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The Effects of Exercise on Mood in Older Adults: A Meta-Analytic Review

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This meta-analysis examined the exercise-mood relationship in older adults. 158 effect sizes (*ESs*) from 32 studies were grouped into experimental-versus-control, gains, and correlational *ESs*. Each study was coded for moderator variables related to descriptive, design, participant, exercise, and mood-assessment characteristics. Experimental-versus-control ESs for negative (NA) and positive affect (PA) were 0.35 ($p < .05$) and 0.33 ($p > .05$), respectively, with an overall *ES* of 0.34, $p < .05$. The gains *ESs* for NA and PA in an exercise group were 0.39 ($p < .05$) and 0.35 ($p < .05$), respectively, with an overall *ES* of 0.38, $p < .05$. All effects were significantly greater than those for the control groups. Correlational *ESs* of 0.47 and 0.42 were found for NA and PA, respectively. It was concluded that chronic exercise is associated with improved mood in the elderly. Moderating variables and implications for exercise prescription to improve mood in the elderly are discussed.

Key Words: elderly, affect, physical activity

Senior citizens have become the fastest growing segment of our population. In 1880, less than 3% of the total population was older than 65. By 1980, older adults constituted almost 12% of the population. There are now more than 36 million elderly people in the United States, and this number is expected to double by the year 2030. According to current estimates, this would mean that the elderly would represent 22% of the total population (Hoeger & Hoeger, 1996). The 65-and-over group is growing twice as fast as the rest of the population. One reason for this trend is increasing life expectancies. Unfortunately, increased life expectancy does not necessarily equate to increased quality of life.

One of the central issues raised by increased longevity is that of net gain in active functional years versus total years of disability and dysfunction. Muscular strength in most individuals is well maintained until about 45 years of age but then deteriorates by 5-10% per decade thereafter (Rogers & Evans, 1993). Furthermore, loss in muscle mass appears to be the major cause of strength decrease in the elderly (Rogers & Evans). Muscle weakness can compromise everyday activities, leading to dependence on others to help perform day-to-day tasks and increasing the risk of injury resulting from falls. One way to potentially offset or rectify many of the health

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problems and physical deterioration incurred with aging is through exercise (Cress et al., 1991; Fiatarone et al., 1990; Frontera, Meredith, O'Reilly, Knuttgen, & Evans, 1988; Hagberg, Graves, & Limacher, 1989; Kohrt, Malley, & Coggan, 1991; Makrides, Heigenhauser, & Jones, 1990). Of all age groups, the elderly have the most to gain by being active because of the effects of exercise on improved body composition, fitness, longevity, ability to perform personal care activities, and the management of arthritis or other debilitating conditions. Furthermore, there is convincing evidence that greater aerobic power, muscle strength, and flexibility allow the elderly to perform at levels equivalent to people 10-20 years younger, which often equates to a dramatically improved quality of life.

In addition to declines in physical performance with the passage of time, as individuals progress beyond 60 years of age there also tends to be an increased prevalence of mood disturbance (i.e., increased negative affect and decreased positive affect; Fillingim & Blumenthal, 1993; Pfeiffer, 1977) and decrements in some cognitive abilities (Botwinick, 1977; Jacewicz & Hartley, 1987; Schaie, 1994). Age-related changes (i.e., physical, mental, and social) often present challenges to emotional control and stability that exceed those experienced by younger individuals (Spirduso & Mackie, 1995). Physical deterioration, functional losses, loss of friends and family, and even retirement provide unique and potentially overwhelming challenges to the older adult. The fact that almost twice as many individuals over 65 commit suicide each year (Crandall, 1991) might provide some insight into the ramifications of these "challenges" associated with aging. A recent study at the University of Washington (Unutzer et al., 1997) found that elderly individuals with strong depressive symptoms incurred about $5,000 more in medical costs over 4 years than did elderly adults without depression. Unutzer et al. attribute increased costs to the possibility that depression in the elderly exacerbates other medical problems.

A meta-analysis on the effects of exercise on depression (North, McCullagh, & Tran, 1990) concluded that exercise can help decrease depression—even in those who are not initially depressed. North et al. indicated that this effect appears to be even more pronounced in the elderly, but this population was unfortunately not included in the final analysis. Similarly, Landers and Petruzzello (1994) conducted a meta-analysis exploring the effects of physical activity on anxiety. Although exercise was found to be associated with a reduction in anxiety, the effect of age as a moderator variable was not specified. Thus, although it is generally agreed that elderly populations physically respond to exercise in a manner similar to that of younger populations, it is not as clear whether they respond in a similar fashion psychologically, especially with regard to changes in mood.

Anxiety and depression are linked in that they are concepts typically included under the more general rubric of affect, or mood. Other concepts commonly explored and associated with research on mood include anger, vigor, fatigue, confusion, pleasantness, and euphoria (Tuson & Sinyor, 1993). Lazarus (1991) contends that, of these constructs, only anxiety, anger, and euphoria represent true affect. Lazarus also maintains that the terms *mood* and *affect* do not represent the same thing but, rather, different time periods on the emotional continuum. *Mood,* according to Lazarus, represents a transient state, whereas *affect* represents something more enduring. In an attempt to remain consistent with the current literature, however, this study accepts as a precept that the terms *mood* and *affect* can be (and usually are) used interchangeably and that all of these concepts (depression, anxiety, anger, vigor, fatigue, confusion, pleasantness, and euphoria) can be included under the rubric of mood. In fact, Gauvin and Brawley (1993) argue for this approach when examining exercise and mood. They suggest that this might be better suited to the understanding of the relationship of affect and exercise because the models that can be derived from it are intended to be broad and encompassing conceptualizations of affective experience. A model of affect that has a wider focus is more likely to capture the nature of exercise-induced affect. Gauvin and Brawley consistently use the words *mood* and *affect* interchangeably when referring to the effects of exercise along a positive-negative dimension.

