THE OLYMPIC TEXTBOOK OF SCIENCE IN SPORT

EDITED BY RONALD J. MAUGHAN

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AN IOC MEDICAL COMMISSION PUBLICATION

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RONALD J. MAUGHAN, PhD

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Chapter 16

Exercise and Psychological Well-being

PANTELEIMON EKKEKAKIS AND SUSAN H. BACKHOUSE

Although anecdotal reports praising the benefits of exercise not only for the soma but also for the psyche date back to antiquity, the systematic investigation of these effects began no earlier than the 1960s. Particularly in the last decade or so, this research area has witnessed explosive growth, spurred by several factors. First, there has been an overall increase of interest in health-oriented exercise, culminating in the promotion of exercise being one of the cardinal objectives of public health efforts in many industrialized countries. The Surgeon General in the USA and the Chief Medical Officer in the UK published landmark documents outlining the health benefits of exercise, including its psychological benefits. Second, the notion that health is not merely the absence of disease but rather the lifelong active pursuit of a holistic sense of well-being went from a fringe "new age" idea to a widely accepted guiding principle for health professionals. This is evidenced in the development and maturation of such scientific areas as behavioral and preventive medicine. Third, the high-pressure conditions of modern living have led to an increase in the number of individuals suffering from mental health problems such as anxiety and depression. The high cost and side effects of traditional forms of therapy (i.e., pharmacotherapy and psychotherapy) have left researchers, mental health professionals, and patients seeking effective and well-tolerated methods not only of treatment but also of prevention. These conditions have created a fertile ground for the development of the field of "exercise psychology," the scientific discipline concerned with investigating the psychological effects of exercise, as well as the psychological factors that underlie the processes of engaging in, adhering to, and disengaging from regular exercise participation.

The purpose of this chapter is to provide an overview of what exercise psychology research has uncovered about the benefits of exercise for psychological well-being. This survey will span various aspects of well-being, reflecting both the breadth of this concept and the diverse research foci that have emerged within exercise psychology. In discussing the evidence, it is important, rather than portraying exercise as a universally accepted panacea, to acknowledge that not everyone finds the evidence compelling. In fact, whether exercise can truly benefit some aspects of well-being continues to be viewed as an open, if not controversial, question. Even reviewers who have endorsed exercise have pointed out that, in many cases, statements about the psychological benefits of exercise seem to "anticipate rather than reflect the accumulation of strong evidence" (Salmon 2001). An insurmountable stumbling block is the fact that there can be no placebo exercise intervention. Therefore, the element of expectancy, which can be very influential, particularly considering that most well-being-related outcomes are self-reported (in the form of questionnaires or interviews), cannot be fully controlled. In this sense, the methodological rigor of exercise trials, although greatly improved over the years, cannot satisfy the most stringent of criteria, such as those established for evaluating the effectiveness of prescription drugs.

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This problem has led to the phenomenon of different authors examining the same literature and reaching different conclusions. In the early 1980s, based on the few preliminary studies that were available at the time, Morgan (1981) asserted that "the 'feeling better' sensation that accompanies regular physical activity is so obvious that it is one of the few universally accepted benefits of exercise." However, examining this literature at approximately the same time, Hughes (1984) concluded that "the enthusiastic support of exercise to improve mental health has a limited empirical basis and lacks a well-tested rationale." Although the amount of evidence increased and the quality improved, the disagreement among reviewers continues. Following a systematic and in-depth review of the evidence on the effects of exercise on depression, Biddle *et al*. (2001) stated that "overall, the evidence is strong enough for us to conclude that there is support for a causal link between physical activity and reduced clinically defined depression. This is the first time such a statement has been made." At the same time, Lawlor and Hopker (2001), based on a meta-analysis on the same topic, concluded that "the effectiveness of exercise in reducing symptoms of depression cannot be determined because of a lack of good quality research on clinical populations with adequate follow up."

Interestingly, conflicting messages can also be found in official documents, even from the same source. In 1996, the report of the Surgeon General of the USA on the relationship between physical activity and health included the following statement:

> The literature suggests that physical activity helps improve the mental health of both clinical and nonclinical populations. Physical activity interventions have benefitted persons from the general population who report mood disturbance, including symptoms of anxiety and depression, as well as patients who have been diagnosed with nonbipolar, nonpsychotic depression. These findings are supported by a limited number of intervention studies conducted in community and laboratory settings . . . The psychological benefits of regular physical activity for persons who have relatively good physical and mental health are less clear (US Department of Health and Human Services 1996).

However, in 1999, the 458-page report of the Surgeon General on mental health did not mention physical activity among the recognized methods of treatment for anxiety and depression, focusing instead on psychotherapy and pharmacotherapy. Physical activity was only mentioned as one of an "ever-expanding list" of "informal" interventions for coping with stressful life events, alongside "religious and spiritual endeavors" and "complementary healers" (US Department of Health and Human Services 1999). Some possible benefits were acknowledged, echoing the earlier report, but this was followed by the caveat of poor methodological quality:

> Physical activities are a means to enhance somatic health as well as to deal with stress. A recent Surgeon General's Report on Physical Activity and Health evaluated the evidence for physical activities serving to enhance mental health. Aerobic physical activities, such as brisk walking and running, were found to improve mental health for people who report symptoms of anxiety and depression and for those who are diagnosed with some forms of depression. The mental health benefits of physical activity for individuals in relatively good physical and mental health were not as evident, but the studies did not have sufficient rigor from which to draw unequivocal conclusions (US Department of Health and Human Services 1999).

Although a certain dose of disciplinary bias on both sides cannot be ruled out as a possible explanation for these discrepant assessments, a balanced evaluation of the literature would probably lead to the conclusion that, although the extant evidence is promising, there are simply not enough high-quality and large-scale randomized clinical trials of exercise to justify definitive statements about the effects of exercise on most aspects of well-being (Brosse *et al*. 2002). Therefore, perhaps the most appropriate approach at the present juncture is one characterized by careful, cautious, critical, and systematic review of the evidence. Although all scientists strive for objectivity, deciding whether a piece of evidence can be deemed compelling or not has an inherent element of subjectivity that can occasionally blur the line between strict impartiality and advocacy for the presumed good cause of promoting physical activity.

In this review, we focus on anxiety, depression, mood and affect, health-related quality of life, cognitive function, and self-esteem. Because of space limitations, this cannot be an exhaustive list. The research literature also contains interesting studies on the role of physical activity in a wide range of additional parameters of well-being, including sleep (Youngstedt & Freelove-Charton 2005), stress reactivity (Sothmann 2006), and relief from addictions (Donaghy & Ussher 2005). Also because of space constraints, in this broad-scope overview of the field, we focus on meta-analyses and recent systematic reviews of the literature.

Anxiety

Construct description

Anxiety is the negative emotional state that results from the cognitive appraisal of a situation as threatening. This cognitive appraisal, which is considered its essential eliciting mechanism, mainly involves the comparison of two subjectively estimated quantities: the degree of threat (to one's physical self, interpersonal status, or goals) that the situation poses and the capabilities or coping resources of the individual. This is a quintessentially subjective process that is under the influence of the individual's life experiences and personality traits. One of these traits, in particular, called trait anxiety, tends to bias the appraisal process in the direction of consistently minimizing one's perceived capabilities and exaggerating the degree of threat. The anxiety response consists of several clusters of symptoms, including cognitive (worry, apprehension, fear of failure and future consequences), emotional (negative affect), behavioral (nervousness, exaggerated mannerisms, tics), and physiological (increases in heart rate, blood pressure, muscle tension, perspiration, stress hormone levels).

Although a certain degree of anxiety is a common part of everyday life (as we take exams, undergo interviews, or speak in public), anxiety disorders can be extremely disruptive. An anxiety *disorder*, such as Generalized Anxiety Disorder, one of the most common diagnostic classifications according to the *Diagnostic and Statistical Manual* of the American Psychiatric Association, is distinguished by such criteria as the persistence of the symptoms (e.g., at least 6 months), the excessive frequency and intensity of worry, the difficulty or inability to control the worry, and the impairment of social or occupational functioning. Other types of anxiety are distinguished by the specific object of the anxiety, such as anxiety about having a panic attack (as in a Panic Disorder), being embarrassed in public (as in Social Phobia), being contaminated (as in Obsessive–Compulsive Disorder), being away from home or close relatives (as in Separation Anxiety Disorder), gaining weight (as in Anorexia Nervosa), having multiple physical complaints (as in Somatization Disorder), or having a serious illness (as in Hypochondriasis).

