

**Table 1:** Summary of included studies: exercise interventions in alcohol use disorders

Reference/ Type of Study	Sample characteristics	Setting	Diagnosis/Years of problem drinking	Exercise (IG) and control group (CG) details: duration, intensity, frequency	Measurement point	Main Outcomes
Gary & Guthrie, 1972, USA, RCT	IG: n=10 m (38,9 y, range 25-55 y)  CG: n=10 (45,1 y, range 39-56 y)	Inpatient, alcohol treatment ward of a state hospital	IG: 18 y  CG: 18 y  "alcoholics" (diagnosis not reported)	IG: 4wk; 5x/wk running 1 mile/day until a total of 20 miles have been reached  CG: standard care: group therapy, ward clean up, recreation programs	t1: before exercise intervention  t2: after the 4 <sup>th</sup> wk	PhysF: BHR in 2 different positions ↓ (P<0.05 and P<0.25) and EHR at stable workload ↓ (P<.025) in IG  PsychO: self-concept ↑ (P<.005); sleep disturbances ↓ (only reported, no data available!) in IG; ACL and body-concept ↔  AlcO: drinking behavior: ↔
Piorkowski & Axtell, 1976, USA, RCT	IG: n=14 m (42,8 ± 9,7 y) male  CG: n=12 m (43,0 ± 8,9 y)	Inpatient, alcohol rehabilitation center	IG: 19,6 ± 13,3 y  CG: 21,3 ± 7,09 y  "chronic alcoholics" (diagnosis not reported)	IG: 4 wk; 5x/wk circuit training: 10 min calisthenics (warm up), 45 min 22 stations (1 min each station): sit-ups, bench press, biceps curls, cycle ergometer  CG: 3 wk; 5x/wk table games such as cards or checkers	t1: before exercise intervention  t2: after the third wk of treatment	PhysF: aerobic capacity, nr. of cycles of 1 min step-test ↑ (P<.01), RHR ↓ (P<.01) in IG; BHR ↓ in both groups (NS)
Lüdke, 1978, Germany, CT	IG1: n=249 m/52 f IG2: n=75 m/40 f  CG: n=31 m/21 f (age only in age-groups reported)	Inpatient, alcohol and drug rehabilitation clinic	"alcoholics" (diagnosis not reported)	IG1: 100% participation in the exercise program: 4wk; 3x/wk cycle ergometer training 2x/wk 15 min moderate endurance training plus 1x/wk 15x interval training, 30sec max. cycling/30 sec recreational cycling;  IG2: 80% participation in the exercise program of IG 1  CG: no exercise intervention	t1: before exercise intervention  t2 after the 4 <sup>th</sup> wk of treatment	PhysF: (statistical analysis of the data not available): HRI ↓ (significance levels not reported) In IG1: HRI from 24,4 (t1) to 17,8 (t2) in men and from 25,1 (t1) to 18,5 (t2) in women (vs. no changes in CG); In IG2: HRI from 24,6 (t1) to 20,6 (t2) in men and from 25,3 (t1) to 20,8 (t2) in women (vs. no changes in CG)
Mc Kelvy, et al., 1980; USA, RCT	IG: n=31 m (23,7 ± 5,0 y)  CG: n=17 m (24,0 ± 4,2 y) members of the US Navy	Inpatient, alcohol rehabilitation center	IG: 5,5 y  CG: 5,9 y "alcohol-dependence" (diagnosis not reported)	IG: 4wk; 5x/wk running 22 laps i.e. 1.2 miles/day Intensity: 85% of age-predicted HRmax  CG: group discussions, other sedentary activities	t1: before exercise intervention t2: after the 4 <sup>th</sup> wk	PhysF: 1 min step-HR ↓ (P<.05), 3 min step-HR ↓ (P<.001), BHR ↓ (P <.02) in IG

