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

<table>
<thead>
<tr>
<th>Reference/Type of Study</th>
<th>Sample characteristics</th>
<th>Setting</th>
<th>Diagnosis/Years of problem drinking</th>
<th>Exercise (IG) and control group (CG) details: duration, intensity, frequency</th>
<th>Measurement point</th>
<th>Main Outcomes</th>
</tr>
</thead>
</table>
| 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 4th 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 (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 4th 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 4th wk | PhysF: 1 min step-HR ↓ (P<.05), 3 min step-HR ↓ (P<.001), BHR ↓ (P<.02) in IG |
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<tr>
<th>Study</th>
<th>Design</th>
<th>Country</th>
<th>Sample Size</th>
<th>Intervention Details</th>
<th>Follow-up Points</th>
<th>PhysF: aerobic capacity, estimated VO₂ max ↑ (P&lt;.001), BHR ↓ (NS) in IG</th>
<th>AlcO: Rate of abstinence 3 mo follow-up ↑ from 36.9% to 69.3% in IG</th>
</tr>
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</table>
| Sinyor et al., 1981 Canada, multi-centric CT | RCT          | Canada  | 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 | Inpatient, 3 rehabilitation centers for alcoholics  
IG & IG1: 8y “alcoholics” (diagnosis not reported)  
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 | t1: before exercise intervention  
t2 after the 6th wk | PhysF: aerobic capacity, estimated VO₂ max ↑ (P<.001), BHR ↓ (NS) in IG | AlcO: Rate of abstinence 3 mo follow-up ↑ from 36.9% to 69.3% in IG |
| Weber, 1984, Germany, RCT                  | RCT          | Germany | IG: n=23 m (43 y for both groups, SD not reported)  
CG: n=13 m (43 y for both groups, SD not reported) | Inpatient, alcohol rehabilitation clinic  
“alcoholics” (diagnosis not reported)  
IG: 4 mo; 3x/wk progressive running with the aim of 30 min constant running at discharge  
CG: standard care (not reported) | t1: before treatment  
t2: after the 8th wk  
t3: after the 16th wk | PsychO: State anxiety and trait-anxiety ↓ (P<.05); perceived Stress ↓ (P<.05) in IG; depressiveness, psychosomatics, wellbeing, coping (NS)  
Drop out: n= 10 of 23 IG-participants dropped out of IG during the treatment | |
| Murphy et al., 1986. USA, RCT              | RCT          | USA     | 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 | University  
“High volume drinkers” based on The Volume Variability Index. Averaging at least 45 drinks/month or 1.5 drinks/day.  
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. | t1: pre-treatment baseline  
t2: post-treatment  
t3: follow-up (6 weeks) | PhysF: Exercise participants only improved fitness (VO₂ max), p=.001.  
AlcO: At post-treatment, ethanol consumption was sig ↓ in the IG compared to CG2 (no intervention), p<.05.  
NS difference between IG (exercise) and CG1 (meditation). | |
<table>
<thead>
<tr>
<th>Study</th>
<th>IG: n=</th>
<th>CG: n=</th>
<th>HG: n=</th>
<th>Setting</th>
<th>Prescription</th>
<th>Baseline 1</th>
<th>Baseline 2</th>
<th>Follow-up</th>
<th>Within-group differences</th>
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</table>
| Palmer et al., 1988 USA, time-staggered CT | 19 m/7 f (35.6 y, SD not reported) | 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 | t1: before treatment | t2: after the 4th wk | PhysF: estimated VO₂max ↑ (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 | 23 m (37 y, 21-56 y) | 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 | 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 | 14 (sex not reported) | 14 (sex 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 | t1: second -6th day after admission | t2: after the 4th wk | 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 | 28 m/5 f (41.6 ± 7,9 y) | 15 m/8 f (45.2 ± 8,0 y) | 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) |
<p>| Ussher et al. 2004, UK, CT (acute study) | 10 | 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. |</p>
<table>
<thead>
<tr>
<th>Study</th>
<th>n</th>
<th>Age</th>
<th>Diagnosis</th>
<th>Intervention Details</th>
<th>Measurement Points</th>
<th>Main Findings</th>
</tr>
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</table>
| Vedamurthac har et al., 2006, India, RCT | 60   | 40.10 ± 8.23 y (7 f) 18 - 65 y | Inpatient national de-addiction center | IG: Exercise interventions in alcohol use disorders: A single bout of very light intensity exercise, 5–20% HRR, on a cycle ergometer. Counterbalanced, cross-over design.  
C: Standard care (not reported). | t1: 5 min after exercise  
t2: 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. |
| Coiro et al., 2007, Italy, CT (acute study) | 20   | 33-45 y | Outpatients in long-term rehabilitatio n program. | IG: Exercise interventions in alcohol use disorders: A single bout of very light intensity exercise, 5–20% HRR, on a cycle ergometer. Counterbalanced, cross-over design.  
C: Standard care (not reported). | t1: 4 weeks after abstinence  
t2: 6 weeks after abstinence  
t3: 8 weeks after abstinence | 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) |
| Brown et al., 2014, USA, RCT | 50   | 43.5 ± 11.5 y (7 f) 30-80 y | Outpatient and day hospital care setting | IG1: Exercise interventions in alcohol use disorders: A single bout of very light intensity exercise, 5–20% HRR, on a cycle ergometer. Counterbalanced, cross-over design.  
C: Standard care (not reported). | t1: before exercise  
t2: 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 adherent 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 |
Table 1: Summary of included studies: exercise interventions in alcohol use disorders