Societal importance

Exact estimates of the prevalence of mental health problems in general, and anxiety in particular, are difficult to obtain and different surveys often yield different numbers. Moreover, it is believed that the majority of people who need help do not seek help because they prefer to try to address the problems on their own, because of fears about the high cost of diagnosis and treatment, or because of the social stigma that is still attached to mental health problems. Therefore, it is accepted that prevalence figures most likely underestimate the actual prevalence. In the USA, the 1-year prevalence for all anxiety disorders among adults exceeds 16%. Importantly, anxiety is often accompanied by so-called "comorbid" conditions, including depression (at rates of 50% or even higher) and substance abuse.

Construct assessment

Theoreticians make a distinction between anxiety as a state and anxiety as a trait. State anxiety is the acute (or short-term) emotional response that follows the appraisal of threat. Trait anxiety, as noted earlier, is the predisposition to interpret a variety of situations as threatening and to respond to them with increases in state anxiety. The assessment of anxiety in intervention studies usually follows this important theoretical distinction. Thus, studies of the effects of "acute exercise" (i.e., a single bout of exercise) typically focus on changes in state anxiety, whereas studies of the effects of "chronic exercise" (i.e., a program of exercise lasting for several weeks or months) typically focus on changes in trait anxiety. State and trait anxiety are usually assessed by self-report questionnaires. In responding to an item from the state anxiety portion of a commonly used questionnaire, the State-Trait Anxiety Inventory, an individual would be asked to report to what extent he or she feels "anxious" or "worried" at that moment (not at all, somewhat, moderately so, very much so). On the other hand, an item from the trait anxiety portion of the questionnaire would inquire how frequently the respondent "feels that difficulties are piling up so that he or she cannot overcome them" (almost never, sometimes, often, almost always).

Role of exercise

An extensive, although somewhat dated, meta-analytical review reported that bouts of exercise reduced state anxiety, on average, by approximately one-quarter of a standard deviation (0.24 SD) (Petruzzello *et al*. 1991; Landers & Petruzzello 1994) and were no different in lowering state anxiety from other treatments with known anxiety-reducing effects (meditation, relaxation, quiet rest). Factors such as the self-report questionnaire used, the age and health status of the participants and even the intensity of exercise, did not seem to make a difference. On the other hand, aerobic forms of activity (e.g., walking, jogging, swimming, cycling) were found to be effective, whereas non-aerobic modes (e.g., strength or flexibility training) were not. However, non-aerobic modes were vastly underrepresented in the analysis (only 13 effect sizes, compared to 173). Although an initial analysis indicated that activities lasting less than 20 min were not effective in lowering state anxiety, the authors noted that almost half of the effect sizes in that category were derived from studies that compared the effects of exercise to those of known anxiety-reducing treatments. When only the effect sizes from studies involving other comparison groups or conditions were taken into account, activity bouts lasting less than 20 min were just as effective as longer ones.

The same meta-analytic review also showed that long-term exercise interventions were associated, on average, with reductions in trait anxiety by 0.34 SD (Petruzzello *et al*. 1991). Again, factors such as the self-report questionnaire used, the age and health status of the participants, and even the intensity of exercise did not make a difference. The presence of only two effect sizes from studies involving non-aerobic modes of activity did not permit a meaningful comparison of their effectiveness compared with aerobic activities. An interesting finding was that longer activity programs were generally associated with larger effects. Short programs of 9 weeks or less were associated with small effect sizes (0.14–0.17), those lasting between 10 and 15 weeks yielded medium effect sizes (0.36–0.50), and programs lasting 15 or more weeks produced large effect sizes (0.90).

Other meta-analyses examined smaller samples of studies and have led to some contradictory conclusions, although not different numerical findings, because the average effect sizes appear to be in the 0.25–0.35 range, consistently pointing to reductions in anxiety. McDonald and Hodgdon (1991) conducted a meta-analysis focusing specifically on exercise interventions designed to improve aerobic fitness and therefore followed established training guidelines and included assessments of fitness at the beginning and end of the program. The 13 studies on state anxiety yielded an average effect size of 0.28, whereas the 20 studies on trait anxiety yielded an average effect size of 0.25. Importantly, however, although several of the studies examined women, the average effect size for women was not significantly different from zero.

Long and van Stavel (1995) examined 40 studies on the effects of exercise interventions on state and trait anxiety in adults. The average effect size for within-subject contrasts was 0.45, indicating a decrease in anxiety by almost half of a standard deviation, whereas the average effect size for between-subject contrasts (e.g., experimental versus control) was 0.36, indicating a decrease in anxiety by approximately one-third of a standard deviation. The effect was similar for state and trait anxiety. Importantly, in between-subject contrasts, the effect was significantly larger for high-anxious samples (0.51) than low-anxious ones (0.28).

Schlicht (1994) conducted a meta-analysis of 20 studies, published between 1980 and 1990, examining anxiety changes in non-clinical (healthy) samples associated with leisure-time physical activity (not sports training). The average effect size, expressed as a correlation coefficient, was only −0.15, corresponding to a decrease in anxiety by 0.29 SD. This effect was not significantly different from zero and was found to be heterogeneous. The small number of studies included in the analysis, however, did not permit a meaningful test of mediators. Schlicht (1994) concluded that the literature "provides only little support for the hypothesis that physical exercise reduces anxiety."

Finally, Kugler *et al*. (1994) examined 13 studies on the effects of exercise cardiac rehabilitation programs on anxiety. The average effect size (0.31) suggested a decrease in anxiety by almost one-third of a standard deviation. Kugler *et al*. commented that, particularly in light of the increases in anxiety (and depression) commonly experienced by cardiac patients, exercise programs "appear markedly less effective than psychotherapy, for which average effect sizes of more than 0.80 are reported."

The magnitude and consistency of the anxiety-reducing effects, however, is only one aspect of the story. The methodological quality of the studies is another and this is clearly where the challenge lies for future research. There are presently no large-scale, high-quality, randomized clinical trials on the effects of exercise on anxiety. The bulk of the evidence reviewed in the aforementioned meta-analyses comes from small-scale studies with a host of methodologic limitations. According to Salmon (2001), "Many positive reports were uncontrolled or inadequately controlled by procedures which were less involving or less plausible than exercise." According to Scully *et al*. (1998), "Explicating the variables that mediate the relation between exercise and anxiety reduction has proved problematic, a task made doubly difficult because so few studies specify levels of intensity, duration, and/or length of exercise program." Besides such design and methodological issues, authors in recent years have also raised concerns about the validity of some self-report questionnaires commonly used to assess state anxiety in the context of exercise. These questionnaires do not distinguish cognitive symptoms of anxiety (worry, apprehension) from somatic symptoms (tension, nervousness), based on the assumption that these usually occur in unison, as parts of an integrated state anxiety response. However, exercise is a special case in which some of the psychophysiological responses that might otherwise be attributed to anxiety (e.g., increased heart rate, blood pressure, muscle tension) are in fact brought about by the metabolic demands of the activity. In the absence of the defining element of anxiety, namely the perception of threat, the occurrence or dissipation of such somatic symptoms may be unrelated to fluctuations in anxiety (Ekkekakis *et al*. 1999). However, other reviewers tend to discount these concerns. For example, according to Landers and Arent (2001), "It is highly unlikely that this relationship is due to a behavioral artifact," such as expectancy or response distortions.

In summary, the extant evidence indicates that exercise is associated with small to moderate decreases in anxiety. However, in the continued absence of large-scale, carefully controlled, randomized clinical trials with multiple outcome assessments and adequate follow-up, the quality of this evidence remains in question. The views, even within exercise psychology and exercise science, remain divided, a reminder of the subjectivity inherent in evaluating the quality of research.