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<p>Sinyor et al., 1981 Canada, multi-centric CT</p>	<p>IG: n=38 m/11 f (42,0 y) CG1: n=8 m/1 f (42,2 y) CG2: n=8 m/4 f (30 y)  abstinence follow-up: IG n= 87 CG n= 80</p>	<p>Inpatient, 3 rehabilitation centers for alcoholics</p>	<p>IG &amp; IG1: 8 y “alcoholics” (diagnosis not reported)</p>	<p>IG1: 6wk; 5x/wk exercise program: 20 min stretching and calisthenics (warm up), 12 min walking/running, 20 min strengthening, in winter: 45 min. cross-country skiing  CG1: no or not sufficient participation in the exercise program  CG2: standard care in another treatment facility</p>	<p>t1: before exercise intervention t2 after the 6<sup>th</sup> wk</p>	<p>PhysF: aerobic capacity, estimated VO<sub>2</sub>max ↑ (P&lt;.001), BHR ↓ ( NS.) in IG  AlcO: Rate of abstinence 3 mo follow-up ↑ from 36.9% to 69.3% in IG</p>
<p>Weber, 1984, Germany, RCT</p>	<p>IG: n=23 m (43 y for both groups, SD not reported)  CG: n=13 m (43 y for both groups, SD not reported)</p>	<p>Inpatient, alcohol rehabilitation clinic</p>	<p>“alcoholics” (diagnosis not reported)</p>	<p>IG: 4 mo; 3x/wk progressive running with the aim of 30 min constant running at discharge  CG: standard care (not reported)</p>	<p>t1: before treatment  t2: after the 8<sup>th</sup> wk  t3:after the 16<sup>th</sup>wk</p>	<p>PsychO: State anxiety and trait-anxiety ↓ (P&lt;.05); perceived Stress ↓ (P&lt;.05) in IG; depressiveness, psychosomatics, wellbeing, coping (NS)  Drop out: n= 10 of 23 IG-participants dropped out of IG during the treatment</p>
<p>Murphy et al., 1986. USA, RCT</p>	<p>IG: n=9 (m), 25.1 y  CG1: n=9 (m), 25.3 y  CG2: n=13 (m), 24.6 y  Range=21-30 y</p>	<p>University</p>	<p>“High volume drinkers” based on The Volume Variability Index. Averaging at least 45 drinks/month or 1.5 drinks/day.</p>	<p>IG: Group running 3x/wk, each session 70 min. 8 wk total. Intensity individually prescribed on the basis of sub-max cycle test (baseline).  CG1: Home-based meditation 2x daily (20 mins) for 8 wks. Group sessions offered 3x/wk in evenings.  CG2: Completed pre and post-assessments and maintained a behavioural journal for 16 wks.</p>	<p>t1: pre-treatment baseline  t2: post-treatment  t3: follow-up (6 weeks)</p>	<p>PhysF: Exercise participants only improved fitness (VO<sub>2</sub>max), p=.001.  AlcO: At post-treatment, ethanol consumption was sig ↓ in the IG compared to CG2 (no intervention), p&lt;.05.  NS difference between IG (exercise) and CG1 (mediation).</p>

