# Clinical Efficacy of HIIT in Prevention and Management of Depressive Symptoms

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**Abstract** [**Objectives**] To assess the effects of high-intensity interval training (HIIT) in reducing or preventing depression. [**Methods**] A systematic electronic searching of the PubMed, EMBASE, Cochrane Central Register of Controlled Trials (CENTRAL), Web of Science, SPORTSDiscus, PsyCINFO, SCOPUS and CINAHL (EBSCOhost) was initially performed up to June 25, 2024. Randomized controlled trials (RCTs) were included if they contained data on depression taken before and after HIIT treatment. Data were extracted by 2 independent coders. Estimates were examined by using random-effects meta-analysis. [**Results**] 14 independent samples (493 participants) were included. There was a statistically significant reduction in depression symptom following HIIT compared with both continuous training (CT) and control conditions (CON) (HIIT vs. CT: standardized mean difference [*SMD*] = −0.35, 95% confidence interval [*CI*] −0.66 to −0.04, $p$ = 0.025; CON: *SMD* = −0.49, 95% *CI* −0.92 to −0.07, $p$ = 0.022). There were no statistically significant differences between groups in anxiety symptom (HIIT vs. CT: *SMD* = −0.45, 95% *CI* −1.11 to 0.21, $p$ = 0.182; CON: *SMD* = −0.14, 95% *CI* −0.47 to 0.18, $p$ = 0.386). [**Conclusions**] HIIT is associated with decreased concurrent depressive symptoms; the association with anxiety symptoms is weak.

**Key words** Exercise, high-intensity interval training (HIIT), Depression

## 1 Introduction

Depression, with a significant and lasting low mood as the main clinical symptom, is a main type of mood disorder. It can affect a person's feelings, cogitation, behavior, cognitive fu*n*CTion, and physical conditions, which might be caused by a variety of factors such as mood disorders, heredity and so on[1]. With an aggravating trend of aging population in many countries, late-life depression cannot be neglected. Moreover, many chronic physical conditions, such as diabetes, cancer, cardiovascular diseases, chronic pain, and respiratory diseases, give rise to the concurrent depression[2-3]. At present, medication, including selective serotonin reuptake inhibitors regarded as the first-line option, is the main treatment of depression[4]. However, there are many side effects brought by antidepressants, including postural hypotension, cardiovascular and cerebrovascular events, gastrointestinal disorders, epilepsy, and even increased suicide risk[5-6]. To date, more attention has been paid to the contribution of exercise and behavioral therapy in preventing and treating mental illnesses. A meta-analysis including fifty studies found a significant effect ($r$ = −0.14; 95% *CI* −0.19 to −0.10) of exercise on depression[7]. Studies that included a measure of both increased physical activity (PA) frequency and intensity demonstrated stronger associations with depressive symptoms than those that used measures of intensity alone[8].

High-intensity interval training (HIIT), a new strategy that maximizes exercise intensity through short bursts of concentrated effort, has been proposed as a time-efficient exercise intervention that may bring about similar or more effective benefits compared to traditional moderate-intensity aerobic exercise for healthy adults[9] and patients with specific cardiovascular pathologies including coronary artery disease (CAD)[10], heart transplantation[11], and heart failure(HF)[12]. Clinically, HIIT has been found to improve depression and anxiety in a variety of chronic diseases. However, there has been no quantitative assessment of the HIIT in preventing both disorders. The aim of this systematic review is therefore to quantify the effect of HIIT for alleviating symptoms of depression compared with CT and CON using meta-analysis.

## 2 Methods

**2.1 Search strategy** A systematic electronic searching of the PubMed, EMBASE, Cochrane Central Register of Controlled Trials (CENTRAL), Web of Scicience, SPORTSDiscus was initially performed up to June 25, 2024 with no publication date limits. We used a combination of MeSH and free text terms, including HIIT, HIIE, high intensity interval training, high-intensity interval training, high intensity interval exercise, high-intensity interval exercise and depress*, mood, stress, panic, emotions, nervousness, obsession, apprehension, fear, schizophrenia* (a serious mental health condition that affects how people think, feel and behave, posttraumatic, mental health, mental disorders, PTSD. The truncation symbol "*" were used so that the variations would be returned to expand the search scope.

**2.2 Inclusion and exclusion criteria** The article was subsequently read and thoroughly assessed for following inclusion or exclusion criteria: (i) study design: all randomized controlled trials and randomized crossover trials; (ii) intervention: a detailed description of the exercise intervention, including intensity, duration and frequency; HIIT is always performed on devices (*e.g.*, treadmill, cycling) or through other activities such as swimming or walking. Studies would be excluded if HIIT was applied in combination with another intervention (*e.g.*, psychotherapy and physical factors therapy); (iii) control: continuous training , no any exercise intervention or no specific exercise intervention were used in the control group; (iv) outcomes: Studies must have included

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at least one or more well-being measures of depression before and after the exercise intervention using validated scales, including the Beck Depression Inventory (BDI), Hospital Anxiety and Depression Scale (HADS), HDCDS, the Hamilton Rating Scale for Depression (HRSD) or Profile of Mood States (POMS) scale. Conference abstract, case reports, observational studies and studies without available data were excluded.

**2.3 Risk of bias** Methodological quality of the each RCT was independently assessed by two authors according to the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (*PRISMA*) recommendations. The first part of the tool assesses seven specific domains, namely sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting and other issues. The second part assigns a judgement relating to the risk of bias for each domain which includes "low risk" of bias, "high risk" of bias or "unclear risk" of bias. Decisions were compared and discussed to achieve consensus. A third reviewer was consulted if disagreement persisted.