Depression

Construct description

Depression is one of a group of "mood disorders" that also includes mania, bipolar disorder, cyclothymic disorder, and dysthymic disorder. Although depression tends to co-occur with anxiety and some medications that are effective for one are also effective for the other, the two conditions have several distinct features (antecedents, correlates, experiential characteristics, and other consequences). A primary difference is that, although anxiety is often associated with active forms of coping and the eliciting stimulus is still perceived as something that, at least to some extent or with some difficulty, could be dealt with, depression is often characterized by passivity and withdrawal. A common cognitive feature of depression is a pattern of appraisal called "learned helplessness," the persistent belief that one has no viable response options available and that the negative situation one finds oneself in is under the control of external and uncontrollable factors. As a result, the situation is seen as unavoidable, inescapable, or inevitable. The vulnerability to depression is increased by the tendency to make cognitive appraisals characterized by a strong negative bias or irrationality. Specifically, the scope of problems is exaggerated, such that they are seen as having a global impact (e.g., believing that a failure in one domain of life is evidence of failure in one's life overall); the causes are consistently attributed to oneself rather than to others; and negative outcomes are seen as permanent and irreversible.

A diagnosis of Major Depressive Disorder is based on evidence that the symptoms are frequent and severe enough to cause significant distress or impairment in social or occupational function. According to the *Diagnostic and Statistical Manual* of the American Psychiatric Association, an individual must report at least five of the following symptoms during a 2-week period:

1. Presence of symptoms on a nearly daily basis;
2. Depressed mood most of the day;
3. Markedly diminished interest or pleasure in almost all activities;
4. Weight loss;
5. Sleep disturbances (insomnia or hypersomnia);
6. Psychomotor agitation or retardation;
7. Feelings of fatigue or diminished energy;
8. Feelings of worthlessness or excessive guilt;
9. Inability to concentrate or make decisions; or
10. Recurrent thoughts of death or suicide.

Societal importance

Major Depressive Disorder (also known as unipolar major depression), the most common mood disorder, ranks as the leading cause of disability worldwide. In the USA, the 1-year prevalence is approximately 10% but there is a clear gender effect, with women exhibiting a prevalence almost twice as high as that in men. When the costs of diagnosis, treatment, and productivity losses are taken into account, the total economic cost associated with depression is staggering. In the USA, this figure is approximately 20% of the total health care costs, but obviously the problems extend well beyond the economic sphere. Besides having a devastating effect on quality of life, depression is accompanied by a host of other problems, including anxiety, addictions, suicide, and increased risk for chronic, life-threatening physical diseases such as cardiovascular disease and cancer. Friends and family members of depressed patients also suffer consequences, including guilt, frustration, economic burden, and even physical abuse.

Construct assessment

In intervention studies, depression is typically quantified by self-report questionnaires, ratings made by a clinician on the basis of an interview and a standard protocol, or both. For example, an item from a commonly used depression questionnaire, the Beck Depression Inventory, includes four alternatives from which the respondent is asked to choose:

1. I do not feel sad.
2. I feel sad.
3. I am sad all the time and I can't snap out of it.
4. I am so sad or unhappy that I can't stand it.

These alternative statements count for 0, 1, 2, or 3 points toward the total depression score. Similarly, in a commonly used clinical assessment method, the Hamilton Depression Rating Scale, the interviewer has to decide whether a key symptom, such as depressed mood (feelings of sadness, hopelessness, helplessness, or worthlessness) is absent, is reported only upon questioning, is reported spontaneously, is communicated not only verbally but also non-verbally (by facial expressions, posture, or weeping), or is the only kind of mood that the patient reports during the interview. These different assessments then receive 0, 1, 2, 3, or 4 points, respectively, toward the total depression score.

Role of exercise

In the first meta-analysis on this topic, North *et al*. (1990) located 80 studies examining the effects of exercise on depression. Of these, 76 examined the effects of exercise programs, 7 included follow-ups, and 10 examined the effects of single bouts of activity. The overall effect size was 0.53, indicating a decrease in depression by approximately half of a standard deviation. The effect was significantly higher for the 21 studies involving medical or psychological patients (0.94) and the 13 studies in which participation in exercise programs was aimed as a mode of medical rehabilitation (0.97). Although the studies examining changes in trait depression were the minority (16 studies), they yielded larger effects (0.91) compared to those examining changes in state depression (0.45). Age, gender, and mode of activity were not significant mediators. Aerobic forms of activity had antidepressant effects similar to those of anaerobic forms. Likewise, the effects of exercise did not appear to be different from those of psychotherapy. Importantly, the length of the program was shown to be a strong mediator, with longer programs being associated with larger decreases in depression. However, it should be pointed out that there were relatively few long-term studies (lasting for more than 16 weeks). The meta-analysis also found that the effect was larger for published than unpublished studies (possibly suggesting publication bias), for studies using random assignment of participants to conditions, and studies characterized by a medium (as opposed to low or high) degree of internal validity.

McDonald and Hodgdon (1991) examined 15 studies on the effects of aerobic fitness training (running or jogging) on depression. The average effect size was 0.97, indicating a decrease in depression of approximately one standard deviation. Among the 10 studies that identified the gender of the participants, the effect appeared larger for men (1.1) than women (0.66). Furthermore, the effects of age, survey vs. experimental studies, or self-report measure of depression used were not significant. Depressed patients showed larger decreases in depression (1.17) than individuals who were not depressed at baseline (0.83), although this difference was again not statistically significant. McDonald and Hodgdon, who also examined the effects of aerobic fitness training on anxiety, noted that "the decrease in depression scores was greater than the decrease in anxiety-state and anxiety-trait scores."

Kugler *et al*. (1994) identified 15 studies examining the effects of exercise on depression among coronary heart disease patients. The average effect size was 0.46, almost one-half of a standard deviation. As noted in the section on anxiety, Kugler *et al*. expressed some surprise that the effect was less-than-medium, given the fact that heart disease is typically associated with increased levels of depression, thus also increasing the possible margin of improvement.

Craft and Landers (1998) focused on 30 studies examining the exercise–depression relationship among individuals who were clinically depressed or were diagnosed with depression as a result of a medical illness. Nineteen of these studies were different from those included in the North *et al*. (1990) meta-analysis. They reported a large effect size of 0.72, a decrease of nearly three-quarters of a standard deviation. Importantly, different types of exercise (e.g., running, walking, non-aerobic activities) did not differ in terms of effectiveness. Moreover, exercise was not different from other comparison interventions, such as therapy or behavioral interventions but these modalities were represented by a very small number of studies (three and five, respectively). Longer activity programs (9–12 weeks) were more effective (1.18) than shorter programs (8 weeks or less; 0.54). Also, patients who were moderately to severely depressed showed larger decreases (0.88) than those who were mildly to moderately depressed at the beginning of the program (0.34).

Lawlor and Hopker (2001) conducted a targeted meta-analysis, focusing only on randomized controlled trials (i.e., involving random allocation of participants to treatment and comparison groups) that involved adults (over 18 years of age) who had been diagnosed with depression (regardless of severity or method of diagnosis). Importantly, emphasis in this analysis was placed on the quality of experimental evidence, concentrating on three key issues:

1 Whether allocation was concealed (whether randomization took place at a site remote from the study and the records were secured);
2 Whether intention-to-treat analysis was undertaken (i.e., whether all the patients were analyzed in the groups to which they were randomly allocated, rather than including only those who started or completed treatment); and
3 Whether there was blinding (i.e., whether the main outcome was evaluated by an assessor who was blind to treatment allocation).

Of 72 publications identified as potentially relevant, 29 were reviews or commentaries, 15 were non-randomized controlled trials, three involved psychiatric patients with mixed diagnoses, five did not have an outcome measure of depression, and four compared different types of exercise but no non-exercise group, leaving 16 articles describing 14 eligible studies. Ten studies in which exercise was compared to a "placebo" intervention (e.g., lectures, home visits for "chats," occupational therapy) or was used as an adjunct to standard treatment (e.g., counseling, cognitive therapy) included adequate data for quantitative analysis. The average effect size was 1.1, indicating that the depression scores of physically active individuals were lower by slightly more than one standard deviation compared to physically inactive individuals. Contradicting the results of other analyses, the duration of exercise programs was inversely related to effectiveness, with programs lasting less than 8 weeks yielding the largest effect (1.8), and programs lasting more than 8 weeks yielding the smallest effect (0.6). An examination of the six studies that compared exercise with standard interventions for depression produced a non-significant effect size of 0.3, suggesting that exercise was no less effective than standard forms of therapy. Also, aerobic and non-aerobic types of exercise did not differ in their effectiveness.