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Palmer et al., 1988 USA, time-staggered CT	IG: n=19 m/7 f (35,6 y, SD not reported) CG: n=18 m/9 f (38,9 y, SD not reported)	Inpatient, private alcohol treatment hospital	“alcoholics” (diagnosis not reported)	4wk, 3x/wk 20-30min walking and/or running, 20 min stretching, Intensity according to ACSM-guidelines: 60-80% of the age-predicted HRmax  CG: standard care without exercise intervention	t1: before treatment  t2: after the 4 <sup>th</sup> wk	PhysF: estimated VO <sub>2</sub> max ↑ (NS) in IG  PsychO: State anxiety and trait anxiety ↓ (P<.01), depressiveness ↓ (P<.05) self-concept ↑ (P<0.6) in IG
Stiensmeier-Pelster et al., 1989 Germany, RCT	IG: n=23 m (37 y, 21-56 y) CG: n=17 m (42 y, 21-56 y)	Inpatient, specialty hospital for alcohol treatment	“alcoholics” (diagnosis not reported)	2wk; 3x/wk 60 min progressive running combined with walking with the aim of 60 min constant running at discharge, stage-aim after 2wks: 10 min constant running  CG: standard care (not reported)	t1: before treatment  t2: after the second wk	PsychO: Mental state ↑ (P<.01) in IG Change from patients with state-orientated thinking to action-orientated thinking ↑ (P<.001) in IG
Lehofer et al., 1995, Austria, RCT	IG: n=14 (sex not reported) (37,5 y, SD not reported)  CG: n=14 (sex not reported) (34 y, SD not reported)	Inpatient, psychiatric hospital, dept. alcohol treatment (detoxification and rehabilitation)	“alcoholics” (diagnosis not reported)	IG: 4wk, 6-7x/wk 60 min running and/or walking, stretching, coordinative training  CG: standard care (not reported)	t1: second -6 <sup>th</sup> day after admission  t2: after the 4 <sup>th</sup> wk  Acute after exercise in IG: (t1-t6) state-anxiety and mental state	PhysF: BP ↔ (NS)  PsychO: Long-term effect after 4 wk intervention: Trait-anxiety ↓ (P<.03), state-anxiety (NS), health problems and mental state (NS) in IG  PsychO: Acute effects immediately after intervention: State-anxiety ↓ (P<.01), mental state ↑ (P<.01) in IG
Capodaglio et al., 2003, Italy, CT	IG: n=28 m/5 f (41,6 ± 7,9 y) CG: n=15 m/8 f (45,2 ± 8,0 y) HG: n=13 m/5 f (39,3 ± 7,7 y)	Inpatient, alcohol rehabilitation center	DSM IV diagnosis: alcohol-dependence	IG: 2 wk; 5x/wk 50 min exercise program: 10 min stretching, 30 min combined endurance training (walking, cycling, cranking) Intensity in the tests: Borg scale 4; cancel at 85% of HRmax or if Borg scale of 7 should be overreached CG: standard socio-therapeutic care (CBT)	t1: 3 days after medication during the detoxification  t2: after the second wk	PhysF: walking ↑ km/h (P<.01), work capacity ↑ (P<.01), HRmax ↓ (P<.06) in IG vs. HG at t1, ↔ (NS) in IG vs. HG at t2 i.e. IG improved. weight lifting and arm cranking: work capacity ↑ in the IG at t2 so that there was no difference vs. HG, BHR and BP ↔ (NS)
Ussher et al. 2004, UK, CT (acute study)	IG: n=10 CG: n=10	Psychiatric inpatient setting for alcohol	Alcohol dependence: Severity of Alcohol Dependence	IG: A single bout (10 min) of moderate intensity exercise, 40–60% of heart rate reserve (HRR), on a cycle ergometer.	t1: before exercise t2: during exercise t3: immediately after exercise	PsychO: No evidence for sig differences between conditions for baseline versus any subsequent measurement point.

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	For total sample: Age=40.10 y, SD=8.23 y (7 f), range=18-65 y	detoxification	Questionnaire	CG: A single bout of very light intensity exercise, 5–20% HRR, on a cycle ergometer.  Counterbalanced, cross-over design.	t4: 5 min after exercise t5: 10 min after exercise	AlcO: Relative to baseline, sig ↓ in alcohol urges for the IG versus CG during exercise (p=.02), but not at any measurement point following exercise.
Vedamurthachar et al., 2006, India, RCT	IG: n=30 m (35,6 ± 8,1 y)  CG: n=30 m (37,7 ± 7,3 y)	Inpatient national de-addiction center	DSM IV diagnosis: alcohol-dependence IG: SADQ= 33,2 ± 5,5  CG: SADQ= 31,7 ± 6,3	IG: 2 wk; daily 60 min Yoga (breathing and meditation exercises)  CG: standard care (not reported)	t1: after detoxification (7days), medication for those with sleep disturbances  t2: after the 2nd wk	Cortisol values ↓ (P<.001); depressiveness ↓ in both groups but more in IG (P<.001); ACTH decreased in both groups but more in IG (P<.001); prolactin values ↑ (NS)
Coiro et al., 2007, Italy, CT (acute study)	IG: n=10, m (33-45 y)  CG: n=10, m (35-48 y)	Outpatients in long-term rehabilitation program.	DSM-III-R diagnosis: alcohol dependent.  All participants had been alcohol dependent for ≥ 4 y	IG: Participants exercised on a cycle ergometer; initial load of 50W increased by 50W every 3 minutes until subjective exhaustion. Blood samples taken 30 min before exercise, just before exercise, then every 10 mins after exercise for 1 hr. Completed on 3 occasions (4,6 & 8 weeks after abstinence).  CG: One trial of acute exercise on a cycle ergometer; protocol as per IG.	t1: After 4 weeks abstinence  t2: After 6 weeks abstinence  t3: After 8 weeks abstinence	PhysF: Similar basal and exercise-induced changes in physiological variables in both groups in all trials. Similar baseline levels of ACTH and cortisol in both groups on all tests in all trials. Sig ↑ in ACTH and cortisol levels CG following trials. Sig ↑ in ACTH and cortisol levels in IG at wk 6 of abstinence, however, these were sig lower compared to those in CG. Sig ↑ in ACTH and cortisol levels in IG at wk 8 of abstinence, but not sig different to CG.
Brown et al., 2014, USA, RCT	IG1: n=26 (43,5 ± 11,5 y)  IG2: n=23 (45,4 ± 10,0 y)	Outpatient and day hospital care setting	DSM-IV-TR diagnosis: alcohol-dependence	IG1: 12 wk; 1x/wk 20-40 min group aerobic exercise (treadmill elliptical machine and recumbent bicycle) at 55-69% of age-predicted HRmax plus advise to 2-3x/wk non-supervised aerobic exercise plus group behavioral treatment weekly plus incentives for attendance  IG2: 12 wk standard treatment plus 15-20 min advise to exercise based on ACSM recommendations plus incentives for engagement	t1: before exercise intervention t2: after 12 wk intervention t3: 6-mo follow-up	PhysF: level of exercise and VO2max ↑ from t2 to t3 (baseline data not reported) but no differences between IG1 and IG2 at t2 and t3. Among <u>adherent</u> IG1-participants greater min of exercise ↑ (p=.008) and increased VO2max ↑ (p=.025) than in IG2 at t3  PsychO: no sign. changes in depression, anxiety and self-efficacy  AlcO: alcohol use (days and amount) ↓ during treatment (P=.002) and at t2 (P<.001) but no more at t3. Inverse relationship between duration of exercise and alcohol use at t3 (p=.000) in both conditions Feasibility/Adherence: participants attended in 8,44 ± 4,1 of 12 sessions; 62% completed at least 8 out of 12 sessions after 12 weeks