**2.4 Data extraction** A data extraction sheet based on the *Cochrane Handbook for Systematic Reviews*. The data extraction form includes study (author, year, country), sample (number of participant, type of disease), exercise (frequency, intensity of intervention, duration, type) according to the American College of Sports Medicine (ACSM)[13], type of control group (continuous training, care-as-usual, no activity, placebo pill, or other control), and outcome (pre- and post-treatment depression scores). If the primary outcomes (means ± SDs) were not available, we used the changes from baseline (also called a change score), if provided within the study. Moreover, if the study reported results at multiple time points, we chose the final follow up data for several reasons. When more than one rating scale were used in a single study, we would select the most common across studies or the one which data was more reasonable.

**2.5 Statistical analysis** Stata V.18.0 was used to conduct the meta-analyses. Since depression and anxiety score were continuous outcomes, we chose *SMD* as summary statistics used for meta-analysis. And the random effects model was selected due to the similar but identical rating scale across studies. Separate analyses were performed for the following comparisons: (i) Change in depression after HIIT compared to CT; (ii) Change in depression after HIIT compared to CON.

In the meta-analyses of each outcome, we did pre-planned subgroup analyses restricted to trials to compare exercise response according to condition of mental illness risk. We classified it into high risk, moderate risk and low risk based on the mean baseline score measured by respective depression or anxiety scale in the two groups. To assess the robustness of our results, sensitivity analyses were subsequently performed: (i) computing the effects of exercise on depression using fixed effects model or random effects model; (ii) comparing exercise response according to study design (RCT, RCD), mode of exercise, measure time (post intervention, follow-up); (iii) by removing each study in turn. We used the $I^2$ test to assess the statistical heterogeneity of the treatment effect among studies, and the values greater than 50% were regarded as being indicative of moderate-to-high heterogeneity. The trim-and-fill computation was used to estimate the effect of publication bias on the interpretation of the results.

## 3 Results and analysis

**3.1 Studies retrieved** A flow chart detailing the study selection process is given in Fig. 1. A total of 14 RCTs (493 patients) were eligible for inclusion in meta-analysis. The initial searches returned a total of 2 631 articles, of which 1 531 were duplicated articles. Of these, 45 did not fulfill the inclusion criteria and the remaining 14 studies were analyzed. Table 1 summarizes the descriptive characteristics of the 14 studies that met inclusion criteria for the review.

**3.2 Characteristics of included studies** 14 RCTs (3 studies are RCD) were included in the review. Of these studies, 14 reported the change of depression symptom and 10 on anxiety. The scales used to assess depression were varied: HADS ($n=5$); POMS ($n=3$); ZDRS ($n=1$); GDS ($n=1$); HDCDS ($n=1$); (SCL-90) ($n=1$); DASS21 ($n=1$) and VAS ($n=1$). According to the baseline level in the HIIT group, we classified the risk of mental illness to high ($n=1$), moderate ($n=3$) and low ($n=10$). The range of participants' ages from the studies was 24 – 65 years, with the majority having a mean age in the 50 sec or 60 sec. Of the 14 controlled trials, 8 (57%) had a CT group, and 6(43%) a CON group. Mode of exercise varied widely between both HIIT and CT interventions. Mode of HIIT intervention included cycle ergometer ($n=8$), treadmill ($n=3$) and walking ($n=2$). The interval time (range 30 sec – 4 min) and total time (range 15 – 60 min) as well as weekly frequency (range 3 – 7 times) and duration (range 2 – 24 weeks) varied widely between studies. CT intervention ranged from 20 to 45 min per session at intensities between 60% and 80% $VO_2$max/HRmax. Anti-depressants and anxiety medication use was not reported in any study. The outcome was measured after up to 2 years[23] and 5 years[15] in two of the trials and post-treatment in 12 trials. There were statistically significant differences in the baseline of depression between HIIT and control group in three studies[11,19,21].

**3.3 Risk of bias in individual studies** Risk of bias for efficacy analysis for each included RCT is shown in Table 2. Three studies, rated as low risk at not less than six of the seven criteria, were regarded as high quality finally. Only one study was rated as low quality as they met less than three of the criteria. The remaining were rated as moderate quality as they met three to five of the seven criteria. Dimeo *et al.*[26] and Chrysohoou *et al.*[14] assessed and found that there was at high risk of bias in random sequence generation due to allocating participants according to the time of hospitalization and condition of patients. Three studies[16,23-24] clearly mentioned that the people engaged in assignment did not participate in the study. Therefore these studies were assessed to be at low risk of bias in blinding of participants and personnel. The rest of literature had an unknown risk of bias because of unclear information concerning blinding of assignments and assessors. All 14 RCTs reported whole expected outcome.