<table>
<thead>
<tr>
<th>Study</th>
<th>Group</th>
<th>Sex Age</th>
<th>Setting</th>
<th>Condition</th>
<th>Exercise Details</th>
<th>Follow-Up</th>
<th>Outcomes</th>
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<tbody>
<tr>
<td>Reddy et al. 2014,</td>
<td>IG: n=14 (f), 45.5 ± 12.1 y</td>
<td>General hospital</td>
<td>Diagnosis of post-traumatic stress disorder (PTSD) or at least sub-threshold PTSD, based on the PTSD Symptom Scale-Interview (PSS-I).</td>
<td>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.</td>
<td>t1: before exercise</td>
<td>PhysF: Frequency of exercise ↑ in IG vs. CG (p=.01); weekly calories expended ↑ in both IG &amp; CG (p=.01), but group x time interaction NS (p=.06). Estimated VO2 peak ↑ in both IG &amp; CG (p=.01), but group x time interaction NS (p=.21); Moderate-Vigorous PAL ↑ in both IG &amp; CG (p=.08), but group x time interaction NS (p=.57). AlCo: NS ↓ in drinking days (past 2 months) for both IG &amp; CG (p=.06), NS ↓ in heavy drinking days (past 2 months) for both IG &amp; CG (p=.07), NS ↓ in total drinks per week for both IC &amp; CG (p=.60). All group x time interactions NS.</td>
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<td>CG: n=12 (f), 43.2 ± 12.9 y</td>
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<td>Assessment only; no active intervention.</td>
<td>CG: Usual care for alcohol dependence (CBT, motivational interviewing, pharmacological therapy as needed).</td>
<td>t2: 6 months after baseline assessment</td>
<td>AlCo: Both groups showed approx. equal improvements on all 3 measures of consumption (drinks per day, per week, SAD). NS group x time interaction.</td>
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<td>Hallgren et al., 2014,</td>
<td>IG: n=8 18+ (range not reported)</td>
<td>Outpatient alcohol clinic</td>
<td>DSM-IV diagnosis: alcohol dependence.</td>
<td>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).</td>
<td>t1: before exercise intervention</td>
<td>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).</td>
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<td>CG: n=6 18+ (range not reported)</td>
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<td>CG: 8 wk; 5x/wk, 60 mins: MET plus contingency management (CM) for adhering to specific exercise goals.</td>
<td>t2: 2 months (post-treatment)</td>
<td>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).</td>
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<tr>
<td>Hain&amp; et al., 2014, US.</td>
<td>IG: n=16 (sex not reported,18-27 y)</td>
<td>College students</td>
<td>‘Hazardous’ drinkers: ≥ 8 on the AUDIT; ≥ 4 heavy drinking episodes in the past 2 months.</td>
<td>IG: 8 wk; 3x/wk, 60 mins: MET plus motivational enhancement therapy (MET) session.</td>
<td>t1: before exercise intervention</td>
<td>PhysF: Frequency of exercise ↑ in IG vs. CG (p=.01); weekly calories expended ↑ in both IG &amp; CG (p=.01), but group x time interaction NS (p=.06). Estimated VO2 peak ↑ in both IG &amp; CG (p=.01), but group x time interaction NS (p=.21); Moderate-Vigorous PAL ↑ in both IG &amp; CG (p=.08), but group x time interaction NS (p=.57). AlCo: NS ↓ in drinking days (past 2 months) for both IG &amp; CG (p=.06), NS ↓ in heavy drinking days (past 2 months) for both IG &amp; CG (p=.07), NS ↓ in total drinks per week for both IC &amp; CG (p=.60). All group x time interactions NS.</td>
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<td>CG: n=14 (sex not reported,18-27 y)</td>
