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INVITED REVIEW

THE EFFECT OF EXERCISE ON DEPRESSION, ANXIETY AND OTHER MOOD STATES: A REVIEW

A. BYRNE and D. G. BYRNE

Abstract—This paper addresses the current literature related to investigations of the link between exercise treatments and depression, anxiety and other mood states. Results from these investigations are supportive of the anti-depressant, anti-anxiety and mood enhancing effects of exercise programs. There were considered to be, however, a number of potential methodological problems in many of the research studies; the nature of these were considered. Finally, some possible directions for future research are outlined.

INTRODUCTION

WHILE the proposition that mood states can have a profound effect upon physical health has been amply documented in recent times [1], and while there exists a substantial amount of evidence regarding the positive physiological consequences of regular physical activity [2], the body of evidence regarding the effect of exercise upon physical health has been neither apparent nor convincing [3]. Although it is generally assumed that physical fitness serves to increase one's sense of psychological well being, studies attempting to investigate this relationship have yielded equivocal results. Early studies certainly lacked sound, reliable research design methods [4]. There has, however, recently been a shift toward more carefully designed studies in the area [5]. Consequently, there is now a growing set of reliable research evidence indicating that regular exercise alleviates negative mood states, such as depression and anxiety [6–13].

Most health scientists agree that exercise has a positive effect upon physical well being and upon specific physiological variables associated with health and wellness (e.g. heart rate, blood pressure) [4]. In addition, the large majority of both health professionals and exercisers themselves believe that exercise has benefits for the improvement of mood states. Given that exercise may effect both physical and mental health, it would therefore seem important to evaluate research on the efficacy of such programs. By extension, given the pandemic nature of such mental health problems as depression and anxiety, in concert with the cost and potential side- or after-effects of various drugs in the treatment of these problems [14], it would seem important to review the efficacy of exercise as a treatment.

The major aim of the present paper is to review recent (post-1975) studies which have focused on the effect of exercise on mood adjustment. Specifically, the evidence regarding the benefits of exercise for depression, anxiety and other states of disturbed mood is examined. Only studies which were published in referred journals were

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included to ensure that the study methods and results were described in sufficient detail. This resulted in the exclusion of anecdotal studies. Findings from the literature are summarized. Two studies which satisfy the criterion for true experimental designs [15] are considered in detail. In addition, methodological limitations, commonly present in the surveyed research are discussed. Finally, some suggestions, for future directions for research in this area are outlined.

OVERVIEW OF RESEARCH

Table I presents summaries of research findings [16—28] relating to the benefits of exercise for depression, anxiety and other mood disorders for clinical samples, while Table II presents data [3, 23, 29—43] obtained from non-clinical samples. In one study [23], both clinical and non-clinical samples were employed.

The majority of studies involving clinical samples focused on changes in depression while the majority of studies involving non-clinical samples focused on mood states. This no doubt indicates the greater relevance of depressive disorders to subjects in clinical, as opposed to non-clinical, samples. It does, however, make comparison somewhat difficult.

Overall the research evidence support the notion that exercise has psychological benefits for participants. The majority (90%) of studies support both the anti-depressive properties of exercise and the effect of exercise in combatting anxiety. In addition, the studies reviewed generally substantiate the claim that improved mood is associated with exercise.

Very few studies indicated that exercise improved physical fitness, though psychological rather than physiological outcomes were the focal point of most studies. In all of the studies in which fitness gains during treatment were documented, improvements were reported on the measured psychological variables in question. Most studies employed aerobic exercise as treatment. In cases where this type of activity produced measurable improvements in aerobic capacity, it might be assumed that mood improvement is due to the cumulative physiological consequences of these changes. However, data suggest that it is probably not improvements in aerobic capacity that is responsible for mood improvement. A non-aerobic activity (weight training) was found to have equally positive effects on the alleviation of depression as an aerobic activity (running) [17].

The majority of studies employed volunteer samples, often matched or equivalent in some way, but not randomly assigned to groups. A number of studies also had single exercise treatment groups and no control comparison. The vast majority (70%) of studies, did, however, employ control groups.