The terms *mood, affect (positive and negative), psychological benefits,* and *well-being* are often used interchangeably when assessing the effects of exercise on the elderly (or most other populations, for that matter). Nonetheless, studies differ greatly on the components and concepts they include under these labels. For example, in the exercise literature, the phrase *psychological benefits* often includes improvements in cognitive functioning or decreases in stress reactivity (Tuson & Sinyor, 1993). Neither of these concepts is necessarily indicative of improvements in mood or affect, however. *Well-being* also tends to be a rather broad term that can include physical well-being, cognitive functioning, and life satisfaction, in addition to psychological states commonly associated with affect and mood (Tuson & Sinyor). Although *affect* does appear to be interchangeable with *mood* in most of the exercise literature, this might not always be the case when referring to *psychological benefits* or *well-being.* Therefore, if it is concluded that an exercise treatment did not produce psychological benefits or changes in well-being, this might or might not indicate failure to produce a change in mood state, depending on the constructs included under *psychological benefits* or *well-being.*

There have been inconsistencies in the literature reviews regarding the efficacy of exercise for improving mood in the elderly. Although there have been some narrative reviews that have espoused the beneficial effects of exercise on mood in the elderly (Crase & Rosato, 1979; Johnson-Pawlson & Koshes, 1985; Shephard, 1984, 1990), there have been others that have presented a less conclusive view of this effect (Brown, 1992; Fillingim & Blumenthal, 1993; Netz & Jacob, 1994). Part of the problem might stem from the aforementioned inconsistencies in regard to which constructs the reviewers thought comprised the term *mood.*

Differences in the conclusions reached by the reviewers might also be attributed to inherent shortcomings of narrative reviews. Narrative reviews are relatively subjective assessments of the current literature and rely on the "vote-count" method to determine the presence or absence of an effect. They typically do not include all available studies from a given area of research but, rather, those studies the author believes fit well within the intended discussion. Methods are typically subjective and unreported, leaving a problem of replicability. Narrative reviews are limited by both the studies chosen and the limitations inherent to those studies. These reviews typically depend on significant or nonsignificant findings, rather than on the magnitude of a potential effect. Furthermore, there are numerous differences among studies specifically examining the effects of exercise on mood in the elderly that would limit a traditional review's ability to assess these variables' moderating effects on the findings. Some of these differences include (a) differences in measures of mood employed, (b) differences in exercise protocols (including type, duration, intensity, and frequency), (c) differences in participants' preexercise fitness levels, (d) differences in study design (i.e., random assignment, presence of control groups, etc.), (e) differences in the components of mood assessed, and (f) differences between acute exercise and chronic exercise. Fortunately, there is a method whereby the reviewer can objectively assess how design characteristics influence effect size through classification of findings by moderator variables.

A meta-analysis (Glass, 1977) can provide what the traditional narrative review is typically incapable of—a statistically objective, replicable, comprehensive analysis of the effect that an independent variable has on a dependent variable. In order to do this, the results of all available studies (published and unpublished) are quantified to a standard metric, the effect size *(ES),* that then allows the researcher to use statistical techniques as a means of analysis. Also, by combining participants across studies, one is able to greatly increase the statistical power of the analysis. The lack of statistical power is common to behavioral science research because of the relatively low numbers of participants combined with large numbers of variables (Cohen, 1988). The increased power available through meta-analytic techniques often allows the reviewer to detect small, but significant, trends not detected in single studies or narrative reviews. Essentially, a meta-analysis allows determination of the magnitude of an effect.

As previously stated, related meta-analyses (Landers & Petruzzello, 1994; North et al., 1990) have failed to examine the influence of age (particularly "old age") as a moderating variable in the exercise-mood relationship. Considering that the elderly often experience challenges to emotional control above and beyond those typically experienced by younger adults (Spirduso & Mackie, 1995), and that North et al. have suggested that the effects of exercise on depression *appear* to be even more pronounced in the elderly, it is beneficial to devote a meta-analysis to examining the impact of exercise on mood in this previously overlooked population. It is logical, particularly when taking into account the physical and psychological decrements that often accompany aging, to assume that exercise might be even more important for mood improvement in the elderly than it is in younger populations. Relying on the current reviews, however, does not allow for assessing the accuracy of this statement. This study will improve and extend the information provided by existing reviews. The primary purpose of the study was to use meta-analytic techniques to test several hypotheses.

Hypothesis 1

Exercise (cardiovascular, resistance training, or a combination of the two) improves mood (both positive and negative) in the elderly relative to a control condition (Crase & Rosato, 1979; Johnson-Pawlson & Koshes, 1985; Shephard, 1984, 1990).

A number of hypotheses based on study characteristics that could potentially moderate the effects of exercise on mood are also examined.

Hypothesis 2

Studies with longer training protocols produce the greatest improvements in mood. North et al. (1990) found the greatest effect on depression in studies employing a protocol longer than 15 weeks. In addition, although the elderly respond to training in a fashion similar to that of a younger population, the magnitude of the response is often lower, and more time is required to achieve greater fitness improvements (Shephard, 1984, 1990).

Hypothesis 3

Studies using participants with the poorest initial health status produce the largest effect sizes. It is assumed that these individuals have the most to gain from the training and, as such, have the most room for improvement (law of initial values). Additionally, Hatfield, Goldfaib, Sforzo, and Flynn (1987) suggested that absence of improvements in mood might be the result of including elderly participants with initially high fitness/health levels or positive mood scores.

Hypothesis 4

Studies reporting significant fitness gains are associated with the largest effect sizes. This is based on the cardiovascular-fitness hypothesis, which contends that physiological improvements provide the underlying mechanism for psychological changes with exercise. Therefore, a greater physiological improvement is expected to coincide with a greater psychological improvement.

