for four months. There were significant reductions in drinking and alcohol-related consequences at follow up but changes did not differ significantly by study condition (45).

Results from the above-mentioned studies are promising, yet inconclusive and include limitations worth mentioning; such as small sample sizes, lack of comparison with usual care and no data on adherence or subjective measures of exercise. A recent comprehensive systematic review and meta-analysis quantifying effects of PA interventions on SUD, including AUD, found a trend for promising acute effects of exercise but indicated the need for research with more robust designs evaluating both short- and long-term effects (46).

Only one study has explored the experiences of exercise among AUD outpatients. In this Danish qualitative study by Sari and colleagues, 17 patients were interviewed about their reasons for dropping out from an exercise intervention (Danish RCT mentioned above). The authors concluded that participants struggled with the same barriers reported by other groups when starting an exercise regimen, namely type of exercise, social barriers, and emotional barriers (47).

2.3.2.3 *Mechanisms*

To date, the literature on biological effects of exercise on AUD is mixed and the underlying mechanisms of exercise induced effects on alcohol consumption are poorly understood. However, several plausible mechanisms have been proposed. One is the effect on the

dopaminergic system, where exercise is suggested to activate the same reward pathways as alcohol and restore the imbalance created by drinking, making the system less sensitive to alcohol use (32, 48). There is also the effect on the endogenous opiates, where mood-enhancing effects from exercise are suggested to reduce the craving for alcohol (32, 33). Exercise may also positively affect drinking habits by activation of the hypothalamic pituitary adrenal axis (HPA-axis), resulting in lowered stress reactivity, better mood-states and, consequently a decreased urge to drink (32).

2.4 MULTIPLE HEALTH BEHAVIOR CHANGE

Unhealthy behaviors tend to cluster as healthy ones do, and regular exercise is one ingredient in a generally healthy lifestyle which may include, a healthy diet, good sleep, and low risk drinking. Multiple health behavior change (MHBC) involves interventions that promote change in more than one behavior at a time and is suggested to have greater impact on the public health than interventions targeting one single behavior (49).

The interrelation between health behaviors is in theory proposed to occur through shared motivation mechanisms, exactly how is still unclear (50). However, one finding from MHBC research show that success in changing one behavior may increase a person's self-efficacy and confidence in changing other behaviors (49). The literature on MHBC is scarce, but the strongest evidence comes from studies targeting smoking cessation or dietary and increased physical activity (50). For example, a three-armed RCT evaluating multiple behavior interventions for weight management (including exercise and diet) found that individuals who managed to change one behavior were 2 to 5 times more likely to succeed in change of another (51).

2.5 RATIONAL FOR THE CURRENT STUDY

AUD is among the most prevalent psychiatric disorders but those affected are reluctant to seek treatment. Individuals with AUD are at risk of poor somatic and mental health due to consequences from both harmful drinking and for being physically inactive. Available research suggests that structured exercise may have health benefits on somatic health, craving and mood that can be beneficial for individuals with AUD.

Most studies examining effects of exercise on AUD have had a focus on aerobic exercise. Yoga is a popular exercise form that includes physical postures, balance, and flexibility suggested being beneficial for individuals with AUD (52, 53). However, Yoga does to more or less extent include controlled breathing and mindfulness, components shown to have positive effects on depressive symptoms and overall wellbeing (54). Hence, exploring if type of exercise may influence drinking outcomes is of importance. Only one previous trial has examined exercise effects in non-treatment seekers, but without comparison to treatment as usual (45). Thus, there is a need for robust long-term studies in non-treatment seekers.

This study evaluates the effects of exercise as a stand-alone intervention compared to treatment as usual by quantifying effects on consumption as well as exploring individual experiences of exercise as treatment for AUD.

3 RESEARCH AIMS

The overarching aim of this thesis is to evaluate if structured exercise can help reduce alcohol consumption in non-treatment seeking adults with AUD. To achieve this aim, we conducted one randomized controlled trial and one qualitative study. Each study addressed the following research questions:

- I. Compared to usual care what are the effects of aerobic exercise and yoga as stand-alone interventions on alcohol consumption?
- II. What are the individual experiences of aerobic exercise and yoga among non-treatment seeking adults with AUD?

4 MATERIALS AND METHODS

4.1 THE FIT FOR CHANGE TRIAL

This thesis is based on data collected from the *FitForChange trial*, a three-armed community-based randomized controlled trial in Stockholm, Sweden. The trial compared the effects on alcohol consumption (primary outcome) of aerobic exercise and yoga, to TAU. Participants in both Study, I and II participated in this RCT. A description of the study population in the *FitForChange trial* is presented below.

4.1.1 Participants

Participants in the *FitForChange trial* were recruited via advertisement in a local newspaper “Mitt i” on four occasions between January 2018 and August 2019, capturing those who felt they were “*Drinking too much and exercising too little?*”. Those interested contacted the study coordinator for an initial telephone screening to assess eligibility to participate.