The samples in most studies comprised 'normals', that is, individuals without identified clinical mood disorder. The use of normal individuals is not in itself a problem. If however, the aim of research is to generalize findings from treatment groups to the general population, or, more particularly, to those with clinical mood disorders, care needs to be taken not to over use student populations just because they are convenient. Twenty per cent of the studies included in the review employed student samples. Irrespective of the type of samples, their relation to the population need to be clearly stated. Unfortunately, much of the current literature fails to adhere to this guideline.

TABLE 1.—SUMMARY OF RESEARCH FINDINGS RELATING TO THE EFFECTS OF EXERCISE TREATMENTS ON DEPRESSION, ANXIETY AND OTHER MOOD STATES: CLINICAL SAMPLES

	Subjects	Control group	Psychological instruments	Improved physical fitness	Psychological outcome
Depression					
Doyne <i>et al.</i> [16]	Adult depressed women	No	Schedule for Affective Disorders Beck Depression Inventory,	Yes	Improved
Doyne <i>et al.</i> [17]	Adult depressed women	Yes	Lubin Depression Adjective List, Hamilton Rating Scale for Depression Symptom checklist	No	Improved
Greist <i>et al.</i> [18]	Male and female out-patients	No	Beck Depression Inventory,	No	Improved
Hess-Homeier [19]	Depressed outpatients	Yes	Zung Self-Rating Depression Scale	Yes	Improved
Kavanaugh <i>et al.</i> [20]	Depressed post-coronary men	No	Minnesota Multiphasic Personality Inventory (Depression Scale)	Yes	Improved
Martinsen [21]	Male and female psychiatric patients	Yes	Beck Depression Inventory Rating Scale Depression subscale	Yes	Improved
McCann and Holmes [22]	Depressed female college students	Yes	Beck Depression Inventory	Yes	Improved
Anxiety					
Cameron and Hudson [23]	Male and female patients/ male and female recruits	No	Symptom checklist	No	Not improved
Lion [24]	Male and female halfway house residents	Yes	State-Trait Anxiety Inventory	No	Improved
Depression/Anxiety					
Hillyer <i>et al.</i> [25]	Male Juvenile Delinquents residents	No	Beck Depression Inventory, State-Trait Anxiety Inventory, Profile of Mood States	Yes	Improved
Prossner <i>et al.</i> [26]	Male post-coronary patients	Yes	Specific instrument developed for study	No	Improved anxiety: no change in depression
Stern and Cleary [27]	Male post-coronary patients	Yes	Minnesota Multi-phasic Personality Inventory (Depression Scale), Taylor's Manifest Anxiety Scale	No	No Change
Anxiety/Moods					
Sleptoe <i>et al.</i> [28]	Female college students	No	Profile of Mood States (Modified Scale)	No	Improved following low intensity exercise only

TABLE II.—SUMMARY OF RESEARCH FINDINGS RELATING TO THE EFFECTS OF EXERCISE TREATMENTS ON DEPRESSION, ANXIETY AND OTHER MOOD STATES: NON-CLINICAL SAMPLES

Subjects	<Control group	Psychological instruments	Improved physical fitness	Psychological outcome
Depression				
Brown <i>et al.</i> [29]	Male and female college students	Zung Self-Rating Depression Scale	No	Improved
Klein <i>et al.</i> [30]	Male and female recruits	Symptom Checklist	No	Improved
Janoski <i>et al.</i> [31]	Male and female undergraduate students	Self-rating Depression Scale	Yes	Improved
Anxiety				
Bahrke and Morgan [32]	Adult men	State-Trait Anxiety Inventory	No	Improved
Cameron and Hudson [23]	Male and female patients/ Male and female recruits	Symptom checklist	No	Not improved
Wilson <i>et al.</i> [33]	Adult men and women	State-Trait Anxiety Inventory	No	No change
Young [34]	Adult men and women	Life Satisfaction and Health Rating Scales	No	Improved
Moods				
Berger and Owen [35]	Male and female college students	Profile of Moods States	No	Improved
Folkms [36]	Middle-aged males	Multiple Affect Adjective Checklist	Yes	Improved
Kowal <i>et al.</i> [37]	Male and female recruits	Profile of Moods States	Yes	Improved (Males only)
Lichtman and Poser [3]	Adult men and women	Nowlis Mood Scale, Profile of Moods States	No	Improved
Simons and Birkimer [38]	Adult men and women	Profile of Moods States	No	Improved
Stephoe and Cox [39]	Female college students	Profile of Moods States (Modified Scale)	No	Improved following low intensity exercise
Wilson <i>et al.</i> [40]	Adult men	Profile of Moods States	No	Improved
Depression/anxiety				
Hayden and Allen [41]	Male and female college students	Beck Depression Inventory, State-Trait Anxiety Inventory	No	Improved
Anxiety/moods				
Blumenthal <i>et al.</i> [42]	Adult men and women	State-Trait Anxiety Inventory, Profile of Moods States	Yes	Improved
Depression/anxiety/moods				
Fremont and Graighead [43]	Male and female recruits	Beck Depression Inventory, State-Trait Anxiety Inventory, Profile of Mood States	No	Improved

