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The Efficacy of Exercise as a Long-term Antidepressant in Elderly Subjects: A Randomized, Controlled Trial

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Background. Pharmacological treatment of depression in geriatric patients is often difficult. Although unsupervised exercise has been shown to benefit younger depressed patients, there is no evidence that unsupervised exercise can be used as a maintenance treatment for depression in elderly patients. Our aim was to test the feasibility and efficacy of unsupervised exercise as a long-term treatment for clinical depression in elderly patients.

Methods. We studied 32 subjects (71.3 ± 1.2 years of age, mean ± *SE*) in a 20-week, randomized, controlled trial, with follow-up at 26 months. Subjects were community-dwelling patients with major or minor depression or dysthymia. Exercisers engaged in 10 weeks of supervised weight-lifting exercise followed by 10 weeks of unsupervised exercise. Controls attended lectures for 10 weeks. No contact was made with either group after 20 weeks until final follow-up. Blinded assessment was made with the Beck Depression Inventory (BDI), the Philadelphia Geriatric Morale Scale, and Ewart's Self Efficacy Scale at 20 weeks and with the BDI and physical activity questionnaire at 26 months.

Results. Patients randomized to the exercise condition completed 18 ± 2 sessions of unsupervised exercise during Weeks 10 to 20. The BDI was significantly reduced at both 20 weeks and 26 months of follow-up in exercisers compared with controls ($p < .05$–$.001$). At the 26-month follow-up, 33% of the exercisers were still regularly weight lifting, versus 0% of controls ($p < .05$).

Conclusions. Unsupervised weight-lifting exercise maintains its antidepressant effectiveness at 20 weeks in depressed elderly patients. Long-term changes in exercise behavior are possible in some patients even without supervision.

BOTH the World Health Organization and the National Institutes of Health Consensus Development Conference on Late Life Depression have recommended that more clinical trials be conducted in patients over the age of 70 to alleviate the personal and societal burden of depressive illness (1). Although standard treatments have been shown to be efficacious in elderly patients (2) such regimens are often unacceptable to patients or are fraught with side effects in clinical practice (3).

The efficacy of exercise as an alternative treatment in clinically depressed young or middle-aged patients has been established in at least eight randomized controlled trials of varying duration (4). In this clinical population, the efficacy of group or individual exercise is similar to psychotherapy with no direct comparison with pharmacotherapy (5). Both weight lifting and aerobic exercise (running/jogging) have been successfully utilized in these clinical trials (6,7). Although these data have been extrapolated to elderly patients as well, there are in fact only three published studies that have directly tested exercise as an intervention for clinical depression in elderly patients. McNeil and colleagues studied 30 community-dwelling individuals (mean age 73 years) who self-reported mild to moderate depressive symptoms on the Beck Depression Inventory (BDI). Subjects randomly assigned to either walking or a social contact condition for 6 weeks improved by approximately 25% to 30% compared with wait-list controls, who showed no improvement (8). This effect size is equivalent to the placebo arm of most pharmacotherapy trials for depression (9). We conducted a 10-week randomized controlled trial of supervised progressive resistance training (weight lifting) exercise in elderly patients who satisfied the Diagnostic and Statistical Manual of Mental Disorders IV (DSM-IV) criteria for clinical depression (10). We found a 60% improvement in depression in exercisers compared with a 30% improvement in controls who attended a series of health lectures. Blumenthal conducted a randomized controlled trial in 156 men and women (mean age 57 ± 7 years) with major depression comparing aerobic exercise, antidepressant medication, and a combination of medication and exercise. Results at the end of 16 weeks suggested no significant difference between the antidepressant effect of drugs versus exercise and no additive effect of the two (11). The magnitude of reduction with most pharmacotherapy trials for major depression

is approximately 60% (9). Thus, to date, two published studies have found a clinically important treatment benefit associated with exercise in depressed elderly patients.

Several important questions remain to be answered in light of the above research: (i) Is the antidepressant effect of weight lifting sustainable over the long term? (ii) Is the efficacy of exercise in depression dependent upon a supervised mode of delivery or group dynamics? and (iii) Would a short period of supervised training be associated with long-term behavioral adaptations resulting in new patterns of habitual physical activity?