Those included were adults between 18 and 75 years of age, living in Stockholm County, diagnosed with AUD, and reporting hazardous consumption during the past month. Exclusion criteria were those in need of somatic- and/or psychiatric specialist care, musculoskeletal problems preventing exercise, current regular exercise (defined as two or more planned exercise sessions per week), currently in treatment for AUD, pregnancy, or the use of illicit drugs.

4.2 STUDY I

The hypothesis for Study I was that, compared to TAU, alcohol consumption would reduce more in the yoga and aerobic exercise groups. We predicted no significant differences between the two exercise conditions on the primary study outcome.

4.2.1 Method

Those eligible were invited to Riddargatan 1, an outpatient clinic within the Stockholm Centre for Dependency Disorders. Verbal and written information about the study aims and design were given, and a written consent was obtained from all participants before the baseline assessment. Data was collected in paper form and included self-reported questionnaires about alcohol consumption, physical health and PA. Biological markers for heavy alcohol consumption were assessed from blood samples.

Participants were allocated in a 1:1:1 ratio with simple randomization, i.e., randomized by computer-generated random numbers. After the baseline assessment each participant was handed a sealed, opaque envelope with their allocation together with a short rationale describing the intervention arm. Treatment allocation was not concealed from either participants or the assistant conducting the baseline assessments. However, by having a different assistant performing the second assessment, allocation was blinded to the person performing the follow-up. The intervention started one week after the baseline assessment

and follow-up took place at 13-weeks. Those who did not attend follow-up were contacted directly by phone and then up to three times with telephone text messages during a four-week period. For a process chart of the RCT, see figure 1.

4.2.1.1 Measures

Primary study outcome: change in standard drinks per week was assessed with the Time-Line-Follow Back, 30 days (TLFB), and was also used to assess the number of heavy drinking days. During a one-on-one interview the participant was led by the research assistant through a 30-day calendar, filling in drinking days and quantity by using personal memories (i.e., social gatherings, birthdays) to help recall events. The TLFB demonstrates high test-retest reliability (55) and has been found to have satisfactory psychometric properties in Swedish research settings (56).

AUD severity was assessed by the number of diagnostic criteria fulfilled in The Diagnostic and Statistical manual of Mental disorders (DSM-5), where a minimum of two criteria is required the past 12 months to fulfil the diagnosis (8).

Harmful use was measured with the 10-item screening instrument Alcohol Use Disorders Identification Test (AUDIT), with each item scored 0 to 4 and with a maximum score of 40. The test was developed by the WHO (57) to identify harmful and hazardous drinking the past 12 months and has been validated in Swedish (58).

Heavy drinking was assessed with two standard blood biomarkers. Gamma-glutamyl transferase (GGT) which is a liver enzyme and a common marker for indicating alcohol induced liver damage (59). Phosphatidylethanol (PEth), is a metabolite of ethanol and cannot be elevated by anything other than alcohol intake. With both high sensitivity and specificity it is useful for detecting low, moderate, and high alcohol consumption (59).

Data on exercise adherence were collected via Sport Aerobic Training Center (SATS) electronic entry system. In addition, all participants also completed a training diary for registration of exercise performed outside SATS facilities (i.e., non-prescribed exercise).

Additional secondary measures included self-reported physical activity levels, assessed with the International Physical Activity Questionnaire (IPAQ) (60). Physical well-being was assessed with the first question from the SF-12 Health survey, “In general, would you say your health is?” measured on a five-point Likert scale (61). Body mass index, blood pressure and resting heart rate was also recorded. At 13-weeks, alcohol severity (DSM-5) and the AUDIT questionnaire were adjusted to assess the past three months.

Other outcomes in the RCT (not included in this thesis) that will be published in forthcoming papers are: symptoms of depression and anxiety, sleep disturbances, cardiovascular risk factors (assessed from blood samples) and levels of stress that have been assessed both through self-reported measures and by cortisol levels assessed in saliva. Furthermore, an

objective evaluation of PA levels with an accelerometer (ACTiGraph GXT3) worn by participants seven consecutive days before and after the intervention will be reported.