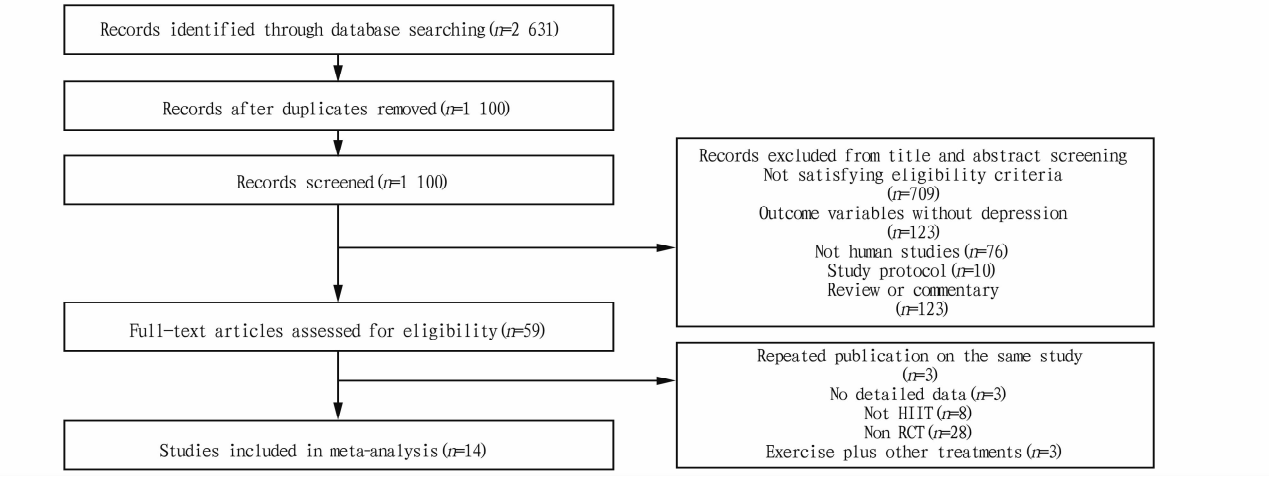


**Fig. 1 PRISMA flowchart diagram of the search process**

**Table 1 Studies included in the analysis**

| Author, year, country | participants | Control | Mode | HIIT intervention | | | Duration | Treatment focus/ outcomes | Mental illness risk |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Intervals | | Total time//min | | | |
| | | | | High | Recovery | | | | |
| Chrysohoou *et al.*[14], 2014, Greece | CHF; 60 years old (*n*HIIT = 33, *n*CON = 39) | CON Usual care(RCT) | Cycle ergometer | 30 sec at 100% max workload | 30 sec rest | 45 | 3 d a week/12 weeks | ZDRS | Low |
| Yardley *et al.*[15], 2017, Norway | HTx; 50 years old (*n*HIIT = 21, *n*CON = 20) | CON Usual care (RCT) | Treadmill | 4 × 4 min at 85% – 95% HRmax) | 3 min at 6 – 20 RPE | 38 | 3 d a week/8 weeks | BDI, HADS | Low |
| Sanudo *et al.*[16], 2015, Spain | FM; 56 years old (*n*HIIT = 16, *n*CON = 12) | CON Usual care (RCT) | Walking | 6 × 1.5 min at 75% – 80% HRmax | 1 min rest | 15 | 2 d a week/24 weeks | VAS | Moderate |
| Dall *et al.*[11], 2015, Denmark | HTx; 52 years old (*n*HIIT = 16, *n*CT = 16) | CT 45 min at 60% – 70% $VO_2$peak (RCD) | Cycle ergometer | 1,2,4 min at > 80% $VO_2$peak | 2 min at 60% $VO_2$peak | 30 | 3 d a week/12 weeks | HADS | Low |
| Freese *et al.*[17], 2014, Athens | MetS; 52 years old (*n*HIIT = 23, *n*CON = 24) | CON Non-exercising (RCT) | Cycle ergometer | 4 – 8 ×30 sec at 9% of fat-free mass | 4 min active recovery with no resistance | 23 – 41 | 3 d a week/6 weeks | POMS | Low |
| Freyssin *et al.*[18], 2012, France | CHF; 54 years old (*n*HIIT = 12, *n*CT = 14) | CT 45 min at the heart rate in VT1 (RCT) | Cycle ergometer | 12 × 30 sec at 60% – 80% the maximal power | 1 min rest | 18 | 5 d a week/8 weeks | HADS | Low |
| Smart *et al.*[19], 2012, Australia | CHF; 60 years old (*n*HIIT = 10, *n*CT = 13) | CT 30 min at 60% – 70% $VO_2$peak | Cycle ergometer | 60 sec at 70% $VO_2$peak | 60 sec rest | 60 | 3 d a week/16 weeks | HDCDS | High |
| Oliveira *et al.*[20], 2013, Spain | Health; 24 years old (*n*HIIT = 15, *n*CT = 15) | CT 24 min at 72% $VO_2$peak (RCD) | Treadmill | 6 – 7 × 2 min at 100% $VO_2$peak | 57 sec rest | 19.2 | 1 – 3 d a week/2 – 3 weeks | POMS | Low |
| Chapman *et al.*[21], 2017, Australia | Mental illness; 38 years old (*n*HIIT = 9, *n*CT = 10) | CT 30-min at 65% – 75% HRmax (RCT) | Treadmill | 3 × 4 min at 85% – 95% HRmax | 3 min at 60% – 70% HRmax | 18 | 3 d a week/12weeks | DASS21 | Moderate |
| Arnardottir *et al.*[22], 2007, Sweden | COPD; 65 years old (*n*HIIT = 28, *n*CT = 32) | CT 27 min at ⩾65% Wpeak (RCT) | Cycle ergometer | 5 × 3 min at ⩾ 80% Wpeak | 3 min at 30% – 40% Wpeak | 27 | Twice a week/16 weeks | HADS | Low |
| Uc *et al.*[23], 2014, America | PD; 65 years old (*n*HIIT = 18, *n*CT = 17) | CT 45 min at 70% – 80% HRmax (RCT) | Walking | 3 min at 80% – 90% of HRmax | 3 min at 60% – 70% HRmax | 45 | 3 d a week/6 weeks | GDS | Low |
| Neunhauserer *et al.*[24], 2016, Australia | COPD; 64 years old (*n*HIIT = 29, *n*CT = 29) | CT 8 – 15 repetitions of strength training exercises (RCD) | – | 7 × 1 min at 70% – 80% peak work rate | 2 min at 50% peak work rate | 21 | 3 d a week/6 weeks | HADS | Low |
| Goldstein *et al.*[25], 2001, the United States | HIV-seropositive; 35 years old (*n*HIIT = 13, *n*CON = 10) | CON Non-exercising (RCT) | Cycle ergometer | 3 min at 70% – 80% HRmax | 2 min at < 70% HRmax | 45 | 3 d a week/12 weeks | BDI, POMS | Moderate |
| Dimeo *et al.*[26], 1999, Germany | Cancer; 40 years old (*n*HIIT = 27, *n*CON = 32) | CON Non-exercising (RCT) | Cycle ergometer | 1 min at >50% HRR | 1 min rest | 30 | Daily | POMS, SCL-90-R | Low |