In studies employing subjects with diagnosed psychological disorders, it was unclear whether the diagnosed disorder was the primary presenting problem. Examples of this are the use of depressed post-myocardial infarction out-patients [20] and depressed college students [22]. While there is evidence that exercise was effective in treating the depressive symptoms of these samples it is unclear whether it would have been effective in treating the primary symptoms of depressive disorders or whether the effect was achieved through other mechanisms such as simple recovery from life-threatening illness.

The acceptability of many studies displayed in Tables I and II is questionable owing to the use of non-experimental and quasi-experimental designs [15]. This is not to say that studies employing such designs have not contributed to the literature; on the contrary, there are many good studies of this type. Perhaps the best example is that one provided by Doyne *et al.* [16]. These researchers reported a study on aerobic exercise as a treatment for depression in women. They employed a time-series multiple baseline AB design in which participants were used as their own controls. Doyne and her colleagues reported a significant decrease in levels of measured depression after aerobic treatment that was maintained at a three month follow-up.

True experimental studies, though often difficult and inconvenient, are necessary for firm conclusions [15]. This type of research provides optimal internal validity because of the random assignment of participants to treatment and control groups. Two good examples of true experimental designs are provided by the work of McCann and Holmes [22] and Doyne *et al.* [17].

The study by McCann and Holmes [22] provided, as they themselves stated, the first controlled evidence concerning the effects of exercise on mood states. They examined the effects of aerobic exercise, relaxation training (which they claimed to be a placebo condition) and no treatment in a sample of 43 college women. The women were selected on the basis of elevated Beck Depression scores although they were not diagnosed as clinically depressed. Before initiation of treatment, all subjects completed the Beck Depression Inventory and a 12 min run fitness test to assess aerobic capacity. Treatment in the form of regular aerobic exercise for 1 hr twice per week then took place for 10 weeks. Subjects in the placebo group underwent a similar regimen of relaxation training while subjects in the non-treatment condition had nothing at all. Beck Depression scores were obtained half way through the treatment period and finally both depression and fitness scores were obtained at termination. The group showed significantly more improvement in depression scores than the relaxation or no treatment group. In addition, the results indicated that subjects in the aerobic exercise condition evidenced consistently and measurably more improvement in aerobic capacity than did the subjects in either of the conditions. The hypothesis that increased aerobic fitness mediated the changes in depression scores however, received little support; the effect occurred in the first five weeks of treatment and did not increase over the remainder of the 10 week trial. This period of time is generally accepted as too brief for sufficient improvement in aerobic capacity to be achieved, and generalization to therapeutic effects on mood is doubtful.

More recently, Doyne *et al.* [17] compared the effectiveness of aerobic and non-aerobic exercise in the treatment of clinical depression in women. A total of 40 women who met the Research Diagnostic Criteria [44] for major or minor depression were

randomly assigned to one of three conditions; an 8-week running (aerobic) program, a weight-lifting (non-aerobic) program or wait-list control condition. Subjects were re-assessed at mid-and post-treatment and 1-, 7- and 12-month follow-ups by administration of the Beck Depression Inventory, Lubin's Depression Adjective List and the Hamilton Rating Scale for Depression. Fitness was assessed using submaximal treadmill testing. Results indicated that both exercise conditions significantly reduced depression compared with the wait-list control condition but were indistinguishable from each other. No significant difference between groups on the fitness measures were reported. These findings indicate that both types of exercise condition significantly decrease depression but that these results are not dependent on achieving an aerobic effect.