Such questions are extremely important to answer because depression is a chronic disorder with high rates of relapse among patients older than 70 years of age (12). In addition, there is a need to develop and test strategies in depressed elderly patients, in particular due to the paucity of data on treatment efficacy in this age group (9). In the elderly population there is a potential risk/benefit advantage to the use of exercise rather than pharmacotherapy as a treatment for depression because of the increased prevalence of medication side effects in geriatric patients as well as the other beneficial effects of exercise that have been demonstrated in this age group (3,13).

We present here Phase II (Weeks 10 through 20) and Phase III (Months 6 through 26) of our randomized controlled trial of progressive resistance training, during which the above hypotheses were tested by changing both the setting and mode of delivery of the exercise intervention. We re-assessed patients after 20 weeks and 26 months to determine the long-term effects on both depressive symptoms and physical activity habits.

Methods

Study Design

The overall design of this randomized controlled trial is shown in Table 1. The results of Phase I have been published elsewhere (14). In Weeks 10 to 20, patients randomized to the exercise intervention continued unsupervised exercise, and both groups were monitored with a brief weekly phone call. After 20 weeks, no further instructions were given, and all subjects were re-assessed at a median of 26 months (range 22–35) after enrollment in the study. There was no significant difference in the follow-up interval between exercisers (26 ± 4 months) and controls (27 ± 4 months; $p = .70$).

Randomization was done by a computer-generated random number list. Allocations were generated by a statistician, placed in sealed envelopes, and opened after baseline assessment. The study procedures were approved by the Human Investigation Review Committee of the Jean Mayer USDA Human Nutrition Research Center on Aging (HNRC) at Tufts University in accordance with the principles of the Declaration of Helsinki as amended in Tokyo (1975) and Hong Kong (1989), and written informed consent was obtained from each subject.

Study Population

Depressed patients were recruited from the community through two volunteer databases, the HNRC and the Harvard Cooperative on Aging. Volunteers older than 60 years of age were sent a letter and a BDI to complete and return. Subjects with a score >12 on the BDI, which is the lower boundary for mild depression, were then contacted by phone. Subjects included in the study fulfilled the DSM-IV diagnostic criteria for either unipolar major or minor depression or dysthymia. Subjects were excluded if demented clinically by DSM-IV criteria; if their Folstein Mini Mental State score was <23; if they were suffering from unstable ischemic heart disease or recent myocardial infarction (<6 months), severe progressive neurological disease, symptomatic inguinal hernia, bipolar disorder, or active psychosis; if they were suicidal; if they were currently seeing a psychiatrist or had been on antidepressant drugs within the last 3 months; or if they were participating in any progressive resistance training. Subjects participating in aerobic exercise more than twice a week in the month prior to enrollment were also excluded.

Interventions

Exercise group.—Training methods during the first 10 weeks of supervised exercise have been published elsewhere (10). Briefly, we employed high-intensity progressive resistance training (PRT) of large muscle groups (both upper and lower body) 3 days a week for 10 weeks. For each machine, the resistance was set at 80% of the one-repetition maximum (1-RM), and subjects performed three sets of eight repetitions. The load was increased at each session as tolerated, and strength measures were repeated every 4 weeks to establish a new baseline. Each session lasted 45 minutes. All sessions were supervised. At the end of 10 weeks of supervised high-intensity PRT, the exercise group was offered three alternatives to continue to train during Phase II:

Table 1. Study Design

Study Phase	Exercise Group Procedures	Control Group Procedures
Phase I (Weeks 1–10)	Supervised exercise in laboratory	Health education lectures
Phase II (Weeks 11–20)	Unsupervised exercise at home, laboratory or health club setting Written exercise log Weekly phone call by investigator	Weekly phone call by investigator
Phase III (Months 6–26)†	No study requirements No contact with investigators	No study requirements No contact with investigators

†The duration of Phase III ranged from 22 to 35 months depending on the date of initial enrollment.