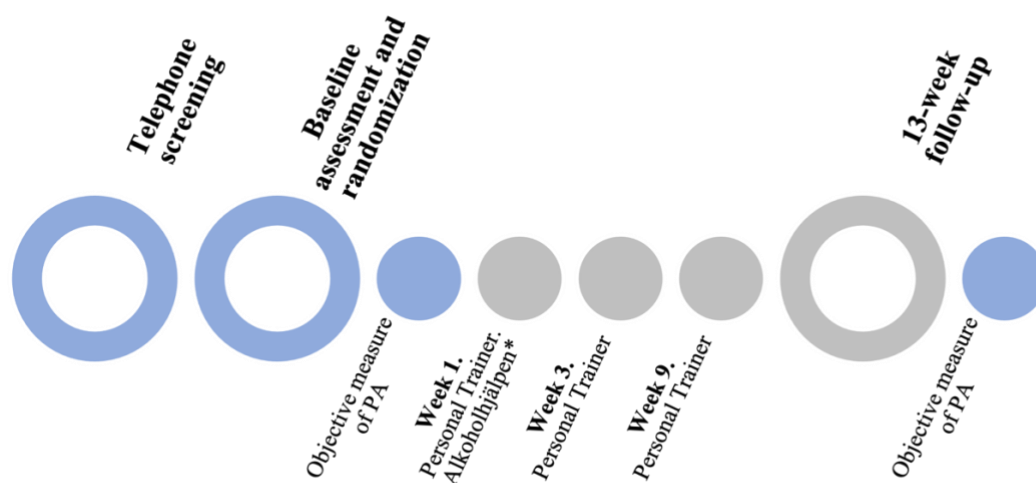


Figure 1. Process flow of the RCT. Grey circles represent the 12-week intervention period. *First of three telephone sessions offered in TAU.

4.2.1.2 Treatment arms

The intention was to keep a naturalistic approach, imitating a real-world scenario. Therefore, already existing facilities for the three intervention arms were used. All exercise took place at SATS which is a modern gym chain with 57 training centers within Stockholm County. Those randomized to any of the exercise arms were offered a free three-month membership card and three supportive sessions (~30 minutes) with a personal trainer (PT). The PTs were instructed to help participants arrange a suitable training schedule and maintain their motivation. To optimize adherence, participants were given a choice of various exercise classes within their randomized group. Participants in both exercise arms were encouraged to do online training if they were unable to go to the gym.

Aerobic exercise consisted of 60 minutes of group training at low, moderate, or high intensity level. Participants were requested to exercise a minimum of three times per week and to begin with light exercise and slowly progress to higher intensities. Available classes were cycling/spinning, aerobic classes, boxercise, and dance-based aerobics. In addition to group classes, participants could also perform individual aerobic exercise on a cross-trainer, treadmill, or stationary bicycle at SATS.

Yoga exercise consisted of 60 minutes of group training, involving physical postures, and breathing exercises from beginner to intermediate level. Classes included ashtanga and hatha yoga (physical postures with breathing exercises), yin yoga and yin release (gentle physical postures with a focus on breathing), and “Les mills body balance” (a combination of yoga,

Pilates, and Thai-chi). Participants in this group were also requested to attend classes at least three times per week.

TAU received telephone counselling with “Alkoholhjälpen” (www.alkoholjalpen.se), a national help service providing information and self-help for individuals wanting to change their drinking habits. In this study Alkoholhjälpen provided up to three telephone sessions (~45 minutes) with a qualified alcohol treatment specialist (psychologist or behavioral scientist). The rationale for these contacts was to discuss alcohol consumption, explore motives for change, barriers to treatment and motivate help seeking in regular health care or with the municipal social services. Participants in the TAU group were offered a free membership at SATS (PT sessions excluded) if they completed the follow-up assessment.

4.2.2 Data analysis

To assess the success of the randomization, differences between the three groups at baseline were analyzed with Analysis of Variance (ANOVA) for continuous variables, and chi square tests for categorical variables. Within-group differences, pre- and post-intervention, was analyzed using paired sample t-tests with a Bonferroni correction ($p < 0.017$), to adjust for multiple testing.

To address the primary research question intention-to-treat (ITT) analyses were performed comparing participants according to randomized allocation, regardless of adherence. Effects of the group interventions on the primary and secondary outcomes at 13-weeks were assessed using Analysis of Covariance (ANCOVA). This is a statistical method applied when comparing group differences, adjusting for pretest scores on the dependent variable. Tests were two-sided and P-values of less than 0.05 were considered statistically significant. Potential differences in age and gender were examined with subgroup analyses. The per-protocol analysis (PP) included those in the exercise groups, exercising ≥ 12 times during the intervention period and those in TAU with at least one contact with Alkoholhjälpen and reporting no exercise.

4.3 STUDY II

Study II was a qualitative study exploring the individual experience of yoga and aerobic exercise among non-treatment seeking adults with AUD, to better understand what drives individual behavior and change during exercise interventions for AUD.

4.3.1 Method

Participants from the *FitForChange* trial that had participated in a minimum of 12 exercise sessions during the intervention period were invited to a semi-structured interview, either face-to-face or by telephone. Such interviews give the interviewer the advantage of preparing questions beforehand, the interviews stay within the studied topic and can provide comparable data. A total of 12 interviews were performed with participants aged 33 to 70 years. Interviews were carried out at two timepoints, between December 2018 and July 2019

(n=7) and in May 2020 (n=5). First time-point was face-to-face at Riddargatan 1, and the second-round interviews was performed by phone due to Covid-19 restrictions.

The interviews had the following focus: thoughts on beginning a change, experiences of making changes in alcohol consumption, experiences of physical or mental change during the intervention, and perceptions on what facilitated the intervention and/or made it more challenging. Open-ended questions were applied to avoid answers that resulted in “yes” or “no”, and follow-up questions were asked to get richer data.