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Reddy et al. 2014, USA, RCT	IG: n=14 (f), 45.5 ± 12.1 y  CG: n=12 (f), 43.2 ± 12.9 y  Range=18-65 y	General hospital	Diagnosed Post-Traumatic Stress Disorder (PTSD) (or at least sub-threshold PTSD), based on the PTSD Symptom Scale-Interview (PSS-I).	IG: 12 Kripalu-based Hatha yoga sessions, 75 min each, adjusted for different fitness levels and incorporated guidelines of trauma-sensitive yoga. The intervention incorporated elements of mindfulness and dialectical behavioral therapy, a specialized form of cognitive behavioral therapy.  CG: Assessment only; no active intervention.	t1: before exercise  t2: immediately after exercise  t3: 1-month after exercise	PsychO: Most IG participants reported a ↓ in symptoms and improved symptom management.  AlcO: A trend toward ↓ alcohol use risk among IG participants relative to CG. However, the change in AUDIT scores over time did not differ by treatment group (p=.59).
Hallgren et al., 2014, Sweden, RCT.	IG: n=8 18+ (range not reported)  CG: n=6 18+ (range not reported)	Outpatient alcohol clinic	DSM-IV diagnosis: alcohol dependence.	IG: 10 wk; 1x/wk, 90 mins: Yoga, low-moderate intensity, with focus on controlled breathing and relaxation techniques. Encouraged to continue exercises at home (3/wk).  CG: Usual care for alcohol dependence (CBT, motivational interviewing, pharmacological therapy as needed).	t1: before exercise intervention  t2: 6 months after baseline assessment	PsychO: No sig. differences in perceived stress or cortisol levels at 6 months. However, morning cortisol levels (nmol/L) were lower in the Yoga group (mean=27.6, SD=11.5) vs. TAU (mean=31.7, SD=12). Approx. equal magnitude improvements in depression/anxiety (yoga vs. TAU).  AlcO: Both groups showed approx. equal improvements on all 3 measures of consumption (drinks per day, per week, SAD). NS group x time interaction.
Weinstock et al., 2014, US.	IG: n=16 (sex not reported, 18-27 y)  CG: n=14 (sex not reported, 18-27 y)	College students	'Hazardous' drinkers: ≥ 8 on the AUDIT; ≥ 4 heavy drinking episodes in the past 2 months.	IG: 8 wk; 3x/wk, 60 mins: MET plus contingency management (CM) for adhering to specific exercise goals.  CG: One 50 min. motivational enhancement therapy (MET) session.	t1: before exercise intervention  t2: 2 months (post-treatment)	PhysF: Frequency of exercise ↑ in IG vs. CG (p=.01); weekly calories expended ↑ in both IG & CG (p=.01), but group x time interaction NS (p=.06). Estimated V02 peak ↑ in both IG & CG (p=.01), but group x time interaction NS (p=.21); Moderate-Vigorous PAL ↑ in both IG & CG (p=.08), but group x time interaction NS (p=.57).  AlcO: NS ↓ in drinking days (past 2 months) for both IG & CG (p=.06), NS ↓ in heavy drinking days (past 2 months) for both IG & CG (p=.07), NS ↓ in total drinks per week for both IG & CG (p=.60). All group x time interactions NS.
Georgakouli et al. 2015, Greece, CT (acute study)	IG: n=17, m/f, (31,6 ± 3,2 y)  CG: n=17, m/f, (33,5 ± 1,3 y)	Laboratory	For men: >14 drinks per wk or >4 drinks per occasion . For women: >7 drinks per wk or >3 drinks per occasion	IG: One trial of acute exercise of moderate intensity (50-60% of the HR reserve) for 30 min on a cycle ergometer.  CG: As per IG, above.	t1: before exercise intervention  t2: immediately following the exercise	PhysF: Higher post-ex γ-glutamyl transferase levels (p<.005) in the IG only. Aspartate aminotransferase levels ↑ (p<.001) in both groups; alanine aminotransferase levels ↑ (p<0.01) in IG only. A trend for higher (p=.07) baseline levels of thiobarbituric acid-reactive substances, which