**NOTE** CHF: chronic heart failure; HTx: heart transplantation; FM: fibromyalgia; MetS: metabolic syndrome; COPD: chronic obstructive pulmonary disease; PD: Parkinson disease; HIV: human immunodeficiency virus; HIIT: high-intensity interval training; CON: non-exercising control group; CT: continuous training group; RCT: randomized controlled trial; RCD: randomized crossover design; Wpeak: peak exercise capacity; VT1: first ventilatory threshold; HRmax: maximum heart rate; $VO_2$peak: peak oxygen consumption; RPE: rated perceived exertion; HRR: heart rate reserve; ZDRS: Zung Depression Rating Scale; BDI: Beck's Depression Inventory; HADS: Hospital Anxiety and Depression Scale; VAS: Visual Analogue Scale; HDCDS: The Hare-Davis Cardiac Depression Scale; DASS21: Depression Anxiety Stress Scale; GDS, Geriatric Depression Scale; POMS: Profile of Mood States; SCL-90-R: Symptom Check List.

**Table 2 Risk of bias in individual studies**

| Study | Random sequence generation | Allocation concealment | Blinding of participants and personnel | Blinding of outcome assessment | Incomplete outcome data addressed | Selective outcome reporting | Other bias | Decision |
|---|---|---|---|---|---|---|---|---|
| Arnardottir *et al.* [22] | Low | Low | Unclear | Unclear | Low | Low | Unclear | Moderate quality |
| Chapman *et al.* [21] | Low | Low | Unclear | Unclear | Low | Low | Low | Moderate quality |
| Chrysohoou *et al.* [14] | High | Unclear | Unclear | Unclear | Low | Low | Low | Moderate quality |
| Dall *et al.* [11] | Low | Low | Unclear | Unclear | Low | Low | Low | Moderate quality |
| Dimeo *et al.* [26] | High | High | Unclear | Unclear | Unclear | Low | Low | Low quality |
| Freese *et al.* [17] | Low | Unclear | Unclear | Unclear | Low | Low | Low | Moderate quality |
| Freyssin *et al.* [18] | Low | Unclear | Unclear | Unclear | Low | Low | Unclear | Moderate quality |
| Goldstein *et al.* [25] | Low | Unclear | Unclear | Unclear | Low | Low | Unclear | Moderate quality |
| Neunhauserer *et al.* [24] | Low | Low | Low | Low | Low | Low | Low | High quality |
| Oliveira *et al.* [20] | Low | Unclear | Unclear | Unclear | Low | Low | Unclear | Moderate quality |
| Sanudo *et al.* [16] | Low | Low | Low | Low | Low | Low | Unclear | High quality |
| Smart *et al.* [19] | Low | Unclear | Unclear | Unclear | Low | Low | Unclear | Moderate quality |
| Uc *et al.* [23] | Low | Low | Low | Low | Low | Low | Low | High quality |
| Yardley *et al.* [15] | Low | Unclear | Unclear | Unclear | Low | Low | Low | Moderate quality |

### 3.4 Main analysis

**3.4.1** Depression. 14 studies reported baseline and post-treatment data from depression scales. Of these, 8/14 had a CON group and 6/14 had a CT group. In a pooled analysis of all 14 trials, the HIIT intervention led to a mean greater reduction in depression score than any other treatment strategy, without statistically significant between-study heterogeneity (Fig. 2). Visual interpretation of funnel plots suggested no obvious evidence of asymmetry. In this analysis there was publication bias on Begg's Test ($p = 0.743$) and Egger test ($p = 0.912$), indicating no evidence of publication bias. The trim-and-fill computation showing no trimming performed and data was unchanged.

**3.4.2** HIIT versus CT. Compared to CT intervention, HIIT showed statistically significant difference ($SMD = -0.35$, 95% $CI$ $-0.66$ to $-0.04$, $p = 0.025$) in the analysis of two high quality studies and six moderate quality studies (with a total of 223 participants) (Fig. 2). We detected no significant heterogeneity between the trials ($I^2 = 37.4\%$, $Tau^2 = 0.072$, $p = 0.131$). We made sensitivity analysis where random or fixed effects model were used respectively. This did not significantly change the results (Table 3). We did another sensitivity analysis for study design, measure time and intervention type. These also failed to explain heterogeneity. Heterogeneity was still constant when each study was removed in turn. But result changed significantly ($p = 0.07$, $SMD = -0.29$, 95% $CI$ $-0.61$ to $0.02$, $I^2 = 35\%$) after Smart *et al.* [19] was excluded.