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<td>CG: One 50 min. motivational enhancement therapy (MET) session.</td>
<td>t2: 2 months (post-treatment)</td>
<td>AlCo: NS ↓ in drinking days (past 2 months) for both IG &amp; CG (p=.06), NS ↓ in heavy drinking days (past 2 months) for both IG &amp; CG (p=.07), NS ↓ in total drinks per week for both IC &amp; CG (p=.60). All group x time interactions NS.</td>
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<tr>
<td>Georgakouli et al. 2015, Greece, CT (acute study)</td>
<td>IG: n=17, m/f, (31.6 ± 3.2 y)</td>
<td>Laboratory</td>
<td>For men: &gt;14 drinks per wk or &gt;4 drinks per occasion. For women: &gt;7 drinks per wk or &gt;3 drinks per occasion</td>
<td>IG: One trial of acute exercise of moderate intensity (50-60% of the HR reserve) for 30 min on a cycle ergometer.</td>
<td>t1: before exercise intervention</td>
<td>PhysF: Higher post-ex γ-glutamyl transferase levels (p&lt;.005) in the IG only. Aspartate aminotransferase levels ↑ (p&lt;.001) in both groups; alanine aminotransferase levels↑ (p&lt;.01) in IG only. A trend for higher (p=.07) baseline levels of thiobarbituric acid-reactive substances, which</td>
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<td>CG: n=17, m/f, (33.5 ± 1.3 y)</td>
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<td>CG: As per IG, above.</td>
<td>t2: immediately following the exercise</td>
<td>AlCo: NS ↓ in drinking days (past 2 months) for both IG &amp; CG (p=.06), NS ↓ in heavy drinking days (past 2 months) for both IG &amp; CG (p=.07), NS ↓ in total drinks per week for both IC &amp; CG (p=.60). All group x time interactions NS.</td>
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<tr>
<th>Study</th>
<th>Intervention</th>
<th>Outcome Measures</th>
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<tbody>
<tr>
<td>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)</td>
<td>Long-term residential care facility ICD-10 diagnosis of alcohol dependence. IG: 4.43 y CG1: 7.63 y</td>
<td>t1: before exercise intervention t2: after exercise intervention (12 months)</td>
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<td>ICD-10 diagnosis of alcohol dependence. IG: 4.43 y CG1: 7.63 y</td>
<td>PhysF: Active participants in the exercise program showed a significant improvement in PAL (group x time interaction: kcal p&lt;.001, steps per wk p=.002).</td>
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<td>Long-term residential care facility ICD-10 diagnosis of alcohol dependence. IG: 4.43 y CG1: 7.63 y</td>
<td>PsychoO: 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).</td>
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<td>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.</td>
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</tbody>
</table>

Abbreviations:

ACL = Adjective Check List, ACSM = American College of Sport Medicine, ACTH = Adrenocorticotropic Hormone, 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, HRH: 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, ICD = ICD-10 diagnosis of alcohol dependence. IG: 4.43 y CG1: 7.63 y | Long-term residential care facility ICD-10 diagnosis of alcohol dependence. IG: 4.43 y CG1: 7.63 y | 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). |
|                        | PsychoO: 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. |

↓ = reduced, ↑ = increased, ↔ = unchanged