Although this meta-analysis showed that exercise interventions produce large effects, it has drawn some criticisms from reviewers within exercise science for what was perceived as an overly critical tone. Specifically, Lawlor and Hopker (2001) concluded that "The effectiveness of exercise in reducing symptoms of depression cannot be determined because of a lack of good quality research on clinical populations with adequate follow-up." For example, they noted that the absence of a difference between aerobic and non-aerobic forms of activity might indicate that "The effect is due to psychosocial factors, such as learning a new skill or socializing, rather than to the exercise itself." After all, none of the studies involved exercise performed in social isolation and one study that directly compared exercise to a social-contact control group found that these treatments were equally effective in reducing depression. Of the 14 studies that were examined, randomization was concealed in only three, intention-to-treat analyses were undertaken in only two, and assessment of outcome was blinded in only one. None of the 14 studies satisfied all three of these quality criteria, leading the authors to state that "most studies were of poor quality." These words have been characterized as "a bit harsh" despite acknowledging that "if the prescription of exercise for [major depressive disorder] required approval from the Food and Drug Administration, it probably would not pass current standards" (Brosse *et al*. 2002). Other authors have been more dismissive of the concerns expressed by Lawlor and Hopker, questioning whether such factors as conducting outcome assessments with a blinded assessor, as opposed to self-reports, would make an important difference (Landers & Arent 2007).

An examination of the meta-analytical findings indicates that exercise is associated with lower depression scores. The magnitude of the effect is moderate to large and the effects seem consistent. There is also agreement that, although there are numerous studies, only a few can withstand any serious methodological scrutiny. The question then becomes whether more emphasis and faith can be placed on the fact that most studies, regardless of quality, show substantial and consistent benefits or on the fact that the body of evidence overall would not pass muster against established and time-honored criteria for evaluating the quality of experimental research. This is not an easy question, as is evident from the ongoing controversy in the literature. What is clear is that this is not a "black or white" issue and the criticisms, "harsh" or not, warrant serious consideration.

As a case in point, let us consider the arguably most complete study on the effects of exercise on depression conducted to date (Blumenthal *et al*. 1999). In this study, 156 men and women, 50 years of age or older, who had been diagnosed with major depressive disorder, were randomly assigned to one of three 16-week treatment conditions:

1 Exercise (three sessions per week, lasting for 45 min each, at 70–85% of heart rate reserve);

2 Antidepressant medication (using the popular serotonin reuptake inhibitor sertraline hydrochloride or Zoloft™); or

3 A combination of the exercise and antidepressant treatments.

At the end of the treatment period, both clinician-rated and self-reported levels of depression were reduced compared to baseline, with no significant differences between the groups. At the 10-month follow-up (6 months after the conclusion of treatment), self-reported depression scores were also not different across the three groups. However, the participants in the exercise group had a lower rate of depression (30%) than those in the medication (52%) and combined-treatment groups (55%). Furthermore, of the participants who were in remission after the initial 16-week treatment period, those who had been assigned to the exercise-only group were more likely to have partly or fully recovered after 6 months than those in the medication and combined (exercise plus medication) groups (Babyak *et al*. 2000). This somewhat puzzling finding was interpreted by the authors as possibly indicating that exercise helps participants develop "a sense of personal mastery and positive self-regard," whereas the exclusive reliance on or the inclusion of medication "may undermine this benefit by prioritizing an alternative, less self-confirming attribution for one's improved condition" (Babyak *et al*. 2000).

On the one hand, this study overcame several of the methodological shortcomings of earlier studies, having an adequate sample size, including both men and women, and examining individuals who were depressed at baseline rather than a convenience sample. Furthermore, the study involved reasonably long treatment and follow-up periods, two comparison conditions, and more than one standard measure of the main outcome variable (i.e., both self-reports and clinician ratings of depression). Finally, the study did involve an "intention-to-treat" analysis, thus accounting for the possible biasing effects of the less than perfect adherence and often substantial dropout rates commonly associated with exercise and medication interventions.

However, this study could not address other potentially important problems. First, there was a selection bias, because the participants were all volunteers who responded to advertisements for a research study of "exercise therapy for depression." Thus, as discussed by Babyak *et al*. (2000), it is possible that an "antimedication" bias among some participants might have influenced the results. Perhaps associated with volunteerism, the participants were also highly educated and physically healthy. Furthermore, the possibility of "spontaneous recovery" cannot be excluded as there was no no-treatment control condition. Because there can be no true "placebo" exercise intervention, many control interventions (e.g., wait list) are really of questionable meaningfulness, because they fail to control for expectancy. Moreover, because the exercise was conducted in a group environment, it is possible that the beneficial effects of exercise were partly or fully mediated by social interaction. Finally, there is no way to fully account for treatment crossovers that can take place during the follow-up period (e.g., participants opting to switch or discontinue treatments). These limitations, which are clearly not trivial, underscore the fact that even large, costly, and well-designed studies that produce seemingly robust results supporting the beneficial role of exercise should be viewed cautiously.

Besides studies examining the strength of the association between exercise and depression, or reviews focusing on the consistency and quality of the experimental evidence, research is also focusing on such critically important questions as the dose–response relationship and the biological mechanisms that might underlie the beneficial effects of exercise on depression. On the issue of dose–response, there is consensus that "There is little evidence for dose–response effects, though this is largely because of a lack of studies rather than a lack of evidence" (Dunn *et al*. 2001). A recently published randomized clinical trial with adults diagnosed with mild to moderate major depressive disorder compared four 12-week exercise conditions, crossing two levels of energy expenditure (7.0 or 15.5 $kcal \cdot kg^{-1} \cdot week^{-1}$) and two frequencies (3 or 5 days per week), and a "placebo exercise" intervention consisting of flexibility exercises performed 3 days per week. At the end of the programs, the effect of frequency was not significant but that of energy expenditure was, with the higher dose leading to lower clinician ratings of depression than the lower dose and "placebo," the latter two being no different from each other (Dunn *et al*. 2005).

On the issue of biological mechanisms, research is focusing mainly on the apparent ability of exercise to act as a natural analog of pharmacological interventions by correcting deficiencies in serotonin and norepinephrine neurotransmission (Meeusen 2006). Such deficiencies are considered hallmarks of clinical depression and anxiety and, consequently, have been the targets of antidepressive and antianxiety medications (i.e., serotonin- and norepinephrine-specific reuptake inhibitors).

Mood and affect

Construct description

Anxiety and depression are subjective states that generally follow specific patterns of cognitive appraisals (threat or helplessness, respectively). However, there are other salient subjective states that either have a loose connection to a cognitive appraisal or can even occur in the absence of a cognitive appraisal. "Moods" are believed to be linked to certain patterns of thought. However, unlike emotions, the target or eliciting stimulus might not be something obvious or specific. On the contrary, it could be something that happened a long time ago (e.g., a recollection of an unpleasant childhood event), something that could potentially occur in the distant future (e.g., that one's child might grow up to be a criminal), or even a large, existential question (e.g., wondering whether one's life has meaning or is consistent with what one had envisioned). Thus, moods are often "diffuse" and long-lasting, associated with a low tendency to act in response (i.e., "do something about it"), and even an inability to identify precisely why one feels the way that one does at a given moment. Moods are related to emotions in several ways. For example, one can be in an "anxious mood" or a "depressed mood" when one is bothered by persistent or ruminating thoughts of threat or inevitability not necessarily linked to a specific recent or impending situation or event. Furthermore, being in a certain mood lowers the threshold for the induction of the consonant emotion. For example, waking up in a worrisome or nervous mood might predispose one to evaluate many situations arising that day as posing a threat and, thus, respond with frequent state anxiety reactions.

"Affect" is an even more general term that refers to the defining subjective quality of all valenced (pleasant or unpleasant) states, including moods and emotions (Ekkekakis & Petruzzello 2000). Affect is an inherent component of all emotions and moods (it is what makes them "feel" pleasant or unpleasant) but can also occur independently of these, as in the case of the strong unpleasant sensations that accompany pain and injury or the sense of exhaustion that accompanies strenuous exercise on a hot, humid day. Affect is distinct from emotion and mood in that, as concepts, they also include several additional components such as cognitive appraisals, attributions to (proximal or distal) eliciting stimuli, and behavioral reactions (e.g., facial expressions or postural adjustments). In other words, moods and emotions are considerably more complex and multifaceted constructs than affect. Affect is commonly viewed as varying in terms of two key underlying dimensions: valence (pleasure vs. displeasure) and perceived activation or arousal. The combination of these two dimensions, which are theorized to be orthogonal to each other, produces four main variants of affective experience:

1 High-activation pleasant affect, characterized by energy, vigor, or excitement;

2 High-activation unpleasant affect, characterized by tension or distress;

3 Low-activation unpleasant affect, characterized by fatigue, boredom, or depression; and

4 Low-activation pleasant affect, characterized by calmness or relaxation.

Societal importance

Numerous exercise studies have examined changes in mood or affect. One category of studies has focused on the effects of regular exercise or physical activity participation on "baseline" or average levels of mood and affect. Another category of studies has examined whether single bouts of exercise can "make people feel better" in a transient sense (during exercise, as well as in the minutes and hours following the exercise bout). Of particular interest for the studies in the latter category is the question of dose–response, which includes questions pertaining to the lowest "dose" (intensity, duration) that can improve affect, the dose that can optimize affective change, and the dose that might induce a deterioration, instead of an improvement, in affect. Besides the relevance of dose–response research to the issue of well-being, it is also believed that it might shed light on the severe public health problem of physical inactivity. Simply put, because humans generally tend to do what makes them feel better but avoid what makes them feel worse, it is reasonable to assume that they would avoid those doses of exercise that consistently make them feel worse.

Construct assessment

Mood and affect are typically assessed by questionnaires or rating scales. Mood questionnaires focus on either a single mood state (e.g., euphoria) or various assortments of mood states, most commonly the six mood states contained in the 65-item questionnaire entitled the Profile of Mood States (tension, depression, anger, vigor, fatigue, and confusion). These questionnaires can be administered with different time-frame instructions, ranging from "How do you feel right now?" to "How have you felt during the past month, including today?" depending on the purpose of the study. Measures of affect, given the broad scope of this construct, tend to focus on a few key dimensions that are believed to underlie the domain of affect. Thus, the Positive and Negative Affect Schedule questionnaire includes one scale measuring high-activation pleasant affect (termed "Positive Affect" or "Positive Activation") and another measuring high-activation unpleasant affect (termed "Negative Affect" or "Negative Activation"). The Activation Deactivation Adjective Check List questionnaire includes one bipolar scale measuring "Energetic Arousal" (ranging from Energy, or high-activation pleasant affect, to Tiredness, or low-activation unpleasant affect) and another measuring "Tense Arousal" (ranging from Tension, or high-activation unpleasant affect, to Calmness, or low-activation pleasant affect). Alternatively, responses during bouts of exercise, when the use of multi-item questionnaires would be impractical, can be assessed by single-item rating scales, such as a scale that measures affective valence (ranging from pleasure to displeasure) and a scale that measures perceived activation or arousal (ranging from low arousal to high arousal). The combination of these two scales can produce a two-dimensional "map" of affective space, on which researchers can plot the trajectory of affective changes during an exercise bout and subsequent recovery period.

Role of exercise

One meta-analysis examined the effects of chronic exercise on mood in older adults, over 65 years of age (Arent *et al*. 2000). The 32 relevant studies that were retrieved were divided into three groups:

1 Experimental vs. control group comparisons;
2 Pre- to post-treatment comparisons; and
3 Correlational studies.

The average effect size from experimental vs. control group comparisons was 0.24. However, after studies in which experimental and control groups differed at baseline were removed, the average effect size rose to 0.34, or approximately one-third of a standard deviation. The effects were similar for increasing scores on "positive" (0.33) and reducing scores on "negative" (0.35) mood variables. The effects were larger for exercise performed on fewer than 3 days per week (0.69) than 3 or more days per week (0.28), when the duration per session was self-selected (0.86), when the duration of the program was up to 12 weeks (0.45–0.48) but no longer (0.19), and when the intensity of exercise was low (0.58) rather than medium (0.26) or high (0.29). The average effect size from pre- to post-treatment comparisons was 0.38. Again, there was no difference in the extent to which exercise was associated with increases in "positive" (0.35) and decreases in "negative" (0.39) mood variables. Finally, the average effect size from correlational studies was 0.46, and this was again similar for increases in "positive" (0.42) and decreases in "negative" (0.47) mood variables. Although certainly informative, this meta-analysis was limited by the fact that mood and affect were considered interchangeable constructs and no information was provided as to exactly which "positive" and "negative" mood variables were included (other than to say that the studies that were selected assessed "some construct of mood").

A recent meta-analysis targeted 158 studies on the effects of aerobic exercise on changes in high-activation pleasant affect from before to after a bout (Reed & Ones 2006). Effect sizes were weighted for sample sizes and corrected for the unreliability of measurement and other possible sources of bias. Overall, the analysis indicated that exercise treatments were associated with an increase in high-activation pleasant affect by almost one-half of a standard deviation (average effect size of 0.47), whereas control or comparison treatments were associated with a small decrease (0.17). The positive effect of exercise was larger for individuals who had the lowest pre-exercise scores (0.63), for exercise of low intensity (0.57), for exercise duration up to 35 min (0.46–0.57), for low and moderate "doses" of exercise (product of intensity and duration, 0.45–0.46), and for assessments taken up to 5 min post-exercise (0.61). Interestingly, studies that attempted to control three or more threats to internal validity were associated with larger effect sizes (0.49–0.50) than less well-controlled studies (0.30).

A series of recent studies has started to delineate the important relationship between the intensity of exercise and the affective responses that occur during and after an exercise bout. The picture that is emerging at this early stage is that at:

1 *Low levels of intensity:* during-exercise changes tend to be mostly positive, characterized primarily by shifts toward a high-activation pleasant affective state;

2 *High and near-maximal levels of intensity:* during-exercise changes are negative in most participants; and

3 *Mid-range intensities:* during-exercise changes tend to vary from individual to individual, with some reporting increases and other reporting decreases in pleasure.

It also appears that the intensity associated with the ventilatory or lactate threshold is the "turning point," beyond which the declines in pleasure begin. Depending on whether the affective changes that occur during exercise are positive or negative, the typically positive changes observed after exercise may represent either the continuation of a positive during-exercise trend or the result of a rapid post-exercise rebound, which tends to be proportional in magnitude to the during-exercise decline. According to a "dual-mode" theoretical model, the affective responses to exercise are the result of the continuous interplay between two general factors:

1 *Cognitive variables:* e.g., self-efficacy, self-presentational concerns, or attributions; and

2 *Interoceptive variables:* e.g., respiratory or muscular cues.

The relative salience of these two factors is expected to vary systematically as a function of exercise intensity, with cognitive variables being the dominant determinants of affect at intensities below and proximal to the ventilatory threshold and interoceptive variables gradually increasing their influence at intensities above the ventilatory threshold and until the point of maximal capacity (Ekkekakis 2003; Ekkekakis *et al*. 2005). This model has implications for the extent to which cognitive techniques that are commonly used to control affective responses to exercise (e.g., attentional dissociation, cognitive reframing, or boosting self-efficacy), particularly among novice exercisers, can remain effective as the intensity rises. The dual-mode theory suggests that, as the intensity of exercise begins to exceed the level associated with the ventilatory threshold, the role of cognition in controlling affect is reduced, as a barrage of inherently unpleasant interoceptive cues flood consciousness. Therefore, interventions designed to improve the ability of novice exercisers to self-monitor and self-regulate their exercise intensity may be warranted.

Cognitive function

Construct description

Cognitive function depends on such critically important abilities as perceiving, recognizing, and interpreting sensory stimuli, storing information in memory and retrieving it when needed, and using these data to make appropriate behavioral decisions. Some cognitive abilities are based on knowledge (such as verbal fluency and comprehension or wealth of vocabulary) and are termed "crystallized" abilities. These typically continue to improve over the course of one's lifetime and tend to resist the effects of aging. However, other cognitive abilities, which are process-based (e.g., the speed and accuracy of perception and decision making), termed "fluid" abilities, seem to be susceptible to aging-related declines. The decline in such abilities can begin as early as the third decade of life and is typically accelerated after the age of 70 years. On average, between 30 and 90 years of age, humans lose approximately 15% of their cerebral cortex and 25% of their cerebral white matter, with the frontal, parietal, and temporal cortices being affected the most. Not surprisingly, the loss of brain tissue and the decline in cognitive function parallel each other.