Method

SELECTION AND INCLUSION OF STUDIES

Studies were included in the analysis if they investigated the effects of physical activity or exercise on some construct of mood in older adults. Based on the information provided in each study, the activity or exercise was classified as either cardiovascular exercise, resistance training, or a combination of these. This classification process, particularly for studies examining "physical activity," was based on activities (and activity groupings) described by the American College of Sports Medicine (1995) in their exercise prescription guidelines. Although classifying activities such as gardening and housework was not an issue for the experimental studies (none examined these types of activity), a fourth classification level termed "unspecified physical activity" was added for the correlational studies, some of which examined a broader or less defined classification of physical activity. For the purposes of this analysis, at least one of the following three conditions must also have been met to satisfy the definition of *older adults:* (a) The mean age of the study sample was >65 years; (b) there must have been at least one exercising group with a mean age >65 years; or (c) if mean ages were not provided, the age range of exercise participants must have had a lower bound of at least 60 years. These parameters were established based on the societal definition of *elderly* (>65 years of age) and from age ranges or mean ages included in studies that used samples from senior centers or nursing homes.

All English-language studies meeting these criteria and available before March 1998 that could be located were included. Most of the studies were identified through computer searches of PsycLit, ERIC, SPORTDiscus, *Dissertation Abstracts,* HealthStar, and MedLine. Key terms used in the searches focused on exercise (e.g., *strength training, aerobic, physical activity),* participant classification (e.g., *elderly, older adults),* and mood adjectives (e.g., *mood, depression, happiness).* A complete listing of key terms is available from the primary author. Cross-checking of references in the related literature and hand searches of *Psychological Abstracts* and *Social Science Citation Index,* as well as of relevant journals in the areas of gerontology, psychology, and exercise science, were also used to ensure an exhaustive literature search.

The literature search initially identified over 100 potentially useful studies. On review, 36 of these studies met the necessary criteria for inclusion. Of these, four were excluded from the analysis because of insufficient data to calculate *ES*s. The remaining 32 studies were included in the analysis. Three databases were constructed using these 32 studies, and they were analyzed independently. This was done in order to include correlational studies, studies that did not use a control group for comparison, and studies that used groups that were not equivalent at pretest on the dependent variable of interest. This was also done in order to include all possible comparisons while attempting to minimize violations of the assumption of independence. Although this procedure might not have completely ruled out this violation, it was considered to be superior to the other alternatives—picking one representative *ES* for each study or combining all *ESs* for a study into one average *ES.* In either of the latter cases, potentially useful information could have been lost. Instead, a total of 168 *ES*s for the 32 studies were calculated. These were then divided into *ESs* from experimental-versus-control-group comparisons ($n = 61$), gains *ESs* (pre-post comparisons, $n = 83$), and correlational *ESs* ($n = 24$).

CALCULATION OF *ESs*

In this meta-analysis, Hedges's g was the *ES* measure of choice. Hedges's (1981) formula for computing this *ES* is

$$ES = \frac{M_E - M_C}{SD_{pooled}}$$

where $SD_{pooled} =$

$$\sqrt{\frac{(N_E - 1)SD_E^2 + (N_C - 1)SD_C^2}{N_E + N_C - 2}}$$

In the case of gains *ESs,* $M_E - M_C$ becomes $M_{post} - M_{pre}$. If the necessary means and standard deviations were not available, *ES* was calculated using F, t, r, or p values if available, as outlined by Rosenthal (1994). *ESs* were corrected for positive bias resulting from small sample sizes (Hedges & Olkin, 1985) and were weighted by the inverse of the variance (Hedges & Olkin).

A negative *ES* for studies assessing negative affect would indicate a relative improvement (i.e., lower scores would be better). In order to evaluate the effect of exercise on global mood, improvements in mood were reflected by positive *ESs*. To keep *ES* direction consistent across negative and positive affect, negative-affect *ESs* were multiplied by - 1 . As a result, any improvement in mood was reflected by positive *ES* values. Average *ESs* were calculated as outlined by Hedges and Olkin (1985).

CODING OF STUDIES

The included studies were coded for a number of characteristics based on a priori decisions regarding potential moderator variables for the exercise-mood relationship in the elderly. These characteristics were classified as design and descriptive characteristics, participant characteristics, exercise characteristics, and mood-assessment characteristics. Separate forms were used for each of the three databases (experimental-vs.-control *ES*, gains *ES*, or correlational *ES*). Moderator variables were identified through the previous related meta-analyses (Landers & Petruzzello, 1994; North et al., 1990) and suggestions made by authors in the gerontology literature.

Design and Descriptive Characteristics. Glass, McGaw, and Smith (1981) have argued that studies should not be excluded from review based on methodological rigor. Instead, they argue for examining study design issues in an a posteriori fashion. Studies were coded for information regarding publication status (published vs. unpublished) and comparison-group activity (for experimental-vs.-control *ES* only). Studies were also coded for number of threats to internal validity based on the description of threats by Campbell & Stanley (1963).

Participant Characteristics. Studies were coded for health status and fitness level of the participants before treatment. This information was based on the assessment of the author(s) of each study and/or on demographic and fitness-assessment data. These data were then compared with standards established by the American College of Sports Medicine (1995). In addition, experimental-versus-control-*ES* studies were coded for equivalency of treatment, and control groups, on the dependent variable of interest (mood) at pretest. This latter characteristic was determined through *t* tests of the pretest means if equivalency had not been evaluated by the author of each study.

Exercise Characteristics. Because exercise was the independent variable of interest, a number of potential moderating characteristics were identified from the available literature and previous meta-analyses. Studies were coded for exercise type (or treatment type in general for gains-ES analysis), exercise paradigm (acute vs. chronic), frequency of exercise, time per session, weeks of participation, and intensity of exercise. In order of preference, intensity categories were determined from (a) American College of Sports Medicine (1995) definitions, (b) National Strength and Conditioning Association (Baechle, 1994) definitions, or (c) classification by individual study authors. In addition, significance of cardiovascular-fitness improvement was coded based on information provided in individual studies regarding significantly increased VO_{2max} (or predicted VO_{2max}). In the rare cases that this information was not provided, categorization was based on significant decreases in resting heart rate or significant improvements in resting blood pressure.

