## Title

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## Publication Date

2015-10-01

## DOI

10.1016/j.jsat.2015.04.007

Peer reviewed

HHS Public Access

Author manuscript

*J Subst Abuse Treat*. Author manuscript; available in PMC 2016 October 01.

Published in final edited form as:

*J Subst Abuse Treat*. 2015 October ; 57: 36–40. doi:10.1016/j.jsat.2015.04.007.

# The impact of exercise on depression and anxiety symptoms among abstinent methamphetamine-dependent individuals in a residential treatment setting

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## Abstract

**Background—**This paper reports data from a study designed to determine the impact of an 8-week exercise program on depression and anxiety symptoms among newly abstinent methamphetamine (MA)-dependent individuals in residential treatment.

**Methods—**One hundred thirty-five MA-dependent individuals, newly enrolled in residential treatment, were randomly assigned to receive either a 3-times-per-week, 60-minute structured exercise program for 8 weeks (24 sessions) or an equivalent number of health education sessions. Using mixed-modeling repeated-measures regression, we examined changes in weekly total depression and anxiety scores as measured by the Beck Depression Inventory and Beck Anxiety Inventory over the 8-week study period.

**Results—**Mean age of participants was 31.7 (*SD* = 6.9); 70.4% were male and 48% Latino. Analyses indicate a significant effect of exercise on reducing depression (β = −0.63, *P* = 0.001) and anxiety (β = −0.95, *P* = 0.001) symptoms (total scores) over the 8-week period compared to a health education control group. A significant dose interaction effect between session attendance and exercise was found as well on reducing depression (β = −0.61, *P* < 0.001) and anxiety symptoms (β = −0.22, *P* = 0.009) over time compared to the control group.

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The content of this article is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute on Drug Abuse.

Conflict of interest declaration: none

Clinical trial registration details: ClinicalTrials.gov Identifier: NCT01103531

**Conclusions—**Results support the role of a structured exercise program as an effective intervention for improving symptoms of depression and anxiety associated with MA abstinence.

### Keywords

Methamphetamine; Treatment; Exercise; Depression and Anxiety Symptoms

## INTRODUCTION

Aerobic exercise and physical activity have been strongly recommended as health promotion and disease prevention approaches by the World Health Organization (WHO) and the Department of Health and Human Services (Leavitt, 2008; WHO, 2007). Exercise also has been shown to positively promote psychological wellness (Blumenthal, Williams, Needels, & Wallace, 1982; Goodwin, 2003), as well as effectively reduce and lower symptoms associated with a variety of disorders, including mood disorders (anxiety and depression; Barbour, Edenfield, & Blumenthal, 2007; Craft & Perna, 2004; Martinsen, 2008; Rethorst, Wipfli, & Landers, 2009; Smits et al., 2008), panic disorder (Broocks et al., 1998), dysphoric moods (Fremont & Craighead, 1987), and cognitive disorders (Alzheimer's; Lautenschlager et al., 2008).

A growing body of studies lend support for the use of structured exercise as an alternative intervention for substance use disorders, including promoting smoking cessation (Zschucke, Heinz, & Ströhle, 2012), reducing cannabis craving (Buchowski et al., 2011), and promoting sustained recovery among those in recovery (Palmer, Palmer, Michiels, & Thigpen, 1995). Some studies also have examined the effectiveness of exercise as an adjunct therapy for the treatment of substance use disorders (Brown et al., 2009; Skrede, Munkvold, Watne, & Martinsen, 2006; Zschucke et al., 2012;); however, to date, there are no studies on the utility of exercise for addressing methamphetamine (MA) dependence, a significant public health problem (Gonzales, Mooney, & Rawson, 2010; Maxwell & Brecht, 2011). This is a gap in the field, considering that problems with anxiety and depression have been shown to be associated with MA relapse and treatment retention, especially for newly abstinent MA abusers during the early phases of the recovery process (Cohen, 1988; Darke, Kaye, McKetin, & Duflou, 2008; Newton, Kalechstein, Duran, Vansluis, & Ling, 2004; Simon, Dean, Cordova, Monterosso, & London, 2010; Zorick et al. 2010).