4.3.2 Data analysis

Interviews were audio recorded and transcribed verbatim. Qualitative content analysis was used to analyze data (62). The analysis used an inductive approach, a suitable method when not much is known about the topic studied. This means that patterns and categories are identified from data, instead of analyzing data according to an already existing theory or hypothesis. Furthermore, only the manifest content was analyzed (laughs, sighs, silence were left out) (62). Transcribed interviews were read repeatedly before meaning units were identified, coded, and grouped into sub-categories, generic categories and one main category. The process of generating a description of the studied topic by combining generic categories into main categories is called abstraction (62). For a description of the analytical process, see table 3 under paragraph 5.2.

4.4 ETHICAL CONSIDERATIONS

General ethical aspects of being part of the *FitForChange* trial will be discussed for both Study I and II.

Participants were given both oral and written information about the RCT, they were informed that participation was voluntarily and that they could withdraw from the study at any time. Prior to inclusion all participants signed an informed consent.

Individuals with AUD is a potentially vulnerable group. Thus, to secure participants integrity, collected data was pseudonymized and kept accessible only by the research personnel. Another step to ensure the personal integrity of participants was that the exercise interventions took place at SATS, where the training was part of the regular exercise classes, one could therefore not differ participants from regular visitors of the gym.

The main concern was whether participants were at risk of harm when offered exercise instead of specialist care. Therefore, at the planning stage of the trial, a review of exercise interventions for AUD were performed, which indicated physical activity to be a risk-free intervention with no reported adverse events. Also, the exclusion criteria of the trial were defined to exclude those who potentially needed specialist care. At six weeks, participants in the exercise groups were invited to Riddargatan 1 for a short meeting. One purpose of this meeting was to assess alcohol consumption with the TLFB. Participants who had increased

their consumption with 50% or more compared to baseline were, if they so wished, offered clinical support at Riddargatan 1.

There may be situations where physical activity should be discouraged from a medical perspective. However, the trial did follow the national guidelines of weekly physical activity for adults (18 years and above) recommended by The Public Health Agency of Sweden. Both studies were approved by the Regional Ethics Committee in Stockholm (DNR: 2017/1380-31).

5 RESULTS

5.1 EFFECTS ON ALCOHOL CONSUMPTION

A total of 472 individuals were screened for eligibility and 140 participants were randomized to one of the intervention arms. A majority of those not included refused to participate (27%, n=88) and about half of those mentioned the risk of being randomized to TAU as reason for declining. More women (70%) than men were included. Mean age of participants was 54 years (SD=12; range=21-75), most were employed and lived with a partner. Alcohol consumption at baseline was on average 20 (SD=11) standard drinks/week and most participants fulfilled the criteria for moderate dependence (five criteria). Participants in both exercise groups attended SATS approximately once a week during the 12-week intervention period; aerobic exercise (mean=1.1, SD=0.8, range=0-2.9) and yoga (mean=1.1, SD=1.0, range=0-3.2).

At 13-weeks, 127 participants had completed their follow-up, 125 of those were included in the ITT analysis (Fig. 2A). The within group changes showed a significant reduction of standard drinks per week: aerobic mean Δ = -5.0 (95% CI= -10.3, -3.5), yoga mean Δ = -6.9 (95% CI= -10.3, -3.5) and TAU mean Δ = -6.6 (95% CI = -8.8, -4.4). However, there was no significant difference in weekly consumption between the groups at follow-up. The ITT analysis stratified by gender and age, as-well as the analysis on secondary drinking outcomes (AUD severity and AUDIT) showed the same pattern. Neither the within, or between group analysis on the biological markers PEth and GGT, were statistically significant.

The PP analysis had 59 participants included (those exercising ≥ 12 times during the intervention period and those in usual care with a at least one contact with Alkoholhjälpen). Results showed that the yoga group and TAU had significantly larger reductions in weekly consumption than aerobic exercise (Fig. 2B). The PP analysis also showed equal exercise frequency between groups; aerobic exercise (mean=1.8, SD=0.6, range=1.1-2.9) and yoga (mean=1.9, SD=0.7, range=1.0-3.2). An additional analysis (data not shown) of the baseline characteristics for those included in the PP analysis showed a difference between groups regarding civil status. Indicating that those in yoga group were cohabiting to a larger extent.