Mood-Assessment Characteristics. Each study was coded for assessment of positive and/or negative affect. Improvement in positive affect was defined as an increase in score for a particular scale on which a higher score would be considered "better." Likewise, improvement in negative affect was defined as a decrease in score for a particular scale on which a lower score would be considered better. These dimensions of affect were identified as described by Watson and Tellegen (1985) in their two-factor structure of affect.

CODER RELIABILITY

The primary author coded all studies. Orwin (1994) has suggested that, when this is the case, potential coder drift should be assessed. This process involved selecting 10 of the coded studies at random and recoding them. A per-case agreement rate (number of variables coded the same divided by the total number of variables coded) was calculated for each study. A mean agreement rate of .90 was required to be considered acceptable.

Analyses

Separate analyses were conducted for each of the three categories of *ES*. After calculating the *ESs* for each study, overall *ESs* were calculated for experimental-versus-control-*ES*, gains-*ES*, and correlational-*ES* data. Average *ESs* were also calculated for each level of the moderator variables. Tests for homogeneity were conducted. This procedure is similar to an ANOVA in that the total variance (Q_T) can be partitioned into between (Q_B) and within (Q_W) variance (Hedges & Olkin, 1985). These analyses allow the researcher to determine whether or not all the *ESs* are derived from a homogeneous sample. If the sample is heterogeneous, one can then use the test of homogeneity to determine which moderators are potentially accounting for differences in *ES*.

Q_T is tested against a critical value of a X^2 distribution (*df*= number of *ES* - 1) to determine whether all *ESs* are homogeneous. If Q_T is not significant, the *ESs* are assumed to be homogeneous, and, except for testing a priori hypotheses, analysis stops. If Q_T is significant, however, this indicates that the *ESs* are heterogeneous. If this is the case, moderator-variable effects are examined by comparing the appropriate Q_B to a corresponding critical value of a X^2 distribution (*df* = number of levels of the moderator variable - 1). In the event that Q_B is significant, the particular moderator variable contributes to differences among *ESs*. In this case, confidence intervals are computed to test whether or not average *ESs* at each level are significantly different from zero. In addition, follow-up tests are conducted to determine differences between the levels of each significant moderator variable. These contrast procedures for fixed-effects models are outlined by Hedges and Olkin (1985). Within each moderator category, only moderator levels with at least five effect sizes were included in the analyses in order to improve interpretability and stability of results. If Q_H is significant, Q_W can be tested (using *df* = number of *ESs* - number of levels of the corresponding moderator) to determine the homogeneity within the levels of the moderating variable. A significant Q_W simply implies that there are different groups of *ESs* within the levels of the moderator variable of interest. In this case, interactions among variables can be tested.

Because of the lack of information needed to calculate *ES* variances within the correlational studies, one-way ANOVAs were used to test moderator variables if the *ESs* demonstrated a normal distribution (Wolf, 1986). Significant omnibus *F* values were further examined using Scheffé post hoc tests, as has been done in previous meta-analyses (Etnier et al., 1997; Petruzzello, Landers, Hatfield, Kubitz, & Salazar, 1991). Confidence intervals were used to test whether *ESs* were different from zero. As with the other two data sets, only moderator levels with at least five effect sizes were included in the analysis.

Results

The assessment of coder drift using per-case agreement rate (Orwin, 1994) indicated that reliability was acceptable. The mean agreement rate for the 10 randomly selected studies was .98. Agreement rates ranged from .94 to 1.00. Results for each grouping of *ESs* are presented separately.

EXPERIMENTAL-VERSUS-CONTROL-GROUP *ES*

The overall mean *ES* for mood, based on a total of 61 *ESs,* was 0.24 (SD = 0.50), which was significantly greater than zero. The test of homogeneity was also significant, $Q_T(60) = 114.10, p < .001$, warranting further examination of potential moderator variables. Before continuing, however, the effect of nonequivalence on the dependent variable (mood) at pretest was assessed. The Q_B value was significant, $Q_B(2) = 29.38, p < .001$. Studies using a comparison group that had initially better mood at pretest were associated with an average *ES* of -0.34 ($SD = 0.25, p < .05, n = 10$). Because one of the basic assumptions of comparing groups in experimental research at posttest is that they are equivalent on the dependent variable of interest at pretest, these *ESs* (n = 10) were removed from further analysis. It was determined that a negative effect of this magnitude could significantly confound moderator-variable conclusions and was not representative of the overall effect. This removal, however, did not affect inclusion in gains-ES analysis, as nonequivalence was effectively controlled for because of the pre/post nature of the comparisons. The overall mean *ES* for mood was recalculated based on the remaining 51 *ES*s and was found to be 0.34 ($SD = 0.45, p < .05$). This indicates that global mood improved 0.34 of a standard deviation with exercise, thus supporting Hypothesis 1. Q_T was recalculated and was still found to be significant, $Q_T(50) = 80.76, p < .005$. A total of 7 out of 10 moderator variables had a Q_B value significant at the $p < .05$ level. All moderator variables, their Q_B values, significance levels, and corresponding *ESs* are summarized in Table 1. Significant moderator variables are examined next in greater detail.

Design and Descriptive Characteristics. Of the design and descriptive characteristics coded, only comparison-group activity had a significant Q_B value.