**3.4.3** HIIT versus CON. Compared to CON group, HIIT intervention showed statistically significant difference ($SMD = -0.49$, 95% $CI$ $-0.92$ to $-0.07$, $p = 0.022$) in the analysis of one high quality study, four moderate quality studies and one low quality study (with a total of 270 participants), as shown in Fig. 3. The heterogeneity between the trials was substantial indicated by the $I^2$ test ($I^2 = 64.4\%$, $Tau^2 = 0.176$, $p = 0.015$). The sensitivity analyses showed on Table 3. Results were robust when random or fixed effects model was applied in analysis. And the heterogeneity decrease to 0% after one study (Chrysohoou *et al.* [14]) was excluded. But the result still showed a significant difference ($p = 0.062$, $SMD = -0.27$, $CI$ $-0.55$ to $0.01$). We supposed that the high risk of this study in random sequence generation could contribute to it. Mean age and HIIT characteristics (duration, interval intensity and weekly frequency, time) did not predict the change in depression.

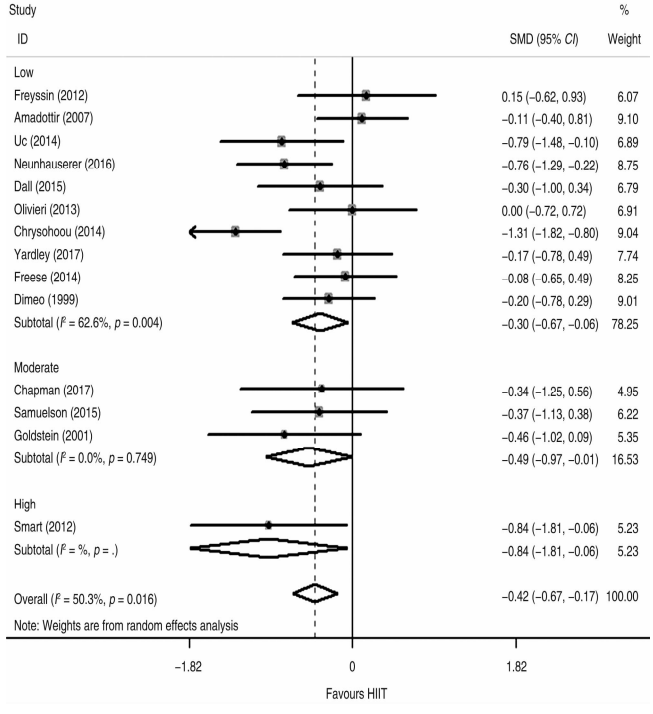


**Fig. 2 Change in depression after HIIT**

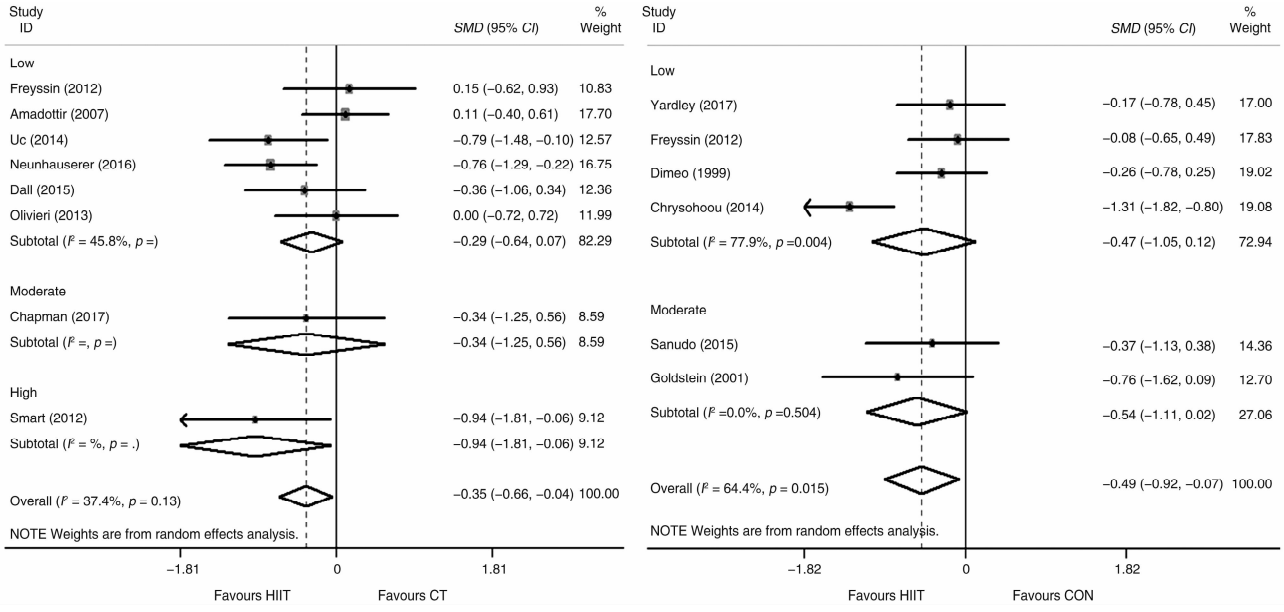


**Fig. 3 Change in depression after HIIT compared to CT and CON**

**Table 3 Sensitivity analyses on depression**

| Outcome | Analysis | RCTs ($n$) | *SMD* | 95% *CI* | $p$-value | $I^2$ | Trim and fill effect size (95% *CI*) |
|---|---|---|---|---|---|---|---|
| HIIT VS CT on depression | Model | | | | | | |
| | Random | 8 | −0.35 | [−0.66, −0.04] | 0.025 | 37.4% | Unchanged |
| | Fixed | 8 | −0.34 | [−0.58, −0.10] | 0.005 | 37.4% | Unchanged |
| | Design | | | | | | |
| | RCD | 3 | −0.43 | [−0.87, 0.02] | 0.059 | 30.1% | |
| | RCT | 5 | −0.31 | [−0.76, 0.14] | 0.176 | 47.8% | Unchanged |
| | Time-point | | | | | | |
| | Post intervention | 7 | −0.28 | [−0.61, 0.04] | 0.086 | 35.7% | Unchanged |
| | Follow-up | 1 | −0.79 | [−1.48, −0.10] | 0.025 | 0 | N/A |
| | Mode | | | | | | |
| | Cycle ergometer | 4 | −0.19 | [−0.64, 0.26] | 0.400 | 40.5% | Unchanged |
| | Treadmill | 2 | −0.12 | [−0.68, 0.44] | 0.680 | 0% | Unchanged |
| | Walking | 1 | −0.79 | [−1.48, −0.10] | 0.025 | 0% | N/A |
| HIIT VS CON on depression | Model | | | | | | |
| | Random | 6 | −0.49 | [−0.92, −0.07] | 0.022 | 64.4% | −0.60[−0.99, −0.21] |
| | Fixed | 6 | −0.51 | [−0.76, −0.26] | 0.000 | 64.4% | −0.61[−1.00, −0.21] |
| | Time-point | | | | | | |
| | Post intervention | 5 | −0.56 | [−1.05, −0.07] | 0.026 | 68.3% | Unchanged |
| | Follow-up | 1 | −0.17 | [−0.78, 0.45] | 0.594 | 0 | N/A |
| | Mode | | | | | | |
| | Cycle ergometer | 4 | −0.60 | [−1.20,0.00] | 0.051 | 75.6% | Unchanged |
| | Treadmill | 1 | −0.17 | [−0.78, 0.45] | 0.594 | 0% | N/A |
| | Walking | 1 | −0.37 | [−1.13, 0.38] | 0.334 | 0% | N/A |

## 4 Discussion

As far as we are aware, this is a systematic review and meta-analysis that has specifically focused on examining the effectiveness of HIIT at improving symptoms of depression compared with continuous exercise and a non-exercising control group. Physical activity (muscle resistance, coordination, occupational, sports, conditioning and balance training) can decrease fatigue, depressive symptoms, sleep disorders[27], but has no effect on anxiety in Parkinson's disease (PD)[28-29]. As showed in figures above, our review is consistent with those references. The potential explanation is that young people more easily suffer from anxiety disorders[1]. But the majority of the included studies have a mean age of 50 years old, which means that the evidence base is scarce for the young. In spite of this, the HIIT intervention can be consid-

ered an effective non-pharmacological treatment for depression in older adults due to the fact that late-life depression is becoming a major social burden with increased health care costs and risk of suicide, morbidity. It is worth mentioning that the effects of HIIT on depression in chronic conditions, such as heart disease, cancer, PD and COPD, might be smaller than effect sizes in populations just with anxiety or mood disorders. Because the depression may be caused by poor physical conditions or potential side-effects of medical treatments in these chronic disease patients, the symptoms of depression are hard to be relieved before the primary affections get treated. In addition, the patients suffered from cancer, chronic pain or other medical conditions with a low level of anxiety or depression at pre-treatment may show a relatively smaller degree of improvement after treatment than those with a high level at pre-treatment, which is consistent that majority of included studies' baseline level of depression or anxiety was low in this review.

Although there was only one study rated as low quality, majority of studies were rated as moderate quality due to the unclear risk with insufficient information about allocation concealment, blinding of participants and outcome assessment, which limited the reliability of results. Begg's test and Egger test indicated no evidence of publication bias in the pooled analysis. But we need to be cautious about it due to the small amounts of included studies and high heterogeneity between different control groups. There were differences in participants, scales of assessment, types of interventions across studies and the heterogeneity indicated significant in some comparisons. Therefore, it is questionable whether pooling studies in meta-analyses is appropriate in this review. We did pre-planned subgroup analyses according to pre-treatment condition of mental illness risk. No further subgroups could be created given the lack of studies, such as type of disease. Sensitivity analyses could also be performed in the limited comparison (study design, exercise type), which showed that the high heterogeneity could be caused by few studies in some comparison. After two studies were omitted, heterogeneity has a significant reduction, but this did not reverse the results. In addition, we used a random-effects model throughout to incorporate heterogeneity into our analyses. The sensitivity analysis, however, showed that there was no statistically significant difference between random effects model and fixed effects model. Although we have tried to minimize the effects of heterogeneity, results in this review should still be treated with caution. In the regression analysis, the primary modifiable elements of HIIT protocols, defined here as duration, interval intensity and weekly frequency, time spent at high-intensity, did not significantly predict the change in depression and anxiety.

## 5 Conclusions

Some limitations of our review should be noted. Firstly, we limited the review to RCTs. It is possible, however, that study designs other than RCTs would have given valuable insight. Secondly, there were only 3 studies were assessed as high quality and wide heterogeneity between participants, making it difficult to generalize conclusions. Thirdly, only two studies reported follow-up results. There were no sufficient follow-up data to demonstrate the longer lasting effects on improvement in depression and anxiety symptoms following HIIT. Despite these limitations, we have demonstrated that HIIT conveys benefits to psychological health which in the case of improving depression symptom may be superior to the effect of traditional continuous training and inactivity, especially for the elderly.

## References


[1] KESSLER RC, ANGERMEYER M, ANTHONY JC, *et al.* Lifetime prevalence and age-of-onset distributions of mental disorders in the World Health Organization's World Mental Health Survey Initiative[J]. World Psychiatry, 2007, 6(3): 168 – 176.

[2] MOUSSAVI S, CHATTERJI S, VERDES E, *et al.* Depression, chronic diseases, and decrements in health: Results from the World Health Surveys[J]. The Lancet, 2007, 370(9590): 851 – 858.

[3] FREEDLAND KE, CARNEY RM. Depression as a risk factor for adverse outcomes in coronary heart disease[J]. BMC Medicine, 2013, 11: 131.

[4] ALEXOPOULOS GS. Pharmacotherapy for late-life depression[J]. Journal of Clinical Psychiatry, 2011, 72(1): e04.

[5] STUBBS B. A meta-analysis investigating falls in older adults taking selective serotonin reuptake inhibitors confirms an association but by no means implies causation[J]. American Journal of Geriatric Psychiatry, 2015, 23(10): 1098.

[6] COUPLAND C, DHIMAN P, MORRISS R, *et al.* Antidepressant use and risk of adverse outcomes in older people: population based cohort study [J]. BMJ, 2011, 343: d4551.

[7] KORCZAK DJ, MADIGAN S, COLASANTO M. Children's physical activity and depression: A meta-analysis[J]. Pediatrics, 2017, 139(4): e20162266.

[8] COONEY GM, DWAN K, GREIG CA, *et al.* Exercise for depression [J]. Cochrane Database of Systematic Reviews, 2013(9): CD004366.

[9] ROBINSON MM, DASARI S, KONOPKA AR, *et al.* Enhanced protein translation underlies improved metabolic and physical adaptations to different exercise training modes in young and old humans[J]. Cell Metabolism, 2017, 25(3): 581 – 592.

[10] VILLELABEITIA-JAUREGUIZAR K, VICENTE-CAMPOS D, SENEN AB, *et al.* Effects of high-intensity interval versus continuous exercise training on post-exercise heart rate recovery in coronary heart-disease patients[J]. International Journal of Cardiology, 2017, 244: 17 – 23.

[11] DALL CH, GUSTAFSSON F, CHRISTENSEN SB, *et al.* Effect of moderate- versus high-intensity exercise on vascular fu*n*CTion, biomarkers and quality of life in heart transplant recipients: A randomized, crossover trial[J]. The Journal of Heart and Lung Transplantation, 2015, 34(8): 1033 – 1041.

[12] O'CONNOR CM, WHELLAN DJ, LEE KL, *et al.* Efficacy and safety of exercise training in patients with chronic heart failure: HF-ACTION randomized controlled trial[J]. JAMA, 2009, 301(14): 1439 – 1450.

[13] GARBER CE, BLISSMER B, DESCHENES MR, *et al.* American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise[J]. Medicine & Science in Sports & Exercise, 2011, 43(7): 1334 – 1359.

[14] CHRYSOHOOU C, TSITSINAKIS G, VOGIATZIS I, *et al.* High intensity, interval exercise improves quality of life of patients with chronic heart failure: A randomized controlled trial[J]. QJM, 2014, 107(1): 25 – 32.

[15] YARDLEY M, GULLESTAD L, BENDZ B, *et al.* Long-term effects of high-intensity interval training in heart transplant recipients: A 5-year follow-up study of a randomized controlled trial[J]. Clinical Transplantation, 2017, 31(1): e12868

[16] SANUDO B, CARRASCO L, DE HOYO M, *et al.* Vagal modulation and symptomatology following a 6-month aerobic exercise program for women with fibromyalgia[J]. Clinical and Experimental Rheumatology, 2015, 33(1 Suppl 88): S41 – S45.
[17] FREESE EC, ACITELLI RM, GIST NH, *et al.* Effect of six weeks of sprint interval training on mood and perceived health in women at risk for metabolic syndrome[J]. Journal of Sport & Exercise Psychology, 2014, 36(6): 610 – 618.
[18] FREYSSIN C, VERKINDT C, PRIEUR F, *et al.* Cardiac rehabilitation in chronic heart failure: Effect of an 8-week, high-intensity interval training versus continuous training[J]. Archives of Physical Medicine and Rehabilitation, 2012, 93(8): 1359 – 1364.
[19] SMART NA, STEELE M. A comparison of 16 weeks of continuous vs intermittent exercise training in chronic heart failure patients[J]. Congestive Heart Failure, 2012, 18(4): 205 – 211.
[20] OLIVEIRA BRR, SLAMA FA, DESLANDES AC, *et al.* Continuous and high-intensity interval training: which promotes higher pleasure[J]. PLOS ONE, 2013, 8(11): e79965.
[21] CHAPMAN JJ, COOMBES JS, BROWN WJ, *et al.* The feasibility and acceptability of high-intensity interval training for adults with mental illness: A pilot study[J]. Mental Health and Physical Activity, 2017, 13: 40 – 48.
[22] ARNARDOTTIR RH, BOMAN G, LARSSON K, *et al.* Interval training compared with continuous training in patients with COPD[J]. Respiratory Medicine, 2007, 101(6): 1196 – 1204.
[23] UC EY, DOERSCHUG KC, MAGNOTTA V, *et al.* Phase I/II randomized trial of aerobic exercise in Parkinson disease in a community setting[J]. Neurology, 2014, 83(5): 413 – 425.
[24] NEUNHÄUSERER D, STEIDLE-KLOC E, WEISS G, *et al.* Supplemental oxygen during high-intensity exercise training in nonhypoxemic chronic obstructive pulmonary disease[J]. The American Journal of Medicine, 2016, 129(11): 1185 – 1193.
[25] GOLDSTEIN AB. Compliance to exercise in early symptomatic HIV infection: Possible mechanisms[D]. US: ProQuest Information & Learning, 2001: 5563 – 5563.
[26] DIMEO FC, STIEGLITZ RD, NOVELLI-FISCHER U, *et al.* Effects of physical activity on the fatigue and psychologic status of cancer patients during chemotherapy[J]. Cancer, 1999, 85(10): 2273 – 2277.
[27] ALTMANN LJ, STEGEMOLLER E, HAZAMY AA, *et al.* Aerobic exercise improves mood, cognition, and language fun*C*Tion in Parkinson's disease: Results of a controlled study[J]. Journal of the International Neuropsychological Society, 2016, 22(9): 878 – 889.
[28] SAJATOVIC M, RIDGEL AL, WALTER EM, *et al.* A randomized trial of individual versus group-format exercise and self-management in individuals with Parkinson's disease and comorbid depression[J]. Patient Preference and Adherence, 2017, 11: 965 – 973.
[29] TANAKA K, QUADROS AC JR, SANTOS RF, *et al.* Benefits of physical exercise on executive fun*C*Tions in older people with Parkinson's disease[J]. Brain and Cognition, 2009, 69(2): 435 – 441.