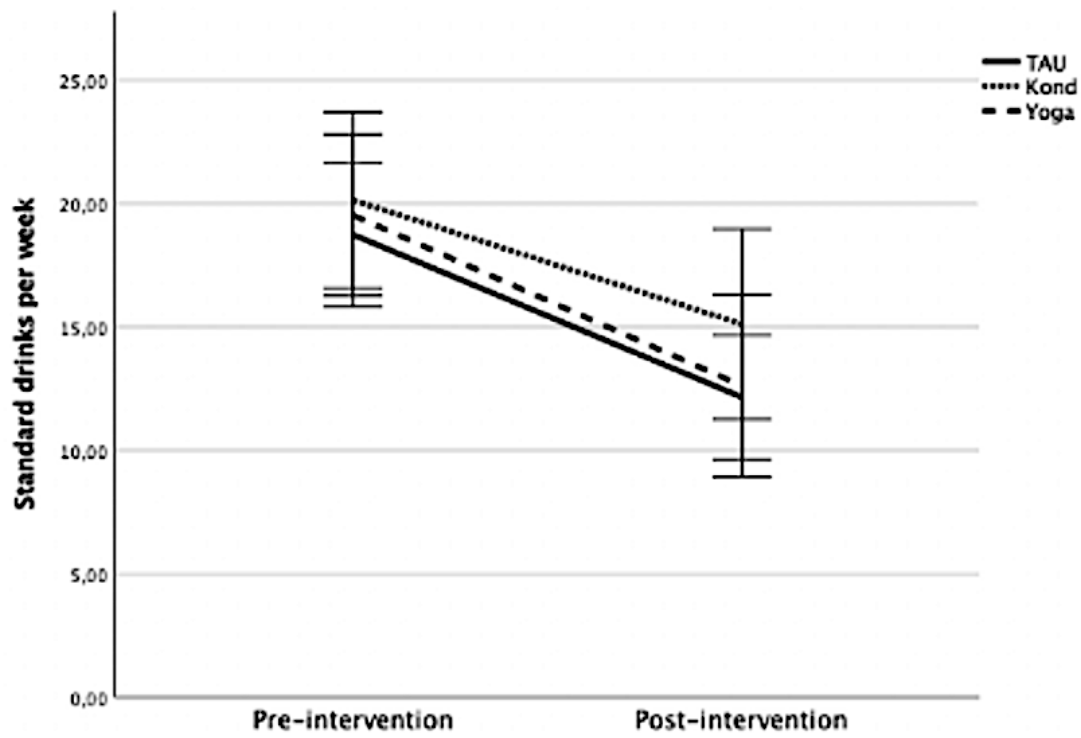


Figure 2A. Changes in mean standard drinks per week pre- to post intervention. Intention-to-treat analysis (n=125).

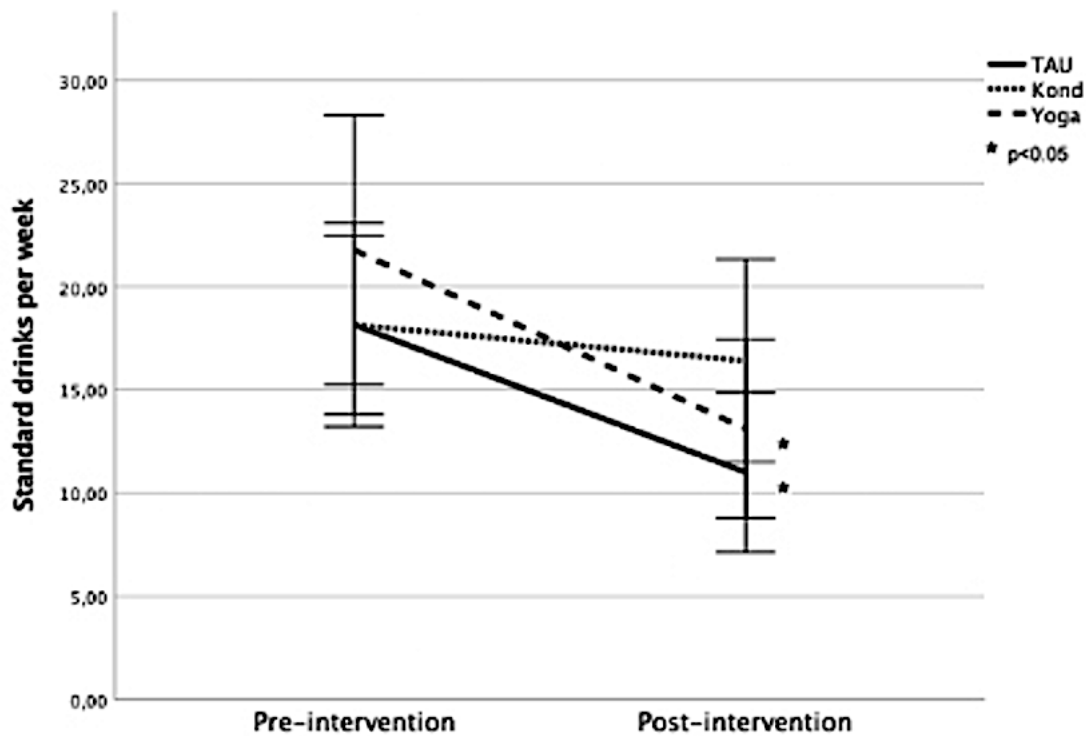


Figure 2B. Changes in mean standard drinks per week pre- to post intervention. Per-protocol analysis (n=59).

5.2 EXPERIENCES OF EXERCISE

One main category was created: *Motivating and maintaining a lifestyle change* with the following four generic categories: initiating factors for lifestyle change, influencing lifestyle change, influencing physical and mental health, and influencing alcohol consumption (Table. 3).

Table 3. Analytical process as described by Elo and Kynges (62) showing results from the qualitative content analysis.

Meaning unit	Code	Sub-category	Generic category	Main category
<i>I had seen an ad in the newspaper, maybe a month or a couple of months before with the message; do you drink too much and exercise too little? And I thought, that fits me.</i>	Appealing	Factors influencing start of treatment	Initiating factors for lifestyle change	Motivating and maintaining a lifestyle change
<i>Yes, first of all it was a whole new world that I have never been to, just going to the gym is new to me, and then ending up in a yoga studio with 20, 65 plus women as the only man, felt very strange</i>	Uncomfortable	Factors influencing exercise	Influencing lifestyle change	
<i>It was of great importance, partly that I feel better, calmer, yes more satisfied and, yes it did a lot for my health to start exercising.</i>	Emotion	Mental well-being	Influencing physical and mental health	
<i>Partly when you are happy and satisfied after exercising, the interest in getting a reward by drinking decreases.</i>	Reward	Factors influencing the consumption	Influencing alcohol consumption	

Changing alcohol consumption as part of a larger lifestyle change, with focus on increased exercise, was perceived as an appropriate and less stigmatized alternative than seeking conventional alcohol treatment.

As participants started to exercise, several factors influenced their behavior change. Being able to exercise according to one's own preferences was perceived as fun and mood-enhancing and was therefore positive for change. However, being in the wrong exercise group with individuals in better shape, different age, or gender had a negative impact on the

lifestyle change. The ability to plan when to exercise, have easy access to the gym and have someone monitoring their progress also influenced change.

Both aerobic exercise and yoga improved participants fitness and physical condition. Furthermore, the intentional planning and positive results from exercise affected participants self-confidence and self-esteem which increased participants motivation to change their alcohol consumption. The reduction in alcohol was a result of reduced cravings after exercise and there was no longer a need to reward oneself with alcohol, as exercise became the reward. Drinking alcohol was described as something that would ruin all efforts and contaminate the body.

6 DISCUSSION

6.1.1 Exercise as a treatment option

Given the low number of individuals seeking help for their harmful drinking, it is relevant to broaden the treatment options for individuals with AUD and to find non-stigmatizing treatment options. Both Study I and Study II are in line with previous research suggesting that individuals with AUD are interested in exercise as treatment (63, 64). Following each advertisement, Study I had more than 100 individuals showing interests to participate. Interestingly, many declined to participate with the given reason of not wanting to be randomized to TAU. In Study II, all participants but one affirmed that they would never seek specialist treatment, as they did not experience themselves having alcohol problems of that extent. Despite this notion, most participants did fulfil a mean of five dependency criteria, indicating a moderate level of dependence. One feature of the stigma related to alcohol treatment is the perception of individuals in treatment as the “alcoholic” who has lost everything (23). This picture is often very far from the truth, as a majority of those with problematic consumption have a mild to moderate dependence, without social problems (65). In Study II the participants emphasized that a lifestyle change with a focus on increased exercise was an appropriate way to change their alcohol habits and at the same time get into better shape.

6.1.2 The effects of exercise on AUD

At 13-weeks, there was a significant reduction of weekly standard drinks in all three groups, a decrease of five to seven drinks per week. However, the results showed no significant difference between the groups. These results are consistent with previous trials evaluating effects of exercise on alcohol consumption (44, 45), with the important difference that in the current trial exercise was offered as a stand-alone treatment for AUD and compared with usual care. TAU in this trial was an active condition performed by Alkoholhjälpen and treatment offered at the Swedish national alcohol helpline has been shown to be more effective compared with spontaneous change in the general population (66). Therefore, the lack of group differences in Study I does not indicate no treatment effect of exercise, but rather an effect similar to TAU.

Both exercise groups reported a mean exercise frequency of approximately once a week, instead of the requested three. Study II did reveal some explanations for the low compliance to the prescribed exercise. Firstly, if the exercise type did not appeal to the individual regarding type of exercise (i.e., wanting to do aerobic training if randomized to yoga and vice versa, or strength training) and secondly, the lack of motivation and time. Low compliance may have underestimated the effects of exercise and possibly affected results. Given that the magnitude of the reduction was equal to TAU, it is however of interest to understand what could have caused these changes.

In Study II, the participants described several explanations for how exercise affected their alcohol consumption. The reduction was described as a result of reduced alcohol urge after exercise. Exercise contributed to emotional regulation by reducing negative emotions such as feeling tense or stressed, but also reinforced positive mood-states such as feelings of happiness and elation. Exercise was therefore described as rewarding enough and consequently, reduced the need to drink. The effect on mood-states and urge has been suggested in previous research as a contributing factor to reduced consumption (33, 41).

Another reason for why alcohol habits changed was the perception that alcohol consumption would destroy hard-earned exercise efforts. Alcohol would contaminate the body and the positive effects from exercise would diminish. The finding is interesting as it sheds light on how change in one health behavior can become a gateway to an overall healthy lifestyle and supports the concept of MHBC (50). As previously described, self-efficacy is a key factor in MHBC, the concept suggest that success in changing one behavior may increase the confidence and increase motivation to improve another (49). An advantage of regular exercise is that positive effects come relatively quickly, this may explain the reinforced self-esteem and self-efficacy among the participants in study II. Supporting the concept of MHBC are results from a Swedish longitudinal study, where favorable health behaviors (tobacco use, diet, and physical activity) were associated with quitting hazardous alcohol use (25).

While most trials evaluating exercise for AUD have focused on aerobic exercise, Study I also evaluated yoga, a type of exercise with lower intensity level than aerobics. Yoga does however, to more or less extent, include breathing techniques and mindfulness with suggested positive effects on mood-states and craving in individuals with SUD (67). When comparing the two exercise interventions, yoga showed larger magnitude effects than aerobic exercise on all outcomes. The per-protocol analysis revealed that regarding drinks per week and days of sobriety, these effects were significantly larger. As adherence was similar in both groups, these differences were probably not caused by individuals in the yoga group doing more exercise. Nor did participants baseline characteristics reveal any explanations for the differences between the groups.

The larger decrease of consumption in the yoga group may be explained by a greater affective response to exercise; e.g., if you experience pleasure or displeasure, tension or relaxation, energy or tiredness while exercising (68). In theory, participants in the yoga group may have experienced a more positive response to exercise than those in the aerobic group and as consequence experienced a larger decrease in the urge to drink. This is supported by research suggesting that aerobic exercise can cause unpleasant feelings, especially when you are not used to exercising (68). Study II did however show that the affective response to exercise is highly dependent on individual preferences. An additional PP analysis on background characteristics (data not shown) revealed that participants in the yoga group were more likely to be married or cohabiting which may have influenced participants drinking behavior as family members have been found to provide support for change (69).

Results from the two biological markers, (Peth and GT) were non-significant in both the within and between group analysis and they did not correspond to the self-reported change in TLFB. Underreporting is common when evaluating consistency between self-reported alcohol consumption and biomarkers (70), and shows the importance of not only relying on self-reported measures when evaluating an intervention. However, the loss to follow-up on biomarkers in this study was almost 30%, which needs to be taken into consideration when interpreting these results, as they derive from a small sample.

6.1.3 Methodological considerations

6.1.3.1 Limitations

Even though recruitment to the trial was successful, a large number of individuals were found non eligible. Of the 472 individuals that were screened for eligibility, only 140 were included. Although many declined to participate for fear of being randomized to TAU, many were excluded because of current regular exercise (20%). However, the study took place in the county of Stockholm and individuals living in city areas tend to exercise more than in rural ones (71), which may explain why many were excluded for this reason.

The study had no control group, i.e., a comparison group receiving no intervention at all. Effects may therefore be due to spontaneous change. For ethical reasons TAU was chosen as comparison group to the experimental groups. Furthermore, including TAU as a treatment arm enabled the comparison of exercise to an intervention that participants would likely seek advice from as a first step to receive help.

Study I had a follow-up at 12 weeks, thus the results do not provide any information of long-term effects of treatment response.

In terms of generalizability, the results are limited to non-treatment seekers interested in starting a new exercise regimen. However, individuals that are reluctant to seek treatment represent the vast majority of those with AUD. Also, more women (70%) than men were included in the study making the results of the intervention more generalizable for women.

In Study II, a larger sample than 12 participants might have given a richer data. But at 12 interviews the information power was sufficiently large in regard to aim, specificity, quality of dialog and analysis method (72). Another possible limitation is the inclusion of those who accepted to be interviewed, i.e., the use of convenience sampling. This might limit the transferability of the results to other contexts. A better sampling approach would have been to use a purposive sample where participants characteristics (e.g., age, gender, group) are the basis of the selection. This was the initial aim, but due to covid-19 we had to reconsider the sampling procedure. However, the distribution of age and gender did not differ much from the sample in Study I.

In Study II, more individuals from the yoga group were interviewed, which also may have affected the results. Another possible limitation in study II was to only include those who had

exercised a minimum of 12 times during the intervention period. This may have excluded those who found it hard to start exercising. However, this inclusion criteria was based upon that interviewing those with little or no experience of the intervention could have resulted in experiences related only to external factors (such as no time or lack of motivation).

Adherence was low in Study I, despite offering PT sessions to monitor and motivate participants. In Study II participants emphasized certain qualities important for a PT such as being humble, and able to provide individual advice depending on previous exercise experience, abilities, and goals. Also, participants in Study II mentioned the lack of individual training with their PT, this was a limitation in the study as greater support may have increased participants motivation and adherence.

The loss to follow up on the biological markers (30%), obviously hampers the possibility of making any firm conclusions of these results.

6.1.3.2 Strengths

The focus on non-treatment seeking individuals is a considerable strength of the study as the vast majority with AUD do not seek treatment. To date, there is no research, that has examined exercise as a stand-alone treatment in this group. Hence, the study adds new valuable information on effects and experiences of exercise interventions in those reluctant to undergo alcohol treatment. This makes the results relevant not only to clinical settings but also for public health.

Compared with previous trials, Study I has a robust methodology suitable for the aim and research questions of the study. The sample size was sufficiently large in terms of statistical power and is one of the largest RCT evaluating effects of exercise on AUD. It is the first one to have a three-armed design, comparing two types of exercise with usual care. Study I did not rely on self-reported measures only to assess exercise adherence and exercise intensity, but also had objective measures, which strengthens the internal validity. The blinded follow-up assessment in Study I should minimize the risk of observer bias. Another potential strength was the option to select different types of exercise classes (within the randomized type), as this in theory should affect adherence.

Study I had a low drop-out rate (10%), which is lower than previous studies with reported loss to follow up of around 30-40% (64). Neither did the loss to follow up differ between treatment groups, strengthening the validity of the results.

A strength of both studies was the naturalistic approach with interventions accessible in the “real-world”; i.e., exercise offered at one of the larger gym chains and the use of a national alcohol help service. The real-world design gives the possibility to maintain the study for a longer time with limited resources and may facilitate replication and accessibility.

Study II is unique, as the qualitative perspective is lacking within the studied area. One strength is that the study gives possible explanations to the results in Study I, highlighting the

importance of self-selected exercise and strengthens the theory of mood-enhancing effects due to exercise in reducing alcohol consumption (33, 41). It also shows the advantage of multiple health behavior change (49).

The choice of individual interviews in Study I allowed participants to talk about their experiences without the risk of peer pressure or dominant participants taking over the discussion, which can be the case when having focus group interviews.

7 CONCLUSIONS

This thesis describes the effect of exercise on alcohol consumption and explores individual experiences of exercise-induced changes in health and consumption.

Results show that for non-treatment seekers, a lifestyle change with focus on increased exercise is an appealing, non-stigmatizing treatment option. Furthermore, results indicated that exercise alone was associated with reductions in consumption comparable to telephone counselling by a specialist and that yoga tends to give greater effects than aerobic exercise.

In addition to increasing physical fitness, exercise have mood-enhancing effects that could decrease alcohol urges and the need to drink. Furthermore, the success of changing exercise habits can increase self-confidence and self-efficacy to change alcohol habits. Being able to self-select the type, location, and intensity of exercise may increase adherence and optimize benefits.

A lifestyle-focused treatment come with many benefits for the individual but also for public health. Promoting exercise in individuals with AUD is important when it comes to health equity and social justice, i.e., the opportunity and possibility to be as healthy as possible. Furthermore, it is efficient and affordable given the small health resources needed and an attractive option that would work well in the real world, both as prevention and treatment for AUD.

8 FUTURE DIRECTIONS

Future research should further explore biological factors associated with exercise induced changes of alcohol consumption. Studies on neurotransmitter systems linked to exercise and AUD are scarce, therefore both acute and long-term interventions should be performed to explore these processes. Also, future studies should include tests of cognitive functioning as exercise induced improvements in cognition might make psychological treatment for AUD more effective. Furthermore, future research should investigate behavioral processes involved when exercise is used as a way to change alcohol use.

Findings from this thesis indicate the importance of supporting individual preferences when offering exercise in the treatment for AUD. Future interventions should, although it may affect replicability, allow participants to choose freely the type of exercise to optimize adherence. Another way to increase compliance is to promote goal setting and monitor the progress of exercise. The use of a PT is effective but should also involve individual exercise sessions. Also, self-monitoring with fitness trackers can be used to promote exercise behaviors.

Exercise could easily be implemented in the treatment of AUD both in primary- and specialist healthcare through physical activity on prescription (PAP), which can be prescribed by licensed health care personnel with adequate knowledge. PAP involves a written prescription with type of activity and dosage according to the individual's goalsetting, preferences, and ability. The health services are, due to its coverage and access for the whole population, a suitable arena for this. PAP can be used both as prevention, first line treatment or as a complement to existing treatment options. However, the use of PAP varies among clinicians. Therefore, clear directions from decision-makers and increased knowledge on the effects of exercise on AUD amongst healthcare professionals are required. Another possible way to implement PA in treatment of AUD is to hire physical therapists (or similar) within treatment settings to assess, implement, and support personalized PA programs.

The promotion of a lifestyle change, with increased exercise, to help reduce alcohol consumption could also be spread by promotional materials through the national alcohol help lines or at health services. This way, the intended target group is easily reached.

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