Use of a no-treatment comparison group, motivational comparison group, or a flexibility/yoga comparison group produced average *ES*s significantly different from zero. Use of a motivational control group was associated with the largest

Table 1 Homogeneity Tests (Q_B) and Post Hoc Analyses for Moderator Variables: Experimental-Versus-Control *ES*

Moderator variable		*df*	Significance level	*ES*	*SD*	*n*	*p*
Design and Descriptive Characteristics							
Publication status	3.57	1	n.s.				
published				0.25	0.30	29	*
unpublished				0.45	0.56	22	*
Comparison-group activity	19.68	3	$p<.001$				
no treatment[a]				046	0.35	23	*
motivational[b]				0.72	0.43	6	*
flexibility/yoga[c]				0.09	0.26	12	*
exercise[c]				0.10	0.60	10	
Exercise Characteristics							
Type of exercise	3.89	2	n.s.				
cardiovascular				0.26	0.46	30	*
resistance training				0.38	0.43	10	*
mixed				0.49	0.43	11	*
Frequency	9.17	1	$p < .005$				
<3 day/week[a]				0.69	0.45	8	*
>3 day/week[b]				0.28	0.42	43	*
Time per session	12.80	2	$p < .005$				
variable (self-selected)[a]				0.86	0.50	7	*
35-45 min[b]				0.05	0.49	9	
>45 min[c]				0.36	0.40	33	*
Weeks of participation	7.40	2	$p < .025$				
1-6 weeks[a]				0.48	0.59	14	*
7-12 weeks[a]				0.45	0.39	10	*
>12 weeks[b]				0.19	0.27	23	*
Intensity of exercise	7.38	2	$p<.05$				
high[a]				0.29	0.46	9	*
medium[a]				0.26	0.40	30	*
low[b]				0.58	0.48	12	*
Exercise-group fitness increase	6.94	2	$p<.05$				
not reported[a]				0.56	0.61	9	*
yes[b]				0.26	0.41	35	*
no			0.55	0.30	7	*	

(continued)

Table 1 ***(continued)***

Moderator variable	Q_B	*df*	Significance level	*ES*	*SD*	*n*	*p*	no[a]
Exercise Characteristics *(continued)*								
Comparison-group fitness increase	10.84	*2*	$p<0.1$					
not reported[a]				0.53	0.53	11		*
yes[b]				-0.02	0.53	7		
no[c]				0.37	0.34	33		*
Mood-Assessment Characteristics								
Mood assessed	0.002	1	n.s.					
positive affect				0.33	0.71	6		*
negative affect				0.35	0.41	45		

Note: Variables that do not share at least one common superscript differ significantly at $p < .05$. n.s. = nonsignificant.
*Differ from zero at $p < .05$

effect, but use of a no-treatment group was still associated with a larger effect than were comparison groups doing flexibility/yoga training or exercise differing in intensity and/or type from the experimental exercise group. The latter two were not different from each other.

Exercise Characteristics. The Q_B value was significant for 6 of the 7 moderator variables describing exercise characteristics: frequency of exercise, time per session, weeks of participation, intensity of exercise, exercise-group fitness increase, and comparison-group fitness increase.

The largest average *ES* for frequency of exercise was related to the studies in which participants exercised <3 days per week. This effect was significantly different from zero. It was also significantly different from the average *ES* associated with exercising >3 clays per week (which was also significantly different from zero).

Surprisingly, the largest average effect for time per session was associated with exercise bouts that were self-selected and thus variable in duration. Exercise bouts in which time was controlled and of a sufficient duration to potentially produce cardiovascular benefit (i.e., 35-45 min) were not significantly different from zero. The exception was exercise that lasted >45 min, which was significant.

All levels of weeks of participation were associated with *ESs* significantly greater than zero. The largest average *ESs* were associated with 1 - to 6- and 7- to 12-week protocols, which were not different from each other but were both significantly greater than protocols lasting longer than 12 weeks. This result does not provide support for Hypothesis 2 and might indicate one way in which elderly participants respond differently than do younger participants to exercise.

Intensity of exercise was also found to be a significant moderator variable. All levels were found to be significantly different from zero, but the average effect associated with low-intensity exercise was significantly greater than that associated with either medium or high intensities. The latter two did not differ from each other. Although a significant Q_W value, $Q_W(48) = 73.38$, $p < .025$, was observed, a detailed analysis of an Intensity x Exercise-Type interaction was not feasible because of the small number of *ESs* constituting a number of the cells of the interaction.

The presence or absence of an exercise-group fitness increase was a significant moderating variable, and all levels were significantly different from zero. Surprisingly, studies that reported no fitness increase were associated with a larger *ES* than were studies reporting a fitness increase. This would appear to contradict Hypothesis 4. However, there was also a large effect associated with studies that did not report changes in fitness altogether. This might confound the conclusions somewhat, because it is impossible to determine under which classification these nine *ESs* might actually fit.

The presence or absence of a comparison-group fitness increase was also a significant moderator. Significant effects were associated with studies in which a fitness increase was not reported or it was found that there was no fitness increase in the comparison group. A fitness increase in the comparison group produced a negative average effect but was not significant. This finding provides some indirect support for Hypothesis 4, because the smallest difference in mood between the treatment and comparison groups occurred when there was an increase in fitness in the comparison group. In studies in which there was not an increase in fitness in the comparison group, the treatment group had a relative improvement in mood.

Mood-Assessment Characteristics. Type of mood assessed (PA or NA) was not associated with a significant Q_B value. This would indicate that both PA and NA were equally improved with exercise, because both levels are significantly different from zero. This provides further support for Hypothesis 1.

GAINS *ES* (PRETEST-POSTTEST COMPARISONS)

Although the homogeneity value was relatively large, it failed to reach significance, $Q_T(82) = 98.77$, $p > .05$. Therefore, only moderator variables related to a priori hypotheses were examined. These moderators are summarized in Table 2. Average global-mood *ESs* were first determined for all exercise groups versus all control conditions. The average *ES* for global mood in exercisers was 0.38. The average *ES* for global mood in control groups was 0.06. The average *ES* for global mood was significantly greater in exercisers than in control groups, $p < .001$; Hypothesis 1 was thus supported. To further analyze these predicted differences between exercisers and controls, differences in positive and negative affect were assessed. Type of mood (PA vs. NA) was broken down by group (exercise vs. control). Exercise was associated with an average *ES* of 0.35 ($SD = 0.43$, $n = 12$, $p < .05$) for positive affect and an average *ES* of 0.39 ($SD = 0.41$, $n = 38$, $p < .05$) for negative affect. These values were not different from each other ($p < .05$), thus providing further support for Hypothesis 1. The corresponding *ESs* for PA and NA in controls were 0.16 ($SD = 0.25$, $n = 5$, $p < .05$) and 0.04 ($SD = 0.24$, $n = 28$, $p > .05$), respectively. Using gains scores, exercise was associated with an average improvement in mood (both