Societal importance

Although a certain degree of cognitive decline is often seen as a normal part of the aging process, there appear to be some striking interindividual differences, with some individuals maintaining seemingly perfect mental sharpness and clarity well into old age. Although most individuals experiencing cognitive decline preserve adequate function to stay independent, in some cases the decline is such that it is recognized as a clinical condition, known as dementia. The most common cause of dementia is Alzheimer's disease, currently afflicting 2–4 million people in the USA alone. In turn, old age, family history of dementia, low levels of educational and occupational attainment, and the apolipoprotein E genotype ε4 allele are the only known risk factors for Alzheimer's disease. Dementia and Alzheimer's disease have a devastating effect on quality of life. They gradually rob patients of their intellectual faculties, eventually making even the most basic forms of self-care and social interaction impossible. Besides increasing the risk of loss of independence, hospitalization, or institutionalization, Alzheimer's disease is associated with life-threatening physical comorbidities, such as stroke, and can ultimately lead to death.

Construct assessment

Cognitive function is multifaceted and, accordingly, can be evaluated in a variety of ways. The simplest tool, used extensively in epidemiological research, is a short survey called the Mini Mental State Examination. During a short conversation, the patient is asked questions designed to assess basic orientation (identify the time and place), memory (name and later recall certain items), attention and calculation (count by seven), and language (follow a three-stage command). Other assessment options include standardized tests designed to assess diverse abilities (e.g., perceptual speed, working memory, tracking, decision making, multitasking), most of which are computerized. Furthermore, cognitive processing is often evaluated by psychophysiological indices. Specifically, in a technique called Event Related Potentials, the electroencephalographical traces following the presentation of several target (uncommon) and non-target (common) stimuli are averaged and compared. A particular element of the waveform, a positive voltage change occurring approximately 300 ms after the presentation of the stimulus (hence named P300 or P3), is examined in terms of its amplitude (which is interpreted as an indication of the extent of recruitment of cognitive resources) and latency (which is interpreted as an indication of the speed of cognitive processing). Finally, given the close correspondence between structural or anatomical changes in the brain and cognitive performance, brain imaging methods, such as magnetic resonance imaging, have also been used.

Role of exercise

The role of exercise in promoting and preserving cognitive function was originally examined based on the rationale that the beneficial effects of exercise on the cardiovascular system might also be reflected in a healthy blood supply to and therefore ample oxygenation of the brain. Over the years, this rationale has been extended and strengthened, as additional mechanisms for a possible beneficial effect on cognitive function have been uncovered. Specifically, exercise has been shown to promote synaptogenesis (the formation of new synapses), neurogenesis (the formation of new neurons), and the upregulation of growth factors that are important to the healthy development and preservation of neural tissue, such as Brain Derived Neurotrophic Factor (van Praag 2006).

The first meta-analysis on the link between exercise and cognitive function examined 134 studies (Etnier *et al*. 1997). The average effect size was small (0.25), indicating an improvement in cognitive performance by one-quarter of a standard deviation. Cross-sectional or correlational designs yielded higher effects (0.53) than chronic (0.33) or acute (0.16) designs. This finding cannot be interpreted in an unequivocal fashion. One possible interpretation is that cross-sectional studies generally have more power, since "fit" or "active" and "unfit" or "inactive" participants generally differ more in terms of fitness compared to how much participants can improve over the course of an exercise training program lasting for a few weeks or months. Another way to approach this finding, however, is by recognizing that the quasi-experimental nature of this evidence does not permit any inferences about causation to be made. In studies of acute exercise, age, mental ability, the intensity and duration of the bout, and the interaction of intensity and duration were not found to moderate the results. Surprisingly, measures of simple reaction time were associated with larger effect sizes than measures of choice reaction time, despite the larger cognitive component of the latter. In chronic exercise studies, although the mental ability of the participants did not moderate the results, their age did. Specifically, the effects were larger for participants aged 46–60 years (1.02) and 18–30 years (0.64), whereas there was no apparent benefit for individuals aged 31–45 years (0.06) or 61–90 years (0.19). The duration of exercise sessions, the days of exercise per week, the total number of exercise sessions, and the changes in fitness were not associated with the size of the effect. In cross-sectional or correlational studies, the age and mental ability of the participants were not significant moderators. However, the effects were again found to be larger for measures of simple than choice reaction time. The authors emphasized that, in both acute and chronic exercise studies, as the number of threats to internal validity increased, so did the effect sizes. This finding underscores the importance of conducting studies characterized by the highest degree of methodological rigor. When only the 17 randomized clinical trials were examined, the average effect size was 0.18, which, although positive and significantly different from zero, was small and of questionable practical importance.

A subsequent meta-analysis of 44 studies focused on the effects of exercise on cognitive performance among children (Sibley & Etnier 2003). The average effect size was 0.32, indicating that children who exercised outperformed children who did not by approximately one-third of a standard deviation. The effect sizes derived from true experiments (0.29), quasi-experiments (0.37), and cross-sectional or correlational studies (0.35) did not differ significantly. Likewise, whether the children were healthy, mentally impaired, or physically disabled, as well as the type of exercise used, were not significant moderators. Middle-school (11–13 years; 0.48) and young elementary school children (4–7 years; 0.40) showed the largest effects. Tests of perceptual skills yielded the largest effects (0.49), whereas math tests (0.20), verbal tests (0.17), and memory tests (0.03) yielded the smallest.

At the other end of the developmental spectrum, in older adults, there has been a history of mixed results. The cause of the inconsistency was elucidated recently, following a proposal that the effects of exercise in older adults do not manifest themselves across the entire range of cognitive abilities but are rather selective, benefiting primarily functions that depend on executive control. This proposal makes logical sense because cognitive skills that have a large executive-control component, and the brain regions that control them, appear to be selectively impacted by aging. This idea was tested in a meta-analysis of 18 randomized fitness intervention trials that involved adults aged 55–80 years (Colcombe & Kramer 2003). Studies were excluded if the design was cross-sectional, the participants were not randomly assigned, the exercise program was unsupervised, or the exercise program did not include an aerobic fitness component. The meta-analysis examined four competing theoretical predictions; namely, that the effects of exercise or fitness would be specific to:

1 *Speed:* tasks representing low-level neurologic functioning, such as simple reaction time;
2 *Visuospatial ability:* ability to transform or remember visual and spatial information, such as redrawing shapes from memory;
3 *Controlled processes:* tasks requiring some cognitive control, such as simple rule-based decision-making or choice reaction time tasks; and
4 *Executive control:* planning, inhibition, and scheduling, such as responding to one cue while suppressing other, simultaneously presented, conflicting, or irrelevant cues.

Exercise training groups showed an average effect size of 0.478, whereas control groups showed an average effect size of 0.164. In other words, exercise training was associated with almost an improvement of one-half of a standard deviation in cognitive performance, regardless of the nature of the task. Importantly, however, the effect was found to be the largest for executive-control tasks (0.68), followed by controlled processes (0.46), visuospatial tasks (0.43), and speed tasks (0.27), thus providing support to the hypothesis that the effects of exercise are selective. Individuals who were trained using a combination of aerobic and strength-training exercises improved significantly more (0.59) than those who used aerobic exercise alone (0.41). Short training programs, lasting 1–3 months, were shown to be effective (0.52), although not as much as programs lasting more than 6 months (0.67). However, programs consisting of short exercise bouts, lasting 30 min or less, were not effective (0.18); bouts lasting 31–45 min (0.61) or 46–60 min (0.47) were necessary for significant effects. Samples consisting mostly of women were associated with a clearly larger effect (0.60) than samples consisting mostly of men (0.15), the latter being only borderline significant. Also, individuals aged 66–70 years reaped the largest benefit (0.69), followed by those aged 71–80 years (0.55) and those aged 55–65 years (0.30).