1. Continued training at the facility (HNRC) on the resistance-training machines (Keiser Sports Health, Fresno, CA) on which they had completed their first 10-week program. Subjects were trained in setting the machines and progressing resistance at each session by use of the Borg Scale of Perceived Exertion (15), to continue to work at approximately 80% of 1-RM. Their initial training load was estimated for them prior to beginning unsupervised exercise. The subjects had no further interaction with the research staff.
2. Home-based training with free weights. Subjects were instructed and given written materials for 10 PRT exercises for large muscle groups of upper and lower limbs. These subjects had their 1-RM on all exercises estimated prior to beginning the exercises and were instructed to progress as per the Borg Scale of Perceived Exertion at 80% of 1-RM each session.
3. Training at a community health facility that provided resistance-training equipment. The selection of machines available was discussed with the primary investigator (PI) (NAS), and a program including the large muscle groups was again chosen. Subjects were instructed on how to estimate progressive training loads of 80% of 1-RM.

For all training options, the amount of exercise prescribed was three sets of eight repetitions at 80% of the estimated 1-RM 2 to 3 days per week. All subjects were instructed to keep a written log of their strength training sessions during Phase II. One hundred percent compliance was defined as completing at least 20 sessions over the course of the unsupervised 10-week period.

Control group.—All subjects not randomly assigned to resistance training attended a series of health education lectures and videos designed as an attention control for the first 10 weeks (10). All sessions were supervised and occurred twice a week for 1 hour. During Phase II , there were no educational sessions, and subjects were given no exercise or other recommendations.

Subject Contact During Phase II

During Phase II, neither group was restricted from commencing exercise in addition to that prescribed or from seeking any treatment for depression. However, no exercise recommendations were given to the control group. All subjects were contacted weekly by telephone by the PI to monitor health status or adverse events. During this brief (5-minute) phone call, a standard set of questions was asked relating to musculoskeletal pain, total medication usage, minor illness, hospitalization, commencement of any psychiatric treatment, visits to a health professional, presence/worsening of suicidal feelings, and participation in exercise. For the exercisers only, any questions concerning their PRT exercise routine were addressed. No psychological counseling was given by phone or in person to any patients during this period.

Long-term Follow-up: Phase III

After Week 20, no further recommendations for exercise or other treatment were made to either group, and no further interactions with the research staff or facility took place. All subjects were re-assessed by mailed surveys approved by the Human Investigation Review Committee between March and September 1997, a median of 26 months (range 22–35) after beginning the study, to determine depressive symptoms using the BDI and current physical activity habits. Subjects who did not respond to the first mailed request were contacted a second time by mail and finally by telephone interview if necessary to complete the survey (n = 3). No subjects were lost to follow-up.

Outcome Measures

Method of collection.—All primary outcome measures of psychological symptoms were performed by a blinded assessor (KMC) at baseline, 6, 10, and 20 weeks. Baseline demographics, medical history and examination, the diagnostic testing psychiatric interview based on the *Diagnostic and Statistical Manual for Psychiatric Disorders IV* (*DSM-IV*) manual, and weekly monitoring for compliance and adverse events were performed by the PI (NAS). All questionnaires were administered by the interviewer except the BDI, which was self-administered at the above time points as well as at the 26-month follow-up. Physical activity habits were obtained by telephone interview during Phase II and by questionnaire or telephone interview at the 26-month follow-up in all subjects. Muscle strength was not assessed during Phases II and III.

Depression.—The primary measure of depression was the BDI (score 0–63). It was chosen because it is valid and reliable in the elderly subjects, allows comparison with the major drug and exercise treatment trials in the literature, quantifies severity of symptoms, and contains both psychological (score 0–42) and somatic (score 0–21) components, thus allowing differentiation of psychological and somatic symptom relief. Clinical symptoms and psychiatric diagnoses were assessed by structured clinician interview at 0 and 10 weeks, according to the *DSM-IV* manual.

Self-efficacy and morale.—The Philadelphia Geriatric Center Morale Scale (score 0–17) was included due to its measures of agitation (score 0–6), loneliness (score 0–6), and attitude toward aging (score 0–5), constructs not measured succinctly in the other depression scales and relevant to depressed elderly patients. Higher scores reflect better morale. An increase in self-efficacy has been proposed as one mechanism of improving mood following exercise training, and therefore Ewart's Scale of Self Efficacy (score 0–100 with higher scores indicating higher self-efficacy) was chosen for its specificity for physical self-efficacy.