Table 2 Homogeneity Tests (Q_B) and Moderator Variable Summaries: Gains *ES*

A priori moderator variable	Q_B	*df*	Significance level	*ES*	*SD*	*n*	*p*
Activity grouping	16.10	1	$p < .001$				
control[b]				0.06	0.25	33	
exercise[a]				0.38	0.41	50	*
Type of activity	31.27	5	p<.001				
no activity[a]				-0.01	0.24	15	
motivational control[a]				0.12	0.28	9	
yoga/flexibility[a]				0.12	0.18	9	
cardiovascular exercise[b]				0.26	0.45	30	*
resistance training[c]				0.80	0.24	8	*
mixed (cardiovascular + resistance)[b]				0.37	0.24	12	*
Intensity	12.99	3	$p < .01$				
no HR increase[a]				0.04	0.26	24	
high[b]				0.29	0.45	12	*
medium[b]				0.38	0.45	25	*
low[b]				0.34	0.31	22	*
Weeks of participation	15.84	3	$p < .005$				
0 weeks (acute)[a]				0.06	0.36	12	
1-6 weeks[a]				0.46	0.44	21	*
7-12 weeks[c]				0.26	0.31	29	*
>12 weeks[a]				0.10	0.29	21	*
Initial health status	5.78	3	n.s.				
not reported				0.35	0.40	12	*
healthy + active				0.27	0.38	6	*
healthy + sedentary				0.19	0.33	47	*
mixed (diseased + healthy/sedentary)				0.44	0.46	14	*
Fitness increase	14.20	2	$p < .001$				
not reported[a]				0.16	0.34	25	*
yes[b]				0.48	0.45	26	*
no[a]				0.16	0.29	32	*

Note: Because of a nonsignificant Q_T statistic, comparisons between group levels were conducted only for those variables related to a priori hypotheses. Variables that do not share at least one common superscript differ significantly at $p < .05$. n.s. = nonsignificant. *Differ from zero at $p < .05$.

positive and negative affect) in the elderly equal to almost two fifths of a standard deviation. This would be considered at least a moderate effect.

Type of activity was examined in order to determine whether type of exercise was associated with different *ESs.* Type of activity was significant and was further differentiated for comparisons of individual levels. Cardiovascular exercise, resistance-training exercise, and mixed (cardiovascular + resistance training) exercise were all associated with effects significantly different from zero. Resistance training produced significantly better effects than all other types of activity. Yoga/flexibility, motivational control groups, and no-treatment controls had average *ESs* that were not different from each other or from zero. Taken as a whole, Hypothesis 1 appears to be supported, because the exercise groups produced the largest *ESs* when contrasted with the activities associated with the comparison groups.

The effects of exercise intensity on mood in the elderly were also evaluated. High, medium, and low intensities were all significantly different from zero but not from each other. Only non-heart-rate-increasing activities failed to reach significance. It appears that the significance of intensity is a result of the difference between nonexercise activities and exercise. There was also a significant effect for weeks of participation. Acute studies were not associated with effects different from zero. Although studies lasting longer than 12 weeks were not different from the acute studies, they were associated with an effect different from zero. Training protocols lasting 1-6 or 7-12 weeks were different from zero and from each other (as well as from the acute and >12-week studies), with protocols of 1-6 weeks being associated with the largest effects. Based on these results, Hypothesis 2 does not appear to be supported. Although significant improvements in mood are seen for some of the more lengthy participation periods, there are also obvious benefits derived from shorter studies. A nonsignificant Q_W value prevented further analysis of interactions.

Initial health status was examined in order to test Hypothesis 3, but this was not a significant moderator variable. All levels were associated with effects significantly different from zero. Most of the *ESs* came from studies using healthy/sedentary or mixed populations. The mixed samples were composed of healthy/sedentary individuals and diseased individuals. Exercise was associated with significantly improved mood across all levels of initial health status.

Hypothesis 4 received considerable support based on the significance of a cardiovascular-fitness variable. Although all levels were significantly different from zero, studies in which a cardiovascular-fitness increase was reported were associated with a significantly larger average *ES* than were studies with no fitness increase or studies not reporting fitness increases. This would suggest that mood improvement in the elderly might be moderated by physiological improvement.

CORRELATIONAL *ES*

The overall mean *ES* for correlational studies was 0.46 (SD = 0.27, n = 24, p < .05), indicating that mood is better in elderly individuals who participate in physical activity/exercise than in those who do not. This result is consistent with the magnitude of the effects seen for experimental-versus-control *ESs* and gains *ESs.* The large effect was seen for both positive (ES = 0.42, SD = 0.38, n=6, p < .05) and negative (ES = 0.47, SD = 0.24, n = 18, p < .05) affect across all forms of physical activity. Further analysis of types of activity was not feasible because of the small number of *ESs* contributing to a number of the levels of this moderator variable. A plot of the means revealed that these ESs were distributed normally, allowing further analysis of moderator variables by way of the omnibus *F* test and contrasts. The only moderator variable that had sufficient numbers of *ESs* in all levels to warrant testing, however, was publication status, which was not a significant moderator, $F(1,22) = .239, p > .05$. Both published ($ES = 0.48$, $SD = 0.19$, $n = 13$) and unpublished ($ES = 0.43$, $SD = 0.35$, $n = 11$) studies were significantly different from zero but not different from each other. Although the small number of contributing correlational studies does not lend itself to in-depth analysis, the overall results appear to provide support for the conclusions reached with the experimental-versus-control *ES*s and gains *ES*s.