(From page 59)

[12] MILANOVIC Z, SPORIS G, WESTON M. Effectiveness of high-intensity interval training (HIT) and continuous endurance training for $VO_2$max improvements: A systematic review and meta-analysis of controlled trials[J]. Sports Medicine, 2015, 45(10): 1469 – 1481.
[13] MOHOLDT T, AAMOT IL, GRANOIEN I, *et al.* Aerobic interval training increases peak oxygen uptake more than usual care exercise training in myocardial infarction patients: A randomized controlled study[J]. Clinical Rehabilitation, 2012, 26(1): 33 – 44.
[14] TSCHENTSCHER M, EICHINGER J, EGGER A, *et al.* High-intensity interval training is not superior to other forms of endurance training during cardiac rehabilitation[J]. European Journal of Preventive Cardiology, 2016, 23(1): 14 – 20.
[15] CURRIE KD, MCKELVIE RS, MACDONALD MJ. Flow-mediated dilation is acutely improved after high-intensity interval exercise[J]. Medicine & Science in Sports & Exercise, 2012, 44(11): 2057 – 2064.
[16] CURRIE KD, DUBBERLEY JB, MCKELVIE RS, *et al.* Low-volume, high-intensity interval training in patients with CAD[J]. Medicine & Science in Sports & Exercise, 2013, 45(8): 1436 – 1442.
[17] SMITH AC, SAUNDERS DH, MEAD G. Cardiorespiratory fitness after stroke: A systematic review[J]. International Journal of Stroke, 2012, 7(6): 499 – 510.
[18] ROBINSON CA, MATSUDA PN, CIOL MA, *et al.* Participation in community walking following stroke: the influence of self-perceived environmental barriers[J]. Physical Therapy, 2013, 93(5): 620 – 627.
[19] MITCHELL JH, SPROULE BJ, CHAPMAN CB. The physiological meaning of the maximal oxygen intake test[J]. Journal of Clinical Investigation, 1958, 37(4): 538 – 547.
[20] PANG MY, ENG JJ, DAWSON AS, *et al.* The use of aerobic exercise training in improving aerobic capacity in individuals with stroke: A meta-analysis[J]. Clinical Rehabilitation, 2006, 20(2): 97 – 111.
[21] MUNARI D, PEDRINOLLA A, SMANIA N, *et al.* High-intensity treadmill training improves gait ability, $VO_2$peak and cost of walking in stroke survivors: Preliminary results of a pilot randomized controlled trial[J]. European Journal of Physical and Rehabilitation Medicine, 2018, 54(3): 408 – 418.
[22] GLOBAS C, BECKER C, CERNY J, *et al.* Chronic stroke survivors benefit from high-intensity aerobic treadmill exercise: A randomized control trial[J]. Neurorehabilitation and Neural Repair, 2012, 26(1): 85 – 95.
[23] GJELLESVIK TI, BRUROK B, HOFF J, *et al.* Effect of high aerobic intensity interval treadmill walking in people with chronic stroke: A pilot study with one year follow-up[J]. Topics in Stroke Rehabilitation, 2012, 19(4): 353 – 360.
[24] CALMELS P, DEGACHE F, COURBON A, *et al.* The feasibility and the effects of cycloergometer interval-training on aerobic capacity and walking performance after stroke. Preliminary study[J]. Annals of Physical and Rehabilitation Medicine, 2011, 54(1): 3 – 15.
[25] BOYD JC, SIMPSON CA, JUNG ME, *et al.* Reducing the intensity and volume of interval training diminishes cardiovascular adaptation but not mitochondrial biogenesis in overweight/obese men[J]. PLOS ONE, 2013, 8(7): e68091.
[26] SCRIBBANS TD, EDGETT BA, VOROBEJ K, *et al.* Fibre-specific responses to endurance and low volume high intensity interval training: Striking similarities in acute and chronic adaptation[J]. PLOS ONE, 2014, 9(6): e98119.
[27] HOLLERAN CL, RODRIGUEZ KS, ECHAUZ A, *et al.* Potential contributions of training intensity on locomotor performance in individuals with chronic stroke[J]. Journal of Neurologic Physical Therapy, 2015, 39(2): 95 – 102.
[28] ASKIM T, DAHL AE, AAMOT IL, *et al.* High-intensity aerobic interval training for patients 3 – 9 months after stroke: A feasibility study[J]. Physiotherapy Research International, 2014, 19(3): 129 – 139.
[29] OUTERMANS JC, VAN PEPPEN RP, WITTINK H, *et al.* Effects of a high-intensity task-oriented training on gait performance early after stroke: A pilot study[J]. Clinical Rehabilitation, 2010, 24(11): 979 – 987.