Review Article

Resistance Training in Depression

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Summary

Background: More than 320 million people around the world suffer from depression. Physical activity and sports are effective treatment strategies. Endurance training has already been intensively studied, but any potential antidepressant effect of resistance training is unknown at present, nor is it clear whether this could yield any relevant benefit in clinical use.

Methods: The PubMed database was selectively searched for recent studies and review articles concerning the use, efficacy, and safety of resistance training in persons with depressive symptoms and diagnosed depression.

Results: Two meta-analyses revealed that resistance training alleviated depressive symptoms with a low to moderate effect size (0.39–0.66). Resistance training in patients with diagnosed depression was studied in seven randomized controlled trials, in which the duration of the intervention ranged from eight weeks to eight months. In six of these trials, the depressive symptoms were reduced. In one trial, a persistent benefit was seen in the resistance-training group at 26 months of follow-up (adherence, 33%). Moreover, resistance training improved strength, quality of life, and quality of sleep. No serious adverse events occurred; this indicates that resistance training in depression is safe.

Conclusion: Resistance training seems to have an antidepressant effect. Open questions remain concerning its effects in different age groups, as well as the optimal training parameters. Further high-quality trials will be needed to document the effect of resistance training more conclusively and to enable the formulation of treatment recommendations.

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The World Health Organization (WHO) estimates that more than 320 million people around the world suffer from depression (1). This results in a massive burden not only on the individual level but also on society as a whole (2). However, only a minority of people with depression receive appropriate treatment (3). The recommendations on guideline-compliant treatment for depression include pharmacological and/or psychotherapeutic interventions (4). Having said that, it is important to note that patients often do not comply with the guidelines on antidepressant medication, for example, by failing to take or prematurely discontinuing their prescribed medication. Moreover, side effects such as nausea, insomnia, weight gain, sexual dysfunction as well as discontinuation symptoms may occur (5).

In addition to mental health symptoms, individuals with depression often also suffer from impaired physical health, especially in the setting of metabolic, hepatic, cardiovascular, and immunological disorders (6).

Therefore, other evidence-based treatment options, such as sport and exercise, are of great importance (7). A systematic review conducted by Martland et al. (2023) found that physical training in depression does not cause severe adverse events. Furthermore, the rate of participation in most studies was ≥ 80% and the interventions were perceived as pleasant and beneficial (8). Physical activity has now been included in the S3 guideline/treatment guideline for unipolar depression with a B level of recommendation: "Patients with a depressive disorder in whom physical exercise is not contraindicated should be recommended to undertake structured and supervised physical training" (4). Reference is also made to the general recommendations on exercise. According to the current WHO recommendations (2020), adults should perform at least 150–300 min of moderate or 75–150 min of intensive aerobic activity per week in order to achieve substantial health benefits (6). Alternatively, combinations of activities from the two intensity levels that produce aerobic activity equivalents are also possible. It is