Given that previous studies have shown that exercise is useful for reducing mood-related symptoms of anxiety and depression, in particular, this study sought to examine the impact of an 8-week structured exercise intervention on reducing depression and anxiety symptoms among a newly abstinent sample of MA-dependent adults compared to a health education condition. It was hypothesized that participants assigned to the exercise condition would demonstrate statistically lower psychological symptoms during the 8-week intervention period compared to participants assigned to health education.

# METHODS

## Participants

Under the approval of the Institutional Review Board (IRB) of the University of California, Los Angeles (UCLA), the present study includes 135 MA-dependent adults who voluntarily participated in a randomized controlled trial (RCT) of exercise compared to health education that took place at a publicly funded residential treatment program that had a small gym (equipped with two treadmills and weight-training resources) between 2010 and 2013 in Southern California.

## Procedures

Participants were recruited to the study upon entry to the residential treatment program. Inclusion criteria were MA dependence, English proficiency, age 18 to either 45 years for men or 55 years for women (per American College of Sports Medicine [ACSM, 2000] guidelines for supervision of exercise by non-physicians), and the ability to attend exercise or health education sessions. Individuals were excluded if they exhibited medical impairment that compromised their safety as a participant, met criteria for opiate dependence, or had a psychiatric impairment that warranted hospitalization or primary treatment (see Mooney et al., 2014, for further details on the study design).

Flyers were posted throughout the treatment facility to recruit study candidates. On-site research staff met with interested MA-dependent participants in a study office to conduct screening and enrollment procedures. Eligible participants signed consent for study participation and completed all baseline measures. A randomized block design approach was used (using a computerized urn randomization program) to assign participants to one of two study conditions: (1) exercise intervention (n = 69) or health education control (n = 66). Randomization to study groups was stratified by gender (male/female) and severity of baseline MA use (high vs. low severity). In previous clinical outcome studies with MA-dependent clients, the median number of days of use has ranged from 16–20. Therefore, we define “low severity” as using MA for 18 or fewer days in the previous month, and “high-severity” as using for 19 or more days in the past month. The study’s data management center (DMC) maintained the urn randomization program and the records that linked participant identification numbers to study condition. See Figure 1 Consort Diagram for study flow.

**Intervention Condition—**The exercise intervention consisted of a progressive aerobic and resistance exercise training program that was conducted with participants three days a week during the 8-week trial (totaling 24 sessions). Exercise sessions were scheduled throughout the day at convenient times for participants (around their routine treatment regimen at the residential facility). Exercise sessions were about 55 minutes in length, structured as follows: 5-minute warm-up, 30 minutes of aerobic activity on a treadmill, 15 minutes of weight training for the major muscle groups—(arms, chest, back, and legs) and a 5-minute cool-down with stretching. Specific exercise maneuvers engaged in during the weight training included chest press, front pull down, leg press, reverse lunges, calf raises, lateral raises, bicep curls, and triceps press. Each session was individual-based, guided and

monitored by a study staff exercise physiologist. Using heart rate monitors, the exercise physiologist worked closely with each individual participant on training days to increase treadmill speed/slope to maintain a heart rate between 60% and 80% of maximum for 30 minutes. Once a participant was able to complete two sets of 15 repetitions of any given exercise, weight was incrementally increased.

**Control Condition—**The control group consisted of structured health education sessions given to participants three days a week during the 8-week trial (totaling 24 sessions). Health education sessions were 55 minutes in length and consisted of various health topics, including stress reduction, health screening, healthy relationships, and sexually transmitted diseases. The sessions were scheduled at a convenient time for clients to attend and were conducted by a trained health educator in a room at the treatment facility in a "group format" (i.e., all participants enrolled were included).