Finally, a recent meta-analysis focused on what has been termed the "cardiovascular fitness hypothesis," or the idea that the beneficial effect of exercise on cognitive function is mediated by improvements in aerobic capacity (Etnier *et al*. 2006). The average effect size was 0.34, indicating that aerobic training and fitness were associated with approximately one-third of a standard deviation improvement in cognitive performance. The 37 studies that were identified were divided into four groups:

1 Cross-sectional designs (mean effect size 0.40);
2 Post-test comparisons (mean effect size 0.27);
3 Pre-post comparisons (mean effect size 0.25); and
4 Correlational studies (mean correlation 0.29).

Within category 1, fitness was not related to cognitive performance overall but only among middle-aged adults; in fact, it was a negative predictor of cognitive performance among children and young adults and was unrelated to cognitive performance among older adults. Within category 2, fitness and cognitive performance were unrelated. Within category 3, gains in aerobic fitness were negatively correlated with improvements in cognitive performance. Age interacted with fitness, in that fitness was a significant negative predictor of cognitive performance only among older adults, and was unrelated to cognitive performance among children, young adults, and middle-aged adults. Health status or the type of cognitive test involved were not shown to be significant mediators in any of the analyses. The clear lack of support for the cardiovascular fitness hypothesis in this analysis opens the door to other explanations for the beneficial effects of exercise on cognitive function, including improved cerebral oxygenation, improved neurotransmitter availability, synaptogenesis, neurogenesis, and upregulation of brain neurotrophic factors.

Self-esteem

Construct description

Self-concept and self-esteem are two constructs at the core of our self-perceptions. They refer to how people see themselves and how they evaluate their worth, their capabilities, and their limitations. Although the two terms are often used interchangeably, self-concept refers to one's self-description and is therefore more "cognitive" in nature, whereas self-esteem refers primarily to the positivity or negativity of these self-perceptions and is therefore more "affective" in nature. Self-concept and self-esteem are believed to have a multidimensional and hierarchical structure. The term "hierarchical" is meant to convey that these constructs have a pyramid-like structure, with multiple domain-specific self-appraisals at the bottom of the hierarchy (i.e., how we see and evaluate ourselves in terms of our physical appearance or capability, in terms of our academic or occupational achievements, in terms of the breadth and quality of our social relationships, and so on) and a global, overarching self-appraisal at the top. Each domain can also have additional subdivisions. For example, the academic domain can be further divided into math, history, science, language, and other subdomains. The term "multidimensional" is meant to convey that our domain-specific (and subdomain-specific) self-appraisals can vary, to some degree, independently of each other. For example, although we may think that we have done a great job in the professional arena, this does not necessarily entail that we must have an equally positive view of our performance as spouses or parents. Likewise, although we may think of ourselves as exceptionally strong in math, we may view our historical knowledge as weak.

Societal importance

The physical aspect of the self is one of its essential components, although the importance assigned to it can clearly vary from one individual to the next. For some, it may acquire central importance, to the extent that global self-worth hinges almost entirely upon one's view of one's body and physical appearance. This unbalanced view of the self is often associated with such serious problems as body dysmorphic disorder, eating disorders (anorexia, bulimia), or obsessive exercise. In turn, these conditions are frequently comorbid with other psychological problems, such as major depressive disorder, social anxiety or phobia, and obsessive–compulsive disorder. Dissatisfaction with a certain aspect of one's physical appearance or with one's overall physical appearance can lead to avoidance of usual activities, development of problems in interpersonal behavior, and social isolation. At the other end of the spectrum, some individuals pay very little attention to their body, viewing it more or less as a vehicle for getting around and as having a negligible role in determining their self-worth. In these cases, overeating and underexercising, or an overall neglect of one's health can occur, often with negative consequences for health and well-being.

It is also important to point out that the physical domain is not unitary. It can consist of several appearance-related aspects (e.g., tallness, leanness, muscularity) and several performance-related aspects (e.g., strength, endurance, flexibility), including general skills (e.g., dexterity, grace, speed) and sport-specific skills (e.g., in basketball or swimming). Given the multidimensional nature of such self-appraisals, these can vary, to some degree, independently. For example, a man might see himself as impressively muscular but lacking in endurance.

Construct assessment

Because self-concept and self-esteem are quintessentially subjective constructs, the typical method used for their assessment is the questionnaire. In recent years, there has been a shift from viewing the self as a unitary construct to conceptualizing the self as multifaceted and context-dependent. Global self-esteem is generally measured by unidimensional inventories, one of the most popular being the Rosenberg Self-Esteem scale. It consists of 10 items, some of which are worded positively (e.g., "I feel that I am a person of worth, at least on an equal plane with others") and some worded negatively (e.g., "I certainly feel useless at times"). Another approach to measurement focuses on domain-specific self-appraisals. In the case of the physical domain, one of the most popular measures is the Physical Self Perception Profile, a multidimensional questionnaire that includes scales measuring perceptions of physical strength, physical condition, sport competence, body attractiveness, and overall self-worth. Additional measures are also available that tap the physical domain such as body image, body satisfaction, and social physique anxiety.

Role of exercise

Given the impact of physical activity on the body, it is reasonable to assume that physical self-esteem can change as a consequence of exercise participation.

Given the hierarchical structure of this construct, domain-specific change may in turn serve to modify global self-esteem. This relationship could prove beneficial because research suggests that self-esteem occupies a central position in the psychology of health and well-being and is related to choice and persistence in a range of achievement and health behaviors (Fox 2000). Indeed, one way that exercise activity may help people "feel better" is through enhanced self-perceptions (such as physical self-worth, physical condition, and physical health) and improved self-esteem.

A number of narrative reviews on the relationship between exercise and self-esteem have concluded that the weight of the evidence supports a positive link between the two. Fox's review (2000), which examined 36 randomized clinical trials, noted that 78% of studies observed positive changes in some aspect of physical self-esteem or self-concept as a result of exercise. However, the strength of the association between exercise and global self-esteem has been questioned.

A recent meta-analysis by Spence *et al*. (2005) on adults over 18 years found an average effect size of 0.23, suggesting that exercise is associated with an increase in global self-esteem of approximately one-quarter of a standard deviation, a small effect. Significant changes in physical fitness were associated with greater changes in global self-esteem (0.32) than exercise that did not elicit such changes (0.15, not significantly different from zero). Initial level of self-esteem, exercise intensity, and length of the program were not significant moderators of the exercise effects. The effects were larger when the program was exercise-based (0.26) or lifestyle-based (0.36) than on programs involving training in skill-based activities, which had no effect (−0.03).

Ekeland *et al*. (2005) focused their systematic review on the effects of exercise on global self-esteem in children and youth. The 23 included studies were divided into two groups which focused either only on exercise or on skill training, counseling, the social setting, or other motivational factors that were part of the exercise intervention. The overall standardized mean difference between the exercise and control group was 0.49, equating to a 10% difference between the groups in favor of the intervention. However, a sensitivity analysis showed that this effect was not significant when the data were re-examined after excluding studies of healthy children, strength-training studies, programs lasting less than 10 weeks, or studies with large baseline differences. When exercise as part of a holistic program was compared with no-intervention, a similar difference emerged (0.51, equating to a 10% difference between the intervention and control group). However, this finding should be interpreted cautiously as only four studies were included in the analysis. What emanates from the meta-analyses that span gender, age, and physical activity domains is the conclusion that physical activity brings about statistically significant increases in global self-esteem, but the effects are small. Indeed, Spence *et al*. (2005) assert that the effects of exercise on global self-esteem have been overstated in the literature.

The only medium-sized effect (−0.41) was reported in the meta-analytical review of McDonald and Hodgdon (1991). This discrepancy may relate to the extent to which the reviewed literature focuses on global self-esteem or on domain-specific components. This is important because, not surprisingly, the magnitude of change brought about by exercise within the specific domain of physical self-perceptions has been found to be larger than changes at the global level (Fox 2000). A recent meta-analysis targeted 121 studies on the effects of exercise on body image (Hausenblas & Fallon 2006). The studies were divided into three groups:

1 Experimental vs. control group studies;
2 Single-group studies; and
3 Correlational studies.

The overall mean effect size from experimental vs. control group comparisons was 0.28, with women reporting a significantly larger effect (0.43) than men (0.39). Similar effects were also found across all the study groupings. In terms of exercise mode, combined aerobic and anaerobic exercise elicited a larger effect (0.45) compared with aerobic (0.25) or anaerobic (0.27) exercise alone. Further, in this study grouping, adolescents had a significantly larger effect (0.71) than university students (0.25) and adults (0.46). However, although the overall mean effect size was larger for the correlational (0.41) studies, this age effect was not replicated, with adolescents in this group of studies reporting significantly smaller effect sizes (0.18) than college-age (0.53) and adult populations (0.59). The use of age categories, rather than mean age, is offered as a possible explanation for these varying results. The overall conclusion of this analysis was that exercise is associated with a more positive body image, but the effects are, once again, small. Furthermore, the extent to which changes in physical self-perceptions are accompanied by improvements in the overall sense of worth or general self-esteem, appears equivocal.