TABLE

Studies on resistance training in depression

Source	Age (years), M (SD) or range	Characteristics	Training/control group/study size (n)	Duration in weeks	Training sessions per week/min per unit	Exercises/sets/ repetition Intensity	Adherence	Main results
Doyne et al., 1987* (25)	28.52 (4.36)	Major or minor depression (SADS, RDC)	Resistance training on equipment/ waiting list/ 40	8	4/ns	10/ns/ns 50–60% estimated MHR	ns	BDI d = 1.07; 95% CI [0.25; 1.86]; HAM-D17 d = 0.84; 95% CI [0.04; 1.65]; DACL d = 1.48; 95% CI [0.61; 2.35]
Krogh et al., 2009 (24)	18–55	Mild or moderate depression (ICD-10)	Circuit training/ relaxation/ 165	16	2/90	10/2–4/8–12 50–75% 1RM	56.2%	No significant effects
Moraes et al., 2019 (23)	70.9 (5.94)	Major depression (DSM-IV)	Resistance training on machines/ LIT/27	12	2/30	4/3/8–12 70% 1RM	< 75%	HAM-D17 and BDI p = 0.044
Pilu et al., 2007 (22)	40–60	Major depression (DSM-IV)	Resistance training on machines/ no intervention/ 30	32	2/60	12/ns/ns ns	< 75%	HAM-D p < 0.0001; d = 1.54; 95% CI [0.69; 2.40]
Singh et al., 1997 (21)	71.3 (1.2)	Major or minor depression or dysthymia (DSM-IV)	Psychopharmacological drugs + resistance training on machines (HIT)/patient education/32	10	3/50	6/3/8 80% 1RM	75%	BDI p < 0.002; GDS p = 0.0004; HAM-D p = 0.008; DSM-IV p = 0.0003
Singh et al., 2001 (20)	71.3 (1.2)	Major or minor depression or dysthymia	Resistance training on machines or home-based training (HIT), from week 20: unsupervised/ patient education/32	20 + follow-Up at 26 months	3/45	6/3/8 80% 1RM	33% (follow-up at 26 months)	20 Weeks BDI p = 0.036; 26 months p = 0.047; d = 0.95; 95% CI [0.22; 1.69]
Singh et al., 2005 (18)	HIT: 69 (5); LIT: 70 (7)	Major or minor depression or dysthymia (DSM-IV)	Resistance training on machines (HIT + LIT)/ standard treatment/ 60	8	3/65	6/3/8 HIT 80% 1RM LIT 20% 1RM	> 95%	HAM-D17 p = 0.14; GDS p = 0.006

*Some of the subjects were put on psychopharmacological drugs in the studies; only Doyne et al., 1987 did not specify any information in this regard.
1RM, one repetition maximum; BDI, Beck Depression Inventory; d, Hedges d effect size (small from 0.2; medium from 0.5; large from 0,7); DACL, Depression Adjective Check Lists; DSM-IV, Diagnostic and Statistical Manual of Mental Disorders 4th Edition; GDS, Geriatric Depression Scale; HAM-D17, 17-item Hamilton Rating Scale of Depression; HIT, high-intensity training; ICD-10, International Classification of Diseases 10th Revision; CI, confidence interval; LIT, low-intensity training; M, mean; MHR, maximum heart rate; n, number; ns, not specified; RDC, Research Diagnostic Criteria; SADS, Schedule for Affective Disorders and Schizophrenia; SD, standard deviation; RCT, randomized controlled trial

further recommended that individuals perform resistance training on 2 or more days per week in order to achieve additional health benefits (8). The recommendations of the American College of Sports Medicine (ACSM) on how to structure health-oriented resistance training are presented in *Box 1*.

To the best of our knowledge, an exercise program that is in line with the WHO recommendations (2020) and that consists of a combination of endurance and resistance training has hitherto not been conducted and systematically evaluated in any studies of patients with depression. Many studies have instead demonstrated the therapeutic efficacy only of aerobic exercise in (mild to severe) depression (9). For example, a meta-analysis performed by Morres et al. (2019) and including 11 randomized controlled trials (RCTs) (n = 455) found a significant antidepressive effect for endurance exercise (g = −0.79; 95% confidence interval: [−1.01; −0.57]; p < 0.00) (10). Jazayeri et al. (2022) found comparable effects between resistance training and endurance training in terms of the reduction in depressive symptoms (11).

Below, we report the results of existing studies on the efficacy of resistance training in the treatment of depression. In doing so, we take into consideration the results regarding the effects on depressive

symptoms as well as on diagnosed depression. From this, we then infer possible implications for clinical practice and point to areas for future research. Based on these results, we make recommendations and identify practical implications for the use of resistance training in the treatment of depression.

Positive effects of resistance training

The health advantages of resistance training go beyond the increase in muscle mass and strength. They encompass, for example, an overall reduction in mortality risk, improved physical and cognitive functioning, a higher rate of cancer survival, as well as optimized metabolism *(Box 2)* (12, 13).

To achieve this, resistance training can be structured in many different ways *(Box 3)*. Weineck (2020) provides an extensive overview of strength training (14), while Bendau et al. (2023), for example, present a summary of potential mechanisms of action (15).

Methods

Based on a selective literature search in PubMed, recent results on the use of resistance training for depressive symptoms and diagnosed depression were brought together. Only meta-analyses and RCTs were included.