## Measures

Given that the main hypothesis of this study was testing the impact of the 8-week exercise intervention on reducing mood symptoms among MA participants (compared to health education), the two primary outcome measures included depression and anxiety symptoms. For this, we used data collected on these measures at baseline (week 0), weekly (at the end of each week), and at study discharge (week 9). Participants voluntarily completed baseline measures and were compensated with $10 gift cards per session for each exercise or education session they attended, once randomized. Depression symptoms were assessed at the end of each week using the Beck Depression Inventory (BDI), a 21-item self-report questionnaire (Beck, Steer, & Garbin, 1988; Beck, Ward, Mendelson, Mock, & Erbauch, 1961). The BDI total score ranges from 0 to 63, with scores of 0 to 13 indicating minimal depression symptoms, 14 to 19 indicating mild depression symptoms, 20 to 28 referring to moderate depression symptoms, and 29 to 63 indicating severe depression symptomatology (Beck et al., 1988). Anxiety symptoms were also assessed at the end of each week using the Beck Anxiety Inventory (BAI). Similar to the BDI, the BAI is a 21-item measure that assesses for symptoms of anxiety (Beck, 1967) using the same total scoring and symptom range breakdown (i.e., higher scores indicating higher anxiety symptomatology). For analyses purposes, we used the total mean weekly scores for each of the mood measures.

Secondarily, we also examined the potential effects of a dose response on changes in mood symptoms, as research indicates that greater exercise adherence (exposure) is associated with better mental health outcomes than less exercise adherence (Wipfli, Rethorst, & Landers, 2008). For this study, dose response was measured by session adherence for both study conditions using sign-in attendance checklists throughout the 8-week trial. Hence, the total number of sessions attended was computed and scored from 1 to 24 for each participant. It should be noted that because all participants in the study were concurrently enrolled in residential treatment for MA dependence, the facility policy was drug abstinence verified by random urine drug screens conducted at least weekly during treatment. If participants tested positive, they were immediately discharged from the facility. Hence MA participants in this study were assumed to be abstinent as verified by the random drug screens used during treatment. According to treatment records, two participants, one in each

group, were discharged from the treatment facility prior to study completion for positive drug tests. These participants were not included in analyses.

### Statistical Analyses

Mixed modeling using a repeated-measures random-effects model was conducted to test for the effects of treatment (dummy coded 1 = *exercise* vs. 0 = *education*) and time (in weeks) as well as the treatment x time interaction on the primary outcome measures (depression and anxiety total scores) over the 8-week study period. An unstructured covariance matrix was specified for the models. To examine dose effect, we examined the three-way interaction of total number of sessions attended x treatment group x time (measurement time point for BDI or BAI). The Hausman test was performed to check for the consistency of the random effects. Normality, linearity, and heteroskedasticity checks performed on the data confirmed that none of the model assumptions were violated. In our power calculations, we estimated that at least 130 participants would be needed to provide the 80% power necessary to detect a mean difference of 3.5 points (*SD* = 5) in depression and anxiety total scores from baseline to week 8 between the two study groups (McGregor et al., 2005).

## RESULTS

### Participant characteristics

The average age of the study sample was 31.7 years (*SD* = 6.9), with ages ranging from 18 to 47. Most of the participants were Latino (48.1%), followed by non-Latino Caucasian (41.5%). There were fewer African American (4.4%), Asian (3.7%), or “Other” (2.2%) ethnic group members. About a third of the sample was female (29.6%), 16.3 % were employed in the month prior to treatment entry, and most (64.7%) had a high school education. In terms of baseline MA use, average days of use was 15.9 in the month prior to treatment entry (*SD* = 9.9). There were no significant differences in baseline characteristics between the two groups. In addition, it should be noted that no harms or unintended effects occurred within either group during the trial.

### Changes in depression and anxiety symptoms over the 8-week trial by condition

Results showed that there were no statistically significant baseline differences in depression BDI scores between the exercise versus the health education control group (13.7 ± 5.3 vs. 12.0 ± 6.3, respectively, $P = 0.21$). We also did not find any significant differences in baseline anxiety BAI scores between the groups (16.5 ± 6.0 for the exercise group vs. 11.9 ± 5.1 for the health education control, $P = 0.08$). Using mixed-effects modeling employing a random-effects repeated-measures model, we examined changes in mood symptoms (depression and anxiety) over the 8-week period. Findings showed a significant effect of exercise on depression symptoms (Treatment x time, $\beta = -0.63$, $P = 0.001$), in that the exercise group participants reported significantly lower depression BDI total scores at the 8-week time point from baseline (M = 2.43, SD =4.22) compared to health education control participants (M = 4.82, SD = 5.71), after controlling for demographics. Likewise, findings showed a significant effect of exercise on anxiety symptoms (Treatment x time, $\beta = -0.95$, $P = 0.001$), in that the exercise group participants reported significantly lower anxiety total

scores at the 8-week time point from baseline (M = 2.18, SD = 4.94) than those in the health education control group (M = 5.11, SD = 7.79).