Discussion

The results of this meta-analysis indicate that, overall, exercise is associated with improved mood in the elderly, thus supporting the main hypothesis. In studies comparing an exercise group with some form of a control group, exercise is related to enhanced mood. This improvement is almost two fifths of a standard deviation, ES=0.34, and appears to be the result of equivalent improvements in both negative and positive affect, $ES = 0.35$ and 0.33, respectively. In studies comparing pre- to posttest changes in mood, exercise is also associated with improved mood in the elderly. Again, this improvement is almost two fifths of a standard deviation, $ES = 0.38$, and the effect appears to be relatively equivalent for both positive and negative affect, $ES = 0.35$ and 0.39, respectively. Correlational studies also support these results. Physically active elderly individuals appear to have an enhanced global mood in comparison with physically inactive elderly individuals. This difference is almost one half of a standard deviation, $ES = 0.48$. Taken as a whole, the results are remarkably consistent across *ES* groupings and provide considerable support for the beneficial effects of exercise on mood in the elderly.

These results are consistent with the conclusions of a narrative and two meta-analytic reviews examining the effects of exercise as an alternative treatment for anxiety and depression among younger and older adults (Landers & Petruzzello, 1994; Moore & Blumenthal, 1998; North et al., 1990). The magnitude of the overall effects found in the present study is in the range of findings in other meta-analyses that have examined the effects of exercise on depression (North et al.) and anxiety (Landers & Petruzzello) in younger adults. Although Moore and Blumenthal's narrative review with older adults focused on a specific construct included under mood (i.e., depression) and on primarily aerobic exercise, the overall conclusions support the role of exercise in reducing negative affect. As with any literature review, however, the conclusions reached by Moore and Blumenthal and by this meta-analysis are somewhat limited by the methodological problems inherent to the included studies.

In particular, this meta-analysis has identified a number of concerns associated with this area of research. The first concern is the number of studies that included groups that were not equivalent on mood at pretest. Comparisons with control groups that were initially better at pretest produced deceptively large negative *ESs* that did not appear representative of the effect in general. By using gains scores as a measure of magnitude rather than experimental-control comparisons, nonequivalence is effectively removed. In the experimental-versus-control data set, the average *ES* obtained once comparison groups that were better at pretest were removed from further analysis (*ES* = 0.34) was almost identical to that obtained for exercise groups using gains scores (*ES*=0.38). This effect was actually reversed (*ES* = -0.34) in studies using comparison groups that had better mood scores at pretest. The effect of nonequivalence of mood scores at pretest alone might help explain why there are so many inconsistencies in narrative reviews and why the use of meta-analytic techniques can help clarify and identify these effects.

Another area of concern is the lack of studies examining the effects of exercise on positive affect in the elderly. Although the effect of exercise on PA was equivalent to that seen for NA, the number of *ESs* on which these conclusions are based were quite discrepant. Only six *ESs* were derived from studies examining PA for experimental-versus-control-*ES* analysis, compared with the 45 *ES*s for NA. Gains-*ES* analysis for PA was based on only 17 *ES*s, compared with the 66 for NA. The research focus appears to be on reducing bad mood rather than increasing good mood. Although it might seem to be a semantic issue, exercise might be much more appealing to the elderly if they were told it could make them feel "good" rather than simply "less poorly."

In addition to using moderator variables to identify sources of concern in the literature, examining certain moderator variables can also provide some insight into potential mechanisms driving the exercise-mood relationship. Exercise type is one such variable. In the two previous related meta-analyses, resistance training was sometimes associated with improvements in mood (North et al., 1990), and at other times it was associated with no improvements in mood (Landers & Petruzzello, 1994). In the present meta-analysis with older adults, the experimental-versus-control and gains-score analyses revealed larger *ESs* for resistance training than for cardiovascular exercise. The average gains *ES* for resistance training was particularly large (0.80) and was considered more representative than the experimental-versus-control *ES*. The latter *ES* was influenced by the type of control group employed, which often consisted of a treatment that would also improve, thereby minimizing the difference between groups. With the gains *ES* the comparisons were pre-post comparisons within the same group of participants and thus better reflected the effect of the treatment. The average effects associated with mixed (cardiovascular + resistance training) exercise also support the influence of resistance training over that of cardiovascular training alone. These results are not surprising when one considers how physically and functionally beneficial strength training is for an elderly population.

A decline in mood might well be expected to accompany the age-related loss of functional abilities caused by deterioration of muscle mass and strength. Strength training might provide the necessary stimulus to improve daily functioning. As seen in previous studies (Cress et a1, 1991; Fiatarone et al., 1990; Frontera et al., 1988), the elderly obviously respond well physically to resistance training. Psychological improvements might coincide with these physical improvements. The other possibility is that weight training increases self-efficacy and self-confidence through a series of graded mastery experiences. This graded mastery, in turn, might allow for more effective coping, which could lead to improved mood.

Social-cognitive theory (Bandura, 1986) contends that perceptions of enhanced capabilities lead to increases in positive affect, and mastery has been identified as one possible mechanism that could explain the exercise-mental health relationship. There is considerable evidence to suggest that self-efficacy is related to affective responses associated with exercise (McAuley, 1991; McAuley, Bane, & Mihalko, 1995; McAuley & Coumeya, 1992). Furthermore, the use of physical activity as a mastery experience that leads to increased self-efficacy has been demonstrated in older adults (McAuley, Courneya, & Lettunich, 1991; McAuley, Lox, & Duncan, 1993). Ewart, Stewart, Gillilan, and Kelemen (1986) examined the usefulness of adding weight training to a walking/jogging exercise program for elderly coronary artery disease patients. Results indicated that arm- and leg-strength efficacy was enhanced in the weight-training group, a finding that might be particularly important in light of the functional relevance of these abilities for the elderly. It is important to acknowledge the potential benefits of strength training (in addition to cardiovascular training) for the elderly and to increase the pool of studies employing this form of exercise. It is obviously a viable form of exercise for this population, but this area is severely lacking in well-developed psychological studies including it in their protocols.

In addition to the psychologically oriented social-cognitive theory, a physiologically oriented hypothesis has also been suggested as an explanation for the exercise-mood relationship. This hypothesis, known as the monoamine hypothesis (Morgan & 0'Connor, 1988), posits that neurotransmitters in the brain (which have been linked to depression, anxiety, and other mood constructs) are changed by both acute and chronic exercise. Most of the research examining this hypothesis, however, has focused on acute bouts of aerobic exercise and younger participants. Considering the lack of effect for a single acute bout of exercise (and the larger effects seen for resistance training) in this study, the monoamine hypothesis might not be the most plausible explanation for the exercise-mood relationship seen in the elderly. Further research into this potential mechanism is needed.