BOX 1

Recommendations for resistance training according to the American College of Sports Medicine (ACSM, 2021) (30)

- **Frequency**
  - Beginners should train each main muscle group at least once per week.
  - For experienced individuals, frequency depends on the training goal.
- **Intensity**
  - Beginners: 60–70% of their 1RM (one repetition maximum) and eight to 12 repetitions per exercise in order to improve muscular fitness.
  - Advanced: Depending on the specific goals, individuals can train at different intensities.
- **Type**
  - Multi-joint exercises involving more than one muscle group and targeting agonistic and antagonistic muscle groups are recommended for all adults.
  - Single-joint and core exercises can also be included in a resistance training program, generally after performing multi-joint exercises for a particular muscle group.
  - A wide range of training machines and/or own body weight can be used to perform these exercises.

Results

Resistance training for depressive symptoms

Although the evidence for strength training in diagnosed depressive disorders is scant, there are several studies that have investigated depressive symptoms in the setting of various mental and physical disorders. This review article includes two meta-analyses that looked exclusively at resistance training (16, 17). Gordon et al. (2018) (16) conducted a meta-analysis of 33 RCTs with a total of 1877 participants. The results showed that regular resistance training resulted in a substantial reduction in depressive symptoms. Here, the mean effect was found to be moderate: $\Delta = 0.66$ ([0.48; 0.83]; $p < 0.001$). Participants in the intervention group ($n = 947$) performed resistance training approximately three times per week over a period of on average 12 weeks. This training appeared to be particularly effective among individuals with mild to moderate depressive symptoms ($\Delta = 0.90$; [0.68; 1.11]). The effects were independent of the overall volume of training as well as the increases in strength and health status of the subjects (16).

A more recent meta-analysis conducted by Carneiro et al. (2020) (17) included four RCTs and showed heterogeneous results regarding the effect of strength training. Of four different analyses in which varying depression-specific parameters were used, two yielded statistically significant results. Overall, effect sizes were small to moderate (0.39–0.62). The duration of the interventions was between 8 and 16 weeks; training frequency was twice (three of the studies) or three times (one study) per week. The duration of training sessions varied between 30 and 90 min, whereby one of the four studies provided no data in this regard. The interventions included machines, free weights, and small-equipment training. The heterogeneity of results and discrepancy between the individual studies need to be taken into consideration in the overall interpretation. Furthermore, in the data analysis conducted by Carneiro et al. (2020), the low-intensity strength training performed by one of the groups in the study by Singh et al. (2005) (18) was classified as a resistance training intervention, although the group trained with only 20% of their 1RM (17, 18). 1RM stands for one repetition maximum, which is the highest weight that a person can manage in a single repetition cycle when performing a particular exercise. It is normally used as a basis on which to specify the weights for strength training.

However, according to Martin et al. (1993), the force used should exceed 30% of 1RM to count as strength training (19). Therefore, further randomized controlled studies are required in this area in order to make far-reaching conclusions (17).

Discussion

Resistance training in depression

There is currently no meta-analysis that has investigated resistance training in a differentiated and targeted manner in adults with diagnosed depression. The selective literature search included seven RCTs that have investigated the effects of resistance training on individuals with mild to severe depression *(Table)*. All studies included in the analysis also formed part of the meta-analyses carried out by Gordon et al. (2018) (16) and Carneiro et al. (2020) (17). The investigation

BOX 2

Possible positive neuronal, musculoskeletal, cardiovascular, and metabolic effects of resistance training (from Westcott, 2012 [12])

- **Neuronal**
  - Increases cognitive performance
  - Improves mental health (higher self-esteem; fewer symptoms of depression and anxiety)
- **Musculoskeletal**
  - Improves everyday functioning (better motor control; increased physical and functional performance)
  - Increases muscle strength and counteracts muscle loss in older age
  - Increases bone density (particularly important in relation to osteoporosis)
- **Cardiovascular**
  - Improves cardiovascular health
  - Reduces resting blood pressure
  - Improves blood lipid profile (less low-density lipoprotein and triglycerides; more high-density lipoprotein)
- **Metabolic**
  - Reduces the risk for metabolic disorders
  - Improves insulin sensitivity
  - Increases basal metabolic rate through more muscle mass; increases lean body mass/reduces body fat percentage
  - Slows down the aging process (among others, mitochondrial structure and function)

periods of these studies varied between 8 weeks and 26 months. Training frequency was between two and four times per week, with training intensity varying between 20 and 80% of subjects' 1RM (18, 20–25). One of the studies provided no specific data on training intensity (22), whereas another study used mean heart rate as a measure of intensity (25). The interventions included training on equipment as well as resistance exercises carried out at home.

Six of the studies showed effects on the depression-specific parameters investigated (18, 20–23, 25). However, it is important to note that some studies included only a small number of subjects and no active control group, or did not take into consideration confounding factors such as social interactions.

Moreover, the study by Krogh et al. (2009) found no significant effects for strength training. Having said that, subjects in the strength training group had fewer days of absence from work compared to the control group (relaxation training: mat exercises/self-massage, light balance exercises, tension and relaxation exercises) (24). At 12 months, a mean difference of −12.1% (95% CI: [−21.1%; −3.1%]; p = 0.009) in absenteeism was seen between the strength training and the relaxation training group. As shown in a meta-analysis conducted by Miller et al. (2020), mind–body exercises (such as tai chi and qigong) are also highly effective compared to endurance and resistance training and in this particular study even achieved the highest effect (26). In relation to the results obtained by Krogh et al. (2009), this might explain why there were no statistically significant differences between the strength training intervention group and the group receiving relaxation training including mind–body exercises. In addition, adherence in that particular investigation was only 56.2%. Adherence in the remaining studies ranged from 33% to over 95%. The lower rate of 33% might be explained by the fact that this was a follow-up study at 26 months, in which participants had the option to continue training of their own accord (18, 20–24).

Moraes et al. (2020) conducted the most recent study on this topic. They compared aerobic training, resistance training, and low-intensity training in a control group as adjunctive treatments to pharmacotherapy for major depressive disorder (MDD) in older patients (23). Compared to the control group, depressive symptoms reduced (treatment response = an at least 50% reduction in symptom severity from before to after the intervention) in the aerobic training and strength training groups, measured using the Hamilton Depression Rating Scale (aerobic training group: $\chi 2$, $p = 0.044$) and the Beck Depression Inventory (strength training group: $\chi 2$, $p = 0.044$) (23). With regard to the training modalities, there is only one study by Singh et al. (2005) that compared different trainings intensities. High-intensity progressive resistance training (80% of 1RM) was more effective compared to low-intensity training (20% of 1RM) in the treatment of older individuals (> 60 years) with depression (18). Furthermore, Singh et al. (2001) found that the interventions also had a sustained effect: At 26 months following the start of the intervention, a third of patients with depression from the training group were still actively training (33% [n = 5/15]). The overall changes at 26 months for the interaction effect of time and treatment, measured using the Beck Depression Inventory, were still greater in those engaging in training (21 ± 2.0 to 13 ± 2.2) compared to control subjects (18.4 ± 1.7 to 14.4 ± 2.2; $p = 0.047$). Moreover, after a phase of supervised training, progressive resistance training in older patients (M = 71.3 years) has been shown to be safe and feasible even in an unsupervised setting (20). In addition to the depression-specific measurement parameters, other positive effects such as increased strength and improved quality of life and sleep were also seen (18, 21, 24). In the study by Singh et al. (2005), the increase in strength was directly associated with the reduction in depressive symptoms ($r = 0.40$, $p = 0.004$) —in contrast to the results obtained by Gordon et al. (2018) (17, 18). Most investigations did not report and/or observe any side effects. Only in very rare cases were adjustments necessary due to musculoskeletal problems. In addition, Singh et al. (2005) saw no significant differences between

the intervention and the control group regarding adverse side effects.

Motivating patients with clinical depression to engage in physical activity

It is often extremely challenging to motivate patients who are depressed and inactive to engage in regular physical activity. Frequently cited barriers to participation in resistance training include risk of injury as well as lack of or difficult access to a health club (27). Furthermore, a lack of support, a high body mass index, the presence of physical comorbidities, and low self-efficacy can also represent barriers (28).