The absence of systematic exercise effects on global self-esteem has been attributed to the fact that such effects are mediated by psychosocial rather than physiologic mechanisms (Fox 2000). The subjective nature of the self means that the mechanisms accounting for change are variable and will depend on the individual's subjective experience of the activity and the setting in which it takes place. Although many mechanisms have been proposed, including change in physical fitness, goal achievement, and social experiences, little evidence exists supporting their efficacy for eliciting change. Finally, it is important to contextualize physical activity. Individuals do not partake in this behavior in a vacuum, so many moderating variables likely exist. Given the highly idiosyncratic nature of the self, the challenge ahead lies in unravelling this complex relationship. In the future, studies may be complemented by idiographic research to explore the different ways that individuals interpret the importance placed on exercise in their everyday lives.

Health-related quality of life

Construct description

Despite the average life expectancy for both men and women continuing to rise in the developed world, *healthy life* expectancy, although increasing, has not matched the pace of total life expectancy. Before the 1970s, the concept of "quality of life" had received little attention in the fields of medicine and public health. However, much has changed since then. Today, according to the World Health Organization, health is not viewed merely as the absence of disease but as a state of complete physical, mental, and social well-being. Attention to quality of life emerged as a natural consequence of this new perspective. The term "quality of life" refers to an individual's perception of his or her position in life, within the context of the surrounding culture and value systems and in relation to the individual's goals, expectations, standards, and concerns. Clearly, this is a multifaceted construct. It is believed to be the product of a complex interaction between the individual's physical health, psychological health, independence, personal beliefs, social relationships, and the physical, social, cultural, political, or economic environment.

Societal importance

The domain of physical health includes such components as perceived levels of energy or fatigue, pain, and discomfort. The domain of psychological health encompasses such elements as body image, emotions, self-esteem, and cognitive vitality. Independence refers to mobility, the ability to carry out activities of daily living, the degree of dependence on medicinal substances or medical aids, and the ability to work. The domain of personal beliefs refers to religion and spirituality. The domain of social relationships includes such notions as social support, human contact, and sexuality. Finally, the environment encompasses a broad array of elements that have direct or indirect relevance to the quality of life, including financial resources, freedom and security, access to high-quality health and social care, opportunities for education and self-improvement, opportunities for recreation and leisure, and an unpolluted and non-congested physical environment.

Of these components of quality of life, the ones that are of particular relevance to exercise and physical activity are the first three: the domains of physical and psychological health, and independence. Collectively, these can be categorized under the rubric of health-related quality of life (HRQL). According to the World Health Organization, this notion refers to the impact of treatments and disease processes on the overall satisfaction with life or, more specifically, with physical, emotional, and social functioning. A paradoxical outcome of medical treatments is that they often reduce morbidity or mortality but they do not always improve the quality of a person's everyday life. Therefore, improvements in physiologic condition or even physical function are not necessarily associated with improvements in HRQL.

Construct assessment

Overall quality of life and HRQL are assessed at a global level (i.e., with measures that tap overall life satisfaction), at the level of specific domains (i.e., with multidimensional measures that assess satisfaction with social relationships, physical health, etc.), or with measures specific to the unique conditions resulting from a certain disease (e.g., measures specific to arthritis, diabetes, or parkinsonism). A measure of global quality of life, the unidimensional Satisfaction with Life Scale, includes questions asking respondents whether or not they agree with the statement that "In most ways, my life is close to my ideal" or "If I could live my life over, I would change almost nothing." A popular multidimensional measure of quality of life, called SF-36, includes 36 items divided into the following eight scales:

1 Physical function;
2 Role limitations resulting from physical problems;
3 General health;
4 Bodily pain;
5 Social function;
6 Role limitations resulting from emotional problems;
7 Mental health; and
8 Vitality.

Role of exercise

A relatively small but growing research literature suggests that physical activity and regular exercise can lead to improvements in HRQL. Rejeski *et al*. (1996) were the first to undertake an extensive review of the literature on physical activity and HRQL. This review was updated recently (Rejeski & Mihalko 2001). Collectively, these reviews examined 45 studies of the relationship between physical activity and HRQL. The overall conclusion was that physical activity is *associated* with improvements in various aspects of HRQL, regardless of age, activity status, or the health of the participants. Yet, Rejeski and Mihalko (2001) acknowledged that a confusing picture emerged when the latest randomized clinical trials were examined. Specifically, half of the studies reported an improvement in HRQL but the other half failed to show a beneficial effect compared to control or comparison treatments. Methodological differences, including varying activity prescriptions, appear to be the root of these disparities. Rejeski and Mihalko commented that there is "little hope of ever integrating extant research, because quality of life has no consistent meaning across studies."

Recently, Netz *et al*. (2005) conducted a meta-analysis on organized physical activity and well-being in older adults without clinical disorders. Although this meta-analysis did not examine HRQL per se, well-being was defined as a multifaceted construct, with emphasis on four general components closely related to HRQL:

1 Emotional well-being;
2 Self-perceptions;
3 Bodily well-being; and
4 Global perceptions, such as life-satisfaction.

Overall, the weighted mean effect size for the physical activity intervention groups (0.24) was almost three times larger than the mean for control groups (0.09). In terms of the constructs assessed, self-efficacy (0.38), overall well-being (0.37), and view of self (0.16) were all positively affected by physical activity and showed the largest treatment–control differences. The same significant difference, however, was not found for life satisfaction, depression, anger, and confusion. Moderator variables were examined, and aerobic exercise (0.29) and moderate intensity exercise (0.34) were found to be the most beneficial for improving well-being. Additional moderators included improvements in cardiovascular capacity (0.32), strength (0.20), and functional capacity (0.32). Overall, based on the findings of this analysis, there appears to be a significant relationship between physical activity and well-being enhancement in older adults. Netz *et al*. (2005) concluded that the small overall effect size could be a result of the fact that no samples with clinical disorders were included in this analysis.

Even though the weight of direct and indirect evidence available at this time supports a positive association between physical activity and HRQL, it should be kept in mind that this line of research is still in its infancy. Strong evidence for a causal relationship is lacking. Although it is plausible that physical activity could improve HRQL, particularly given its established role in preserving health and function, at this point it is also plausible that the observed positive association might be influenced by such factors as volunteerism or expectancy bias. Also, deciphering the influence of mediating and moderating variables is going to be a long and challenging process (Rejeski & Mihalko 2001). Such factors as optimism, health locus of control, hardiness, or the importance placed upon HRQL among different individuals might be influential but their role remains to be clarified.

Conclusions

Having completed this selective survey of the literature on the role of exercise and physical activity in several key components of psychological well-being, let us return to the issue raised in the introduction. At least some of the reasons behind the divergent assessments of the role of exercise are hopefully a little more apparent. On the one hand, there is a remarkable consistency in the evidence for a positive association between exercise and a broad range of components of well-being. Most meta-analyses and systematic reviews agree that there is at least a statistically reliable association and this is clearly not a finding that can be easily ignored. However, there is also the other side. First, most of the effects are small to medium in magnitude. Second, and most importantly, the quality of the evidence, for the most part, is not optimal. Authors both within and outside the exercise sciences have raised some serious concerns, which are highlighted here. Large-scale, randomized clinical trials are a recent development and even these are bound to face challenges. The fact that participants are volunteers and most psychological outcomes are self-reported and therefore subject to expectancy bias, in conjunction with the inability to implement a "placebo" exercise control, make it practically impossible to design a "definitive" exercise intervention study. Despite this, there are methodological steps that can bring future studies at least closer to this untenable ideal: randomization; blinding of outcome assessors; careful selection of outcome measures and protocols; adequate intervention and follow-up periods; and intention-to-treat analyses.

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