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			for women. (National Institute on Alcohol Abuse & Alcoholism)		intervention	remained elevated post-exercise in the IG compared to CG. Sig ↑ post-ex total antioxidant capacity (TAC; p<.01) and uric acid (UA; p<.05) levels were noted in the CG, whereas the TAC (p=.06) and UA (p=.08) levels ↑ and approached sig post-ex in the IG only. No differences in baseline levels of total bilirubin and protein carbonyl between the 2 groups, including post-ex.
Giesen et al. 2016, Germany,	IG: n=14, 11m/3f (52,14 ± 8,08 y)  CG1: n=19, 14m/5f (29,01 ± 7,52 y)  CG2: n=18, 12m/6f (27,28 ± 3,35 y)	Long-term residential care facility	ICD-10 diagnosis of alcohol dependence.  IG: 4.43 y  CG1: 7.63 y	IG: 52 wks, ≥2/wk, 60 min. Targeted a general ↑ in PAL; included aerobic exercise (stationary cycling), functional training & experience-oriented group activities (e.g. outdoor cycling, canoeing). Moderate-to-vigorous intensity, monitored by subjective perception scale, and 80% HR max.  CG1: Socio-therapeutic (standard treatment) in residential care; no exercise component.  CG'': Health comparison group, no intervention.	t1: before exercise intervention  t2: after exercise intervention (12 months)	PhysF: Active participants in the exercise program showed a significant improvement in PAL (group x time interaction: kcal p<.001, steps per wk p=.002).  PsychO: Significant improvements in quality of life (SF-36) in IG compared to CG, specifically physical functioning (p=.012), emotional role functioning (p=.041), mental health (p=.009).  AlcO: Among the active and adherent participants (n=14) no-one relapsed during 12 month follow-up, whereas 4 CG1 patients (n=18) and 3 dropout candidates had ≥1 relapse during the same period.

Abbreviations:

ACL = Adjective Check List, ACSM = American College of Sport Medicine, ACTH = Adrenocorticotrophic Homone, AlcO = Alcohol-related outcomes, m = male, Approx=approximately; BHR= Basal Heart Rate, CG = control group; y =years of age, CT= Non-randomized Controlled Trial, DPB diastolic blood pressure; BP blood pressure, EHR = Exercise Heart Rate, f= female, FAI = functional aerobic index, HG = Healthy Comparison Group, HRI: Heart Rate Index (BHR + RHR immediately after the test + RHR 2 min after test minus 100 divided by 10), HRmax = maximum Heart Rate, IG = intervention group, LoC = locus of control; SBP systolic blood pressure, NS = not significant, P = level of significance, PAL Physical activity level, PhysF = Physical functioning, PsychO = Psychological outcomes, RCT = Randomized Controlled Trial, rep=repetitions RHR =Recovery Heart Rate, SAD=Short Alcohol Dependence questionnaire); SADD=dependence severity level: low 1-9, medium 10-19, high >20SD =standard deviation; VO<sub>2</sub>max = maximal oxygen consumption, Sig=Statistically significant; TAU=Treatment As Usual; TLFB= Time-line-follow-back interview for exercise vs. = versus, wk = week, mo = month, y = years

↓ = reduced, ↑ = increased, ↔ = unchanged