To overcome these hurdles, Blumenthal et al. (2023) recommend using principles of motivational interviewing and action planning concepts, as well as deploying the transtheoretical model of health behavior change (27). It can also be helpful to encourage patients to train together with friends or family members. This can contribute to maintaining commitment and physical activity over the long term and to successfully reducing symptoms (29). In order to ensure that patients turn regular physical activity into a habit so that they can benefit long-term from the positive effects, it is important to not only recommend physical activity but also to follow-up—ideally regularly—on whether patients are adhering to this recommendation and to positively reinforce this (27).

BOX 3

Overview of various forms, organizational options, and exertion parameters in resistance training

Forms of resistance training

- **Using own body weight** (for example: push-ups, pull-ups, [side] plank)
- **On machines** (for example: leg press, lat pulldown tower, shoulder press)
- **Using resistance bands** (for example: hip extension, bicep curls, rowing)
- **Free resistance training** (for example: deadlift, squats with barbell, bench press with dumbbells)
- **Electromyostimulation** (static or dynamic, with own body weight or additional weight/resistance bands)
- **Vibration plate** (static or dynamic, with own body weight or additional weight/resistance bands)

Organizational forms

- **Circuit training**
- **Stationary training**
- **Mixed forms**

Exertion parameters

- **Frequency** (how many training units?)
- **Amount** (how many exercises/sets/repetitions?)
- **Intensity** (resistance in kg)
- **Duration** (the time a muscle is under strain during an exercise)
- **Density** (length of rest periods between sets/exercises)

Perspectives

The aim of this study was to critically evaluate and summarize the current research on resistance training in depression. Most publications in this field are characterized by a high average age of participants, explaining why the effects primarily in young adults are largely unknown. Moreover, all of the studies conducted show gaps in their presentation of training parameters, such as information lacking on the length of rest periods between training sets/units as well as cadence (tempo) during training exercises. Furthermore, social interaction during the interventions should be recorded and, ideally, compared with the control group. However, most studies did not provide any precise information in this regard. The majority of the studies also only used equipment training, thereby limiting findings on other forms of resistance training.

As a result of the significant heterogeneity (training modalities, age, sex, parameters recorded) of the investigations, it is difficult to derive concrete recommendations for resistance training in depression. According to Sawan et al. (2023), health effects can be obtained through resistance training when it is performed in different ranges of intensity (≥ 30%, but < 70% of 1RM) as long as repetitions within a set are performed up to the point of exhaustion or close to muscle failure. Higher intensities are also effective, but potentially carry a greater risk of injury. The included studies showed that different intensities (20–80% of 1RM) were likewise effective. The frequency of training in all investigations was between two and four times per week; thus, a minimum frequency of twice per week appears appropriate. In addition, resistance exercises for the large muscle groups were used in all studies.

The recommendations of the American College of Sports Medicine (ASCM) *(Box 1)* (30) largely align with the training modalities used and can therefore serve as a guide. However, it would be desirable in the future to confirm the effects of resistance training on depression by means of high-quality studies as well as to compare different training modalities (type, intensity, frequency, cadence of training, etc.).

Practical conclusion

Despite the heterogeneous and sometimes non-significant findings, the evidence as a whole points to an antidepressant efficacy for resistance training in depression. Therefore, it appears advisable to offer resistance training as part of a multimodal treatment approach.

The WHO and ACSM recommendations can serve as guidance. It should also be emphasized that resistance training offers great variety in terms of structuring options, thereby covering a wide range of different and individual needs. It is recommended that training be planned and carried out with qualified trainers, or at least to begin with. In addition to its depression-specific effects, one should always emphasize the importance of resistance training for one's

general health, especially in the case of individuals with multiple comorbidities.

There is no evidence as yet with regard to a preference for strength or aerobic training, or the combination thereof, in the treatment of depression. In general, it is advisable to choose a suitable physical activity on the basis of individual needs, abilities, and experience and which can be used as part of a long-term change in behavior.

Conflict of interest statement
The authors declare that they have no conflicts of interest.

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