METHODOLOGICAL LIMITATIONS

Overall there would seem to be support for the notion that exercise status has important consequences for mood states in general and depression in particular. There are, however, a number of potential methodological problems present in the studies discussed and these will now be taken in turn.

First, many researchers have failed to adequately describe their studies, and mainly the type of exercise program employed. There is no consistency in the literature as to the nature of exercise programs advocated to achieve fitness and replication without description is difficult. Moreover, few researchers describe either the initial fitness of subjects or the minimum fitness improvement required by subjects in order to achieve alleviation of mood disorder. Even in those studies in which fitness level was documented, there was seldom a minimum effective level of improvement stipulated, and the type, intensity, duration and number of sessions of exercise per week were often not discussed. Interpretation of outcomes is, therefore, clearly limited.

Second, studies relied largely on global self-rating scales of psychological variables. Although standardized mood scales have usually been tested for validity and reliability, their performance is influenced by a range of factors other than mood *per se* and the potential influence of unanticipated and unmeasured variables can not be assessed. Also, mood scales have usually been designed for clinical populations and therefore may be insensitive to psychological changes in normals (who make up the bulk of the samples employed in this research). Moreover, the range of assessment instruments used in the current literature make comparisons difficult. In addition, some of the measures employed may not, in fact, be appropriate for the task at hand. For example, the use of the Profile of Moods States (see Table I), may be problematic. Buros [45] suggests that the high reliability of this scale reflects its relative lack of sensitivity to changes in mood state, and therefore, may indicate that the test does not really measure fluctuating affective states [3].

Third, results tend to be limited by the differential selection of subjects, typically on the basis of availability and convenience, with little or no concern for their psychological or exercise status. Although selection of individuals with diagnosed affective disorders is necessary to test the link between exercise and psychological states [46], the majority of studies have employed 'normal' subjects and not clinical samples. The use of 'normals', with or without self-reported affective distress,

provides an inadequate sample for a test of whether exercise might be an effective treatment for depression in clinical populations. In addition, the use of volunteers (e.g. students) has limited general validity since they are unlikely to reflect the breadth and severity of depression found in the population at large. Designs have also often lacked random assignment to treatment and no-treatment control conditions. Randomized assignment to treatment groups is the basic minimum requirement for a test of exercise effects on mood, and a no-treatment control condition is crucial to allow the examination of spontaneous remission effects.

Fourth, longitudinal studies and follow-up data are not typically found in the literature. The long-term efficacy of exercise programs on psychological states has not, therefore, been established. In the absence of such data, no comment can be made on whether reported therapeutic effects are maintained after exercise cessation or whether indefinite exercise is necessary to maintain the therapeutic effect.

Finally, replication of studies needed for confirmation of results is missing from the literature. Without replication, the value of many research findings are left very much in question.

FUTURE DIRECTIONS FOR RESEARCH

In order adequately evaluate the effects of exercise on mood states there needs to be a clear specification of the type of exercise programs being used and a careful assessment of the physiological (as well as psychological) changes produced. Different types of exercise programs may have different implications for the anti-depressant, anti-anxiety and mood elevating effects of exercise and specific vs. non-specific effects must be tested [7].

The term exercise includes cardiorespiratory or aerobic endurance, muscular strength, endurance and flexibility, and co-ordination and relaxation [47]. Most studies have used aerobic exercise as the treatment and since this activity has produced measurable changes in aerobic capacity, it has been assumed that mood improvement is due to these changes. In fact, there is no logical reason to infer this. Therefore, while improvement in aerobic fitness has been associated with enhanced mood, the question remains as to whether or not this relationship is causal, and if so, what the mechanism(s) may be involved [48]. In future work the exercise program being employed should be carefully documented, controlled and measured.