It also does not appear that the distraction hypothesis is supported. The distraction hypothesis posits that exercise acts as a "time-out" from daily stressful events. A caveat to this is that exercise should not produce greater effects than do control conditions that conceivably also produce such a time-out. As found in this study, however, improvements in mood for motivational control groups and yoga/flexibility were associated with mean *ESs* that were significantly lower (and not different from zero) than those for exercise (cardiovascular, resistance training, or mixed).

In addition to providing a means of assessing proposed mechanisms, moderator variables can also be used to examine contentions made by other authors. Brown's (1992) contention that the lack of significant findings for mood effects with exercise in the elderly is a result of insufficient training intensity was not supported by the current findings. In fact, the greatest improvements in mood were associated with the lowest intensity of exercise when analyzing the results for the experimental-versus-control *ESs.* Even when looking at pre-post comparisons (gains *ES*), all levels of intensity were at least equivalent. It might be that some of these samples of elderly individuals were in such an unfit condition that even low-intensity exercise produced perceived fitness gains. The effect of intensity on mood might also be influenced by the *type* of exercise. The influence of exercise intensity on mood in the elderly obviously deserves further exploration, especially with studies that control for potentially confounding variables (e.g., duration, initial fitness levels, exercise type).

The findings for the effects of study duration (i.e., number of weeks) were not consistent with those found by North et al. (1990). In that meta-analysis, which did not include elderly participants, reductions in depression were larger for studies using training protocols longer than 15 weeks. The present analysis found that improved mood was not necessarily related to increased number of weeks of participation. In general, the effects appeared to be rather equally distributed across levels of weeks of participation for chronic exercise. This would appear to provide little support for Hypothesis 2. Nonetheless, future research should examine whether these findings, as well as those for intensity, interact with initial fitness levels (McAuley, Mihalko, & Bane, 1996). One potential confound that is often encountered when trying to determine the effects of chronic exercise (particularly on mood states) is the impact of the most recent bout of acute activity. Although it is possible that improvements in mood were the result of an acute bout of exercise before posttest rather than the result of changes that took place with chronic activity, this possibility is made less plausible in light of the fact that the effect size for acute exercise was small (ES=0.06) and nonsignificant. Although the potential influence of an acute bout cannot be ignored, the results do not point to this as the most likely explanation for the changes in affect.

Dunn and Blair (1997) suggest a number of criteria for evaluating scientific literature for public policy decisions. These criteria include consistency, whether the study is sequenced appropriately, whether the results are plausible and coherent, the strength of relation in terms of relative risk, and whether there is a biological gradient. In terms of this meta-analysis, the findings that are relevant to these criteria are as follows: (a) 82% of the effect sizes were in the predicted direction, demonstrating that exercise is related to improvements in mood; (b) 78% of the effect sizes from the experimental studies were in the positive direction, supporting the predicted sequencing that exercise preceded the improvements in mood; (c) findings suggest that plausible mechanisms might include graded mastery experiences and/or improvements in self-efficacy, as well as fitness improvements being implicated as having at least some role; and (d) considering the magnitude of the effects found, risk of exercise appears relatively small—only one study reported any exercise dropouts because of injury. Taken as a whole, this meta-analysis demonstrates at least the consistent findings, the appropriate cause-and-effect sequencing, the plausible and coherent results, and the minimal risk needed to justify making conclusions concerning public policy.

Evidence for a biological gradient, though, is less conclusive because of the nature of the findings for the role of fitness improvements. That is, there was not absolute agreement across the *ES* groupings concerning the importance of a fitness improvement for mood improvements. However, this may beg an important question: Are we examining the most important aspects of fitness improvements in this particular population? The most accepted means of determining a fitness improvement has historically been to assess VO_{2max} changes. This practice unfortunately ignores a relatively important (but often overlooked) component of fitness that might be of greater functional importance to the elderly—strength. Future studies should take this into consideration when determining which measures might be the most useful and meaningful indicators of a fitness improvement in an aged population. Furthermore, future research must examine these effects while making a concerted effort to better assess the impact of exercise dose-response issues, such as exercise intensity and duration, on mood improvements in the elderly.

Summary

Based on these findings, it is apparent that exercise is associated with significant pre- to posttreatment improvements in mood in the elderly, especially when compared with a no-treatment control, motivational control, or yoga/flexibility condition. Based on the significant contribution of variables such as fitness improvements, low initial fitness levels, and frequency of exercise, it would appear that these mood improvements are the result (at least somewhat) of physiological improvements resulting from exercise. The lack of significance (at least in the predicted "physiologically better" direction) of variables such as intensity of exercise and weeks of training, however, indicates that these effects might be caused by much more than this. It might very well be that it is the combination of the graded mastery experience provided by exercise and the objective physiological improvements that causes mood enhancement in the elderly.

"Mood-improving" effects are seen for all types of exercise—particularly resistance training—if examining pre- to posttest changes in mood. The most consistent improvements in mood also appear to be associated with exercise done fewer than 3 days per week, exercise done for more than 45 min or based on participant "needs," and low- to medium-intensity exercise. Future research should focus on further examining the effects of exercise on PA and on the effects of strength training for the elderly. There is much to be learned regarding optimal intensity, frequency, and duration of resistance-training programs in this population, particularly in diseased segments of the population. Furthermore, a concerted effort should be made to examine the effects of a combined cardiovascular and strength-training protocol. This is potentially the most physiologically beneficial exercise protocol for this age group, yet studies examining it are severely lacking. As a final note, research in this area must make more of an attempt to use groups that are equivalent at baseline on the mood measure of interest. Small, but significant, improvements in mood with exercise can be washed out if this is not controlled for in the course of study design.

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