To illustrate how depression and anxiety total scores changed in the 8-week trial, we examined the scores from baseline to week 8. The difference in these scores is illustrated in Figures 2 and 3. As shown, there was an improvement in depression and anxiety total scores for the exercise group compared to the control group when we compared scores for BDI and BAI across the 8-week program to the baseline BDI and BAI scores.

### Dose effect (defined by session attendance) on depression and anxiety symptoms by condition over the 8-week trial

Using linear mixed-effects regression modeling, we examined the extent to which there was a dose-response relationship between number of sessions received and changes in mood symptoms (depression and anxiety) over the 8-week trial. There was no mean difference in sessions attended by study conditions, such that the exercise group averaged 17.4 sessions (*SD* = 7.3) and the health education control group averaged 18.5 (*SD* = 7.0) sessions. Findings showed a significant effect of session attendance ($\beta = -0.52$, $P = 0.03$) for all study participants; however, a significant interaction effect between treatment and session attendance was found on depression ($\beta = -0.61$, $P < 0.001$), indicating a dose response of the exercise intervention on depression total scores (see Table 1). Specifically, participants who attended more exercise sessions had significantly lower symptoms of depression over time, compared to the control group session's attendance and depression symptoms. Similarly, there was a significant effect of session attendance on anxiety symptom reduction for all study participants ($\beta = -0.29$, $P < 0.01$) and a significant interaction effect between treatment and session attendance ($\beta = -0.22$, $P = 0.009$) on anxiety total scores, such that participants who had more exercise sessions had significantly lower symptoms of anxiety over time, compared to the control group session's attendance-by-anxiety symptoms (see Table 1).

## DISCUSSION

MA use induces complex neurobiological and physiological changes in the brain and body that are associated with numerous physical and mental impairments, including depression and anxiety symptoms (Rawson, Gonzales, & Ling, 2006; Zweben et al., 2004). Increasingly, exercise interventions (ranging from 8–12 weeks) have been embraced in health care as a promising approach for populations suffering from an array of health issues (Craft & Landers, 1998; Lautenschlager et al., 2008; Palmer et al. 1995; Skrede et al., 2006; WHO, 2007). This study extends the utility of a structured exercise intervention in mitigating symptoms of depression and anxiety in a group of MA-dependent participants in residential treatment (recently abstinent from MA). Particular attention is given to depression and anxiety since these are problematic in early-abstinent MA users (London et al., 2004; Zorick et al., 2010) and aerobic exercise has led to improvements in such symptoms in a variety of clinical populations (Rethorst et al., 2009).

Consistent with previous studies, we found evidence that an 8-week structured program of exercise produces positive effects by reducing mood-related symptoms of depression and

anxiety among MA-abstinent individuals in treatment. We also found a significant dose effect on mood outcomes for the exercise condition, such that those who participated in more exercise sessions during the 8-week trial had greater symptom reduction in depression and anxiety compared to those who participated in fewer sessions. This relationship did not occur for participants in the education control group.

These study findings can be useful to treatment providers interested in addressing depression and anxiety symptoms commonly exhibited among MA-dependent individuals in early abstinence. Specifically, treatment providers can encourage MA users to engage in the type of exercise used in this study (i.e., aerobic exercise training on a treadmill and weight training for the major muscle groups arms, chest, back, and legs) to help them deal with problematic anxiety and depression symptoms that are linked to relapse and early treatment termination (Cohen, 1988; Darke et al., 2008).

The beneficial effects of the 8-week exercise intervention on reducing depression and anxiety symptoms among MA-dependent individuals in treatment should be viewed in the context of other benefits reported from previous work specific to this study. Specifically, we have found that the exercise intervention also has led to significant improvements in physical fitness indices such as aerobic performance and muscle strength (Dolezal, Chudzynski, Storer, et al., 2013), as well as increases in heart rate variability, a validated index of autonomic nervous system control (Dolezal, Chudzynski, Dickerson, et al., 2013) among the MA-dependent patient sample. Future studies are needed to further explore the specific neurobiological processes that contribute to reductions in symptoms of depression and anxiety as a result of aerobic exercise.

Limitations of this study should be noted. The present sample is based on a treatment-involved clinical sample that participated in a RCT of an 8-week exercise intervention trial while in residential treatment; hence, findings may not be generalizable to MA-dependent individuals in other treatment settings or to those who are not seeking treatment. This study only examined anxiety and depression symptoms via self-reported BDI and BAI measures. Participants in the health education session were exposed to sessions around general health topics, including stress. This may be limiting to the outcomes of this study since stress education may have an impact on anxiety symptoms. It should be noted that this issue is not anticipated given that the educational sessions were about stress in general and not tied to how to reduce stress specific to anxiety symptoms. Lastly, the study sample was predominately male (70%), which reduces the generalizability of the results to both sexes. In spite of these limitations, findings in this study provide valuable information with regard to the potential benefits of exercise within a treatment population who experience dysphoric mood states.

## Conclusions

Collectively, results support the important role exercise plays in improving dysphoric mood symptoms (depression and anxiety) among clinical samples of MA-abstinent patients. Future efforts are needed to characterize the mechanisms by which exercise, alone or in combination with other interventions, exerts its efficacy on changing mood symptoms. Given the unique benefits of exercise on the mental health outcomes of MA-dependent

individuals, treatment programs should consider partnering with wellness or fitness facilities in the local community to better integrate exercise features into treatment regimens.

## Acknowledgments

This study was supported by grant R01 DA027633 from the National Institute on Drug Abuse (NIDA). The authors would like to thank the administrative and treatment staff at the participating treatment program for their support, and they also thank research staff Jose Penate, Vanessa Novoa, Marlon Abrazado, and Patricia Ballesteros for contributing to the implementation of the study.

## References

American College of Sports Medicine. ACSM's guidelines for exercise testing and prescription. 6. Baltimore, MD: Lippincott Williams & Wilkins; 2000.

Barbour KA, Edenfield TM, Blumenthal JA. Exercise as a treatment for depression and other psychiatric disorders: A review. Journal of Cardiopulmonary Rehabilitation and Prevention. 2007; 27:359–367. [PubMed: 18197069]

Beck, AT. Depression: Clinical, experimental, and theoretical aspects. New York: Hoeber; 1967. Republished as *Depression: Causes and treatment.* Philadelphia: University of Pennsylvania Press

Beck AT, Steer RA, Garbin MG. Psychometric properties of the Beck Depression Inventory: Twenty-five years of evaluation. Clinical Psychology Review. 1988; 8:77–100.

Beck AT, Ward CH, Mendelson M, Mock J, Erbauch J. An inventory for measuring depression. Archives of General Psychiatry. 1961; 4:561–571. [PubMed: 13688369]

Blumenthal JA, Williams RS, Needels TL, Wallace AG. Psychological changes accompany aerobic exercise in health middle-aged adults. Psychosomatic Medicine. 1982; 44:529–536. [PubMed: 7163456]

Broocks A, Bandelow B, Pekrun G, George A, Meyer T, Bartmann U, Rüther E. Comparison of aerobic exercise, clomipramine, and placebo in the treatment of panic disorder. American Journal of Psychiatry. 1998; 155:603–609. [PubMed: 9585709]

Brown RA, Abrantes AM, Read JP, Marcus BH, Jakicic J, Strong DR, Gordon MD. Aerobic exercise for alcohol recovery: Rationale, program description, and preliminary findings. Behavior Modification. 2009; 33(2):220–249. [PubMed: 19091721]

Buchowski MS, Meade NN, Charboneau E, Park S, Dietrich MS, Cowan RL, Martin PR. Aerobic exercise training reduces cannabis craving and use in non-treatment seeking cannabis-dependent adults. PLoS One. 2011; 6:e17465. [PubMed: 21408154]

Cohen, J. Statistical power analysis for the behavioral sciences. 2. Hillsdale, NJ: Erlbaum; 1988.

Craft LL, Landers DM. The effect of exercise on clinical depression and depression resulting from mental illness: A meta-analysis. Journal of Sport and Exercise Psychology. 1998; 20:339–357.

Craft LL, Perna FM. The benefits of exercise for the clinically depressed. Primary Care Companion to the Journal of Clinical Psychiatry. 2004; 6:104–111.

Darke S, Kaye S, McKetin R, Duflou J. Major physical and psychological harms of methamphetamine use. Drug and Alcohol Review. 2008; 27:253–262. [PubMed: 18368606]

Dolezal BA, Chudzynski J, Dickerson D, Mooney L, Rawson RA, Garfinkel A, Cooper CB. Exercise training increases heart rate variability in methamphetamine-dependent individuals. Medicine & Science in Sports & Exercise. 2013; 46:1057–1066. [PubMed: 24162556]

Dolezal BA, Chudzynski J, Storer TW, Abrazado M, Penate J, Mooney L, Cooper CB. Eight weeks of exercise training improves fitness measures in methamphetamine-dependent individuals in residential treatment. Journal of Addiction Medicine. 2013; 7:122–128. [PubMed: 23552821]

Fremont J, Craighead LW. Aerobic exercise and cognitive therapy in the treatment of dysphoric moods. Cognitive Therapy Research. 1987; 11:241–251.

Gonzales R, Mooney L, Rawson RA. The methamphetamine problem in the United States. Annual Review of Public Health. 2010; 31:385–398.

Goodwin RD. Association between physical activity and mental disorders and other disorders among adults in the United States. Preventive Medicine. 2003; 36:698–703. [PubMed: 12744913]

Lautenschlager NT, Cox KL, Flicker L, Foster JK, van Bockxmeer FM, Xiao J, Almeida OP. Effect of physical activity on cognitive function in older adults at risk for Alzheimer disease: A randomized trial. JAMA. 2008; 300:1027–1037. [PubMed: 18768414]

Leavitt, M. 2008 physical activity guidelines for Americans. Rockville, MD: U.S. Department of Health and Human Services; 2008 Oct. ODPHP Publication No. U0036

London ED, Simon SL, Berman SM, Mandelkern MA, Lichtman AM, Bramen J, Ling W. Mood disturbances and regional cerebral metabolic abnormalities in recently abstinent methamphetamine abusers. Archives of General Pyschiatry. 2004; 61:73–84.

Martinsen EW. Physical activity in the prevention and treatment of anxiety and depression. Nordic Journal of Psychiatry. 2008; 62(Suppl 47):25–29. [PubMed: 18752115]

Maxwell J, Brecht ML. Methamphetamine: Here we go again? Addictive Behaviors. 2011; 36:1168–1173. [PubMed: 21875772]

McGregor C, Srisurapanont M, Jittiwutikarn J, Laobhripatr S, Wongtan T, White JM. The nature, time–course and severity of methamphetamine withdrawal. Addiction. 2005; 100:1320–1329. [PubMed: 16128721]

Mooney LJ, Cooper C, London ED, Chudzynski J, Dolezal B, Dickerson D, Rawson RA. Exercise for methamphetamine dependence: Rationale, design, and methodology. Contemporary Clinical Trials. 2014; 37:139–147. [PubMed: 24291456]

Newton TF, Kalechstein AD, Duran S, Vansluis N, Ling W. Methamphetamine abstinence syndrome: Preliminary findings. American Journal on Addictions. 2004; 13:248–255. [PubMed: 15370944]

Palmer JA, Palmer LK, Michiels K, Thigpen B. Effects of type of exercise on depression in recovering substance abusers. Perceptual and Motor Skills. 1995; 80:523–530. [PubMed: 7675585]

Rawson RA, Gonzales R, Ling W. Methamphetamine abuse and dependence: An update. Directions in Psychiatry. 2006; 26:131–144.

Rethorst CD, Wipfli BM, Landers DM. The antidepressive effects of exercise: A meta-analysis of randomized trials. Sports Medicine. 2009; 39:491–511. [PubMed: 19453207]

Simon S, Dean AC, Cordova X, Monterosso JR, London ED. Methamphetamine dependence and neuropsychological functioning: Evaluating change during early abstinence. Journal of Studies of Alcohol and Drugs. 2010; 71:335–344.

Skrede A, Munkvold H, Watne Ø, Martinsen EW. Exercise contacts in the treatment of substance dependence and mental disorders. Tidsskr Nor Laegeforen. 2006; 126:1925–1927. [PubMed: 16915316]

Smits JA, Berry AC, Rosenfield D, Powers MB, Behar E, Otto MW. Reducing anxiety sensitivity with exercise. Depression and Anxiety. 2008; 25:689–699. [PubMed: 18729145]

Wipfli BM, Rethorst CD, Landers DM. The anxiolytic effects of exercise: A meta-analysis of randomized trials and dose-response analysis. Journal of Sport & Exercise Psychology. 2008; 30:392–410. [PubMed: 18723899]

World Health Organization (WHO). The World Health Report 2007 - A safer future: Global public health security in the 21st century. Geneva: WHO; 2007. Available from http://www.who.int/whr/2007/en/index.html. (Archived by WebCite® at http://www.webcitation.org/6KGhm2i18)

Zorick T, Nestor L, Miotto K, Sugar C, Hellemann G, Scanlon G, London ED. Withdrawal symptoms in abstinent methamphetamine-dependent subjects. Addiction. 2010; 105:1809–1818. [PubMed: 20840201]

Zschucke E, Heinz A, Ströhle A. Exercise and physical activity in the therapy of substance use disorders. Scientific World Journal. 2012; 2012:901741. [PubMed: 22629222]

Zweben JE, Cohen JB, Christian D, Galloway GP, Salinardi M, Parent D, Iguchi M. Methamphetamine Treatment Project. Psychiatric symptoms in methamphetamine users. American Journal on Addictions. 2004; 13:181–190. [PubMed: 15204668]

## Highlights

- Exercise has a significant effect on reducing depression and anxiety symptoms among methamphetamine-dependent individuals who are newly abstinent
- A significant dose interaction effect was also found between session attendance and exercise on reducing depression and anxiety symptoms over time.
- Results support the role of a structured exercise program as an effective intervention for improving symptoms of depression and anxiety associated with methamphetamine abstinence.

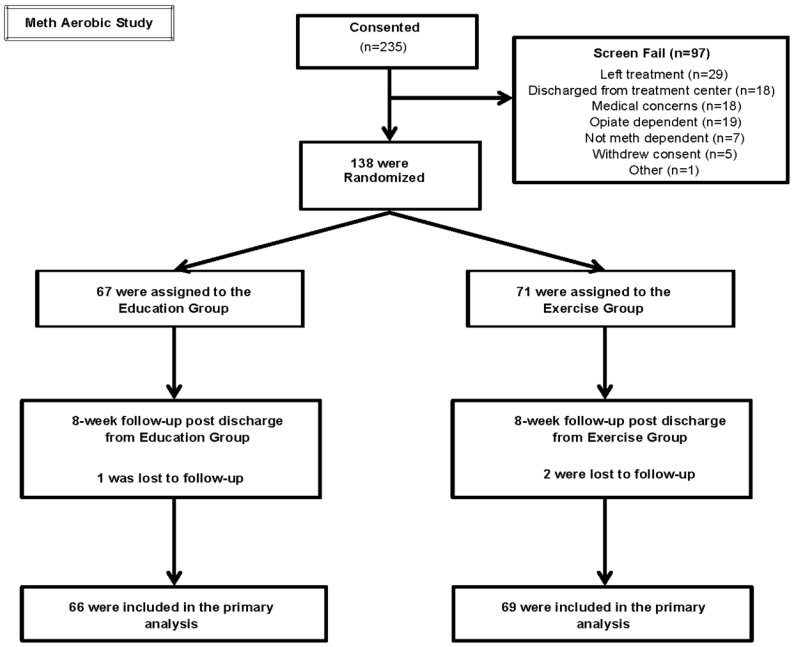


**Figure 1.**
Consort Diagram

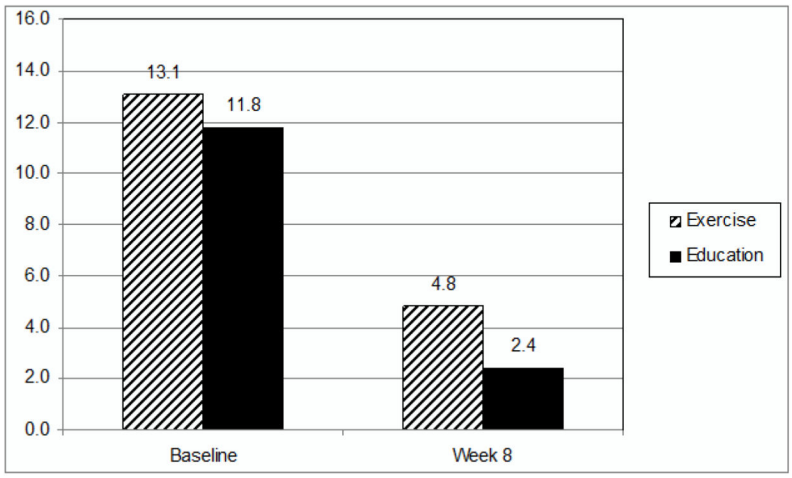


**Figure 2.**
Improvement in depression total scores by study condition from baseline to week 8

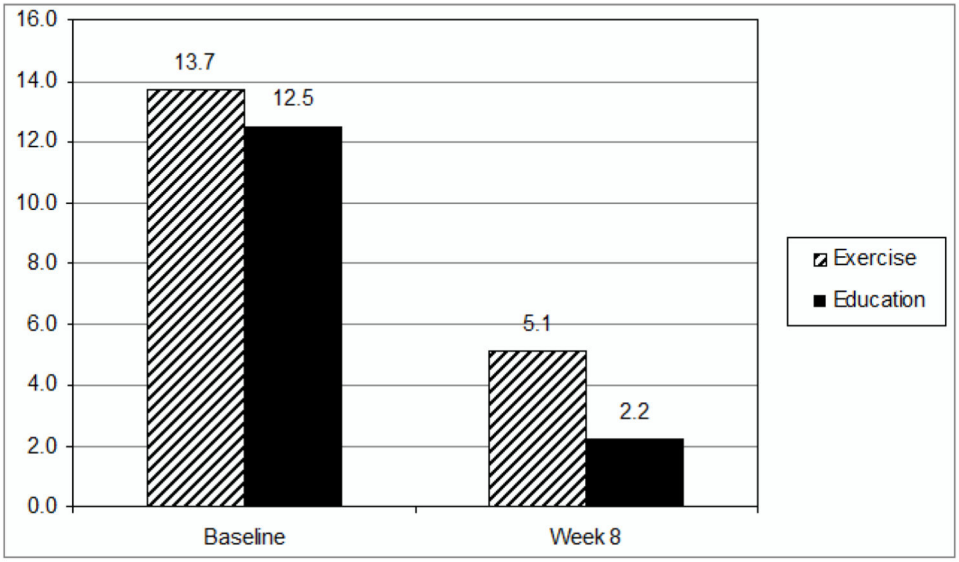


**Figure 3.**
Improvement in anxiety total scores by study condition from baseline to week 8

## Table 1

Linear mixed effects regression model examining dose response of session attendance on depression and anxiety symptoms over the 8-week trial.

| | β Coefficient | 95% lower CI | 95% upper CI | *P*-value |
|---|---|---|---|---|
| **Depression** | | | | |
| Baseline BDI depression | 0.22 | 0.02 | 0.42 | 0.03 |
| Sessions attended | −0.52 | −0.83 | −0.22 | <0.001 |
| Treatment (Exercise=1) | −10.32 | −18.73 | −1.91 | 0.02 |
| Treatment x sessions x time | −0.61 | −0.20 | −1.02 | <0.001 |
| **Anxiety** | | | | |
| Baseline BAI anxiety | 0.23 | 0.03 | 0.39 | <.001 |
| Sessions attended | −0.29 | −0.42 | −0.16 | 0.01 |
| Treatment (Exercise=1) | −6.51 | −9.93 | −3.07 | 0.02 |
| Treatment x sessions x time | −0.22 | −0.42 | −0.06 | 0.009 |