The need for adequate fitness assessment techniques has been amply established [7]. Thompson and Martin [49] give specific recommendations as to the most appropriate tests of physical fitness for health improvement and maintenance programs, advocating the use of submaximal tests such as the Harvard Step Test, the Master's Two Step and the like (47) as an alternative to complex tests of cardiovascular capacity. However this methodological issue is resolved, future work must involve adequate fitness assessment techniques commensurate with the needs and sophistication of the study.

The assessment of treatment outcome, however, also presents a difficult area since it does not represent a unitary phenomenon. Comprehensive taxonomies of outcome indices typically comprise reference to magnitude, universality, safety and stability of mood change. Most studies have focused solely on the magnitude of mood enhancement whereas it has been suggested [47] that outcome profiles may be strongest if

they place greater attention on the stability dimension. Clearly, therefore, more work is needed in this area.

Careful documentation of the specific psychological changes produced by exercise treatment is also important in future research. There is a clear need to strengthen self-report measures of mood states with objective data. The recording of behavioural data by trained observers would seem particularly important in this regard. Objective tests of mood in both clinical and non-clinical populations are available and would avoid many of the problems of self-report measures [46]. Admittedly the use of objective measures is time consuming though many studies of exercise and mood involve small numbers. Greater consistency in terms of the type of psychological instruments employed would also allow for a better synthesis of the cumulative literature.

A more careful selection of subjects is also necessary in future research. Participants should be drawn from non-clinical groups if generalization to the population at large is desired. Especial care needs to be taken, however, when using 'normal' subjects to ensure that they adequately represent the general population. Random selection of subjects is crucial. If however, the aim is to examine the question of whether exercise might be an effective treatment for clinically significant depression, anxiety or other dysfunctional mood states as a potential alternative to formal psychotherapy, clinical samples are required. It is only by the use of relevant samples, that the question of whether a specific population may be affected differently by exercise treatments can be answered [7]. Further research is also needed to examine specific links between components of exercise and their possible therapeutic effect on particular states of mood disturbance [7].

In future research, there is a clear need for an increase in the number of controlled experimental studies with study designs and methods described in sufficient detail to allow replication of past work so that confirmation of results can be achieved. Long-term follow-up is crucial to establish the long-term benefits of exercise on depression, anxiety and other mood states.

Finally, two issues broadly pertinent to the evaluation of therapeutic outcome must be considered in further work on this area. First, where exercise is being evaluated against other forms of therapeutic intervention, contact times must be equalized to ensure that possible outcomes reflect differences in therapeutic procedures rather than simply the amount of attention focused on the individual. Second, where exercise is being evaluated against non-exercise conditions, subjects in the latter group must be involved in some structured activity not involving exertion, in order to control for the possible non-specific effects of attention or human contact on mood elevation. Similarly, the effects of exercise undertaken within a social context should be compared with those arising from self-imposed exercise undertaken as a solitary activity, in order to examine whether exercise or simply social contact associated with exercise programs, acts to achieve moods.

CONCLUSION

While there is general support for the claim that exercise treatments have positive psychological benefits for clinical and non-clinical samples alike, these data need to be interpreted with caution. Nonetheless, the trend in the literature is encouraging.

Including exercise in treatment programs for people with affective disorders has a number of advantages—it is time and cost effective compared to psychotherapy and drug treatment, there are no side effects compared with drug treatment and it is potentially useful as a prophylactic prevention of future affective episodes [50]. Indeed, if exercise was found to be effective in the primary and secondary prevention of mental health problems and if there were no significant after- or side-effects, exercise would hold the potential for becoming a primary treatment of choice [14]. Unfortunately the actual efficacy of exercise programs in the treatment of depression, anxiety and other distressing mood states continues to be based largely in indirect evidence. There have been few attempts to demonstrate that exercise intervention, in a controlled experimental context, results in improved affect. There is now, however, a growing research base to permit experimentation with exercise intervention and to explore the potential efficacy of exercise for the alleviation of psychological symptoms and the prevention of distress [14]. The results from this work give grounds for cautious optimism.

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