Statistical Analysis

Sample size calculations were made on the basis of an 80% power to discern a 25% difference (considered clinically important) in depression outcomes between groups at $p < .05$. On the basis of previous literature for the BDI in exercise trials, we estimated that we required at least 10 subjects in each group to disprove the null hypothesis. All data were analyzed with Statview, SuperAnova (Abacus

Table 2. Baseline Subject Characteristics (n = 32)

Variable	Results	p Value
Age, y	71 (2.0)†	.34
Range	60–84	
Male, %	37	.71
Female, %	63	
Married, %	50	.76
Education, y	14.3 (0.8)†	.65
Medications per day, n	4.0 (0.6)†	.36
Chronic diseases, n	2.7 (0.3)†	.10
Mini Mental State Exam (0–30)	28 (0.3)†	.70
DSM-IV diagnosis		.40
Minor depression, n	17	
Major depression, n	13	
Dysthymia, n	2	
Duration of symptoms, mo	30 (12)†	
Previous use of antidepressant drugs, n	13	.43
Beck Depression Inventory (0–63)	20 (1)†	.84
Hamilton Rating Scale of Depression (0–52)	12 (1)†	.91

Note: *DSM-IV* = *Diagnostic and Statistical Manual of Mental Disorders IV*.
†Values are means with standard error in parentheses.

Concepts Inc., Berkeley, CA) or Systat statistical software (Systat Inc., Evanston, IL). Continuous data are described as the mean ± standard error or median and range as appropriate. Baseline differences in group characteristics were analyzed by unpaired t tests for continuous variables and chi square or Fisher's exact test for categorical data. In analyses comparing medians, a Mann Whitney U test was utilized, and analysis of categorical change was performed by chi square analysis. Outcome analysis was conducted according to the intention-to-treat principle. A repeated measures ANOVA was used to analyze the effect of time and treatment for all outcome variables. Contrasts were performed after the repeated measures ANOVA on all time points for primary depression outcomes within each treatment group. A two-sided p value $<.05$ was considered statistically significant.

Results

Subject Characteristics

Baseline characteristics have been published in detail (10) and are summarized in Table 2. The patients (12 men, 20 women) had a mean age of 71 ± 2 years, with a duration of depressive symptoms of 30 ± 10 months. Clinical diagnoses were divided between major depression (n = 13), minor depression (n = 17), and dysthymia (n = 2), and 63% of patients had been treated in the past with pharmacotherapy, hospitalization, and/or psychotherapy for their depressive illness. Suicide attempts in the past were reported by 12% of patients. There were no significant differences at baseline in any demographic, health status, or psychological variables measured.

Compliance and Adverse Events

Subject attrition.—Two exercisers, one of whom was a control subject (hospitalization for heart failure), were unavailable for the 20-week assessment due to events unrelated to exercise (a fatal asthma attack and a pulmonary embolus secondary to a fractured hip). One exercise participant during Phase I discontinued all exercise at 6 weeks due to a flare in Paget's disease but was included in assessments at 20 weeks and 26 months. One subject in the control group began a weight-training program during Weeks 11 through 20 only but was analyzed according to randomization.

Follow-up data was available at 26 months in 30 out of 32 subjects, or 94%, of the original study group (one death, one refusal among the exercise group).

Table 3. Monitoring and Adverse Events During Phase II (Weeks 11–20)

Variable	Exercise (n = 15)	Controls (n = 14)	p Value
Hospital days	0.2 ± 0.7	0.2 ± 0.2	.37
Visits to a psychiatrist or antidepressant medication or worsening suicidal feelings	0	0	—
Visits to a health professional	2.8 ± 0.6	4.0 ± 2.0	.51
Minor illness	0.6 ± 0.2	0.6 ± 0.4	.92
Musculoskeletal pain (no. of weeks reported)	3.0 ± 0.8	6.0 ± 1.1	.05
Total no. of medications per day	3.8 ± 0.7	3.0 ± 0.5	.25

Compliance with exercise: Phase II.—Ninety-four percent of patients (16/17) initially randomized to exercise began exercise in the unsupervised period, and 14 completed the 20 weeks. These 14 subjects completed an average of 18 ± 2 sessions (range 0–30), compared with the prescribed dose of 20 sessions, and 73% met the definition of full compliance during this period (20 sessions).

Subjects trained at the HNRC (n = 9), in a health club (n = 1), or with free weights at home (n = 4). Compliance was higher (25 ± 2.3 sessions completed) in the home-based group compared with those who trained in the research lab or health club (17.9 ± 2.3 sessions; p = .09).

Long-term exercise behavior: Phase III.—One third of the group initially randomized to exercise was still weight lifting regularly (twice a week or more) at the 26-month follow-up. All of these exercise sessions took place at home or in health clubs. Although one control subject had begun resistance training during Weeks 10 through 20, at 26 months no controls were participating in weight-lifting exercise ($p <$ .05, exercise vs control).

Adverse events.—There were no differences between groups in adverse events in the first 10 weeks. During Phase II, the number of weeks in which musculoskeletal symptoms were reported was significantly less in the exercisers compared with controls (p = .05), and there were no differences between groups in other adverse event categories (Table 3).

Primary Outcomes

Depression.—The exercise group showed significantly reduced depression compared with the control group at both 20 weeks and 26-month follow-up. At 20 weeks, the BDI

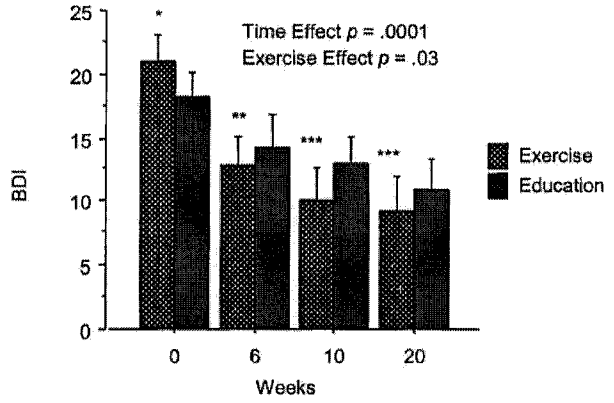

Figure 1. Change in depressive symptoms over the supervised and unsupervised phases of exercise. There was a significant effect of exercise on the reduction in depression over time. Measurements at Weeks 10 and 20 were not significantly different from each other. *Significantly different from Weeks 6, 10, and 20 ($p < .05$); **Significantly different from Weeks 0, 10, and 20 ($p < .05$); ***Significantly different from Weeks 0 and 6 ($p < .05$).

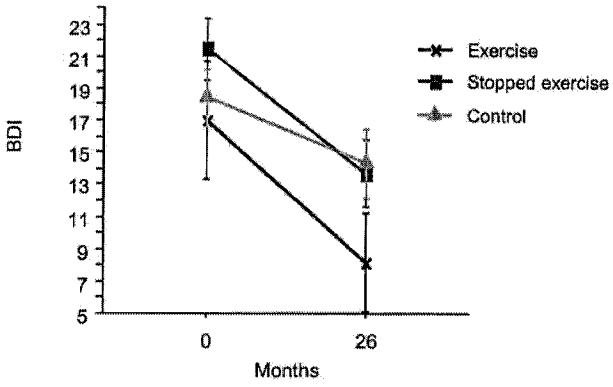

Figure 2. Comparison of relative change in depressive symptoms at 26 months in exercisers who continued to train, those who stopped training, and controls. There was no significant difference between groups at baseline. Time effect: $p < .001$; effect of group assignment: $p = .10$.

decreased from 21 ± 2.0 to 9.2 ± 2.8 in exercisers versus 18.28 ± 1.8 to 11.0 ± 2.36 in controls ($p = .036$, time × treatment interaction) (Figure 1). After 26 months, the overall changes in BDI were still significantly greater in exercisers (21 ± 2.0 to 13 ± 2.2) than in controls (18.4 ± 1.7 to 14.4 ± 2.2; $p = 0.047$ for the time × treatment interaction). Secondary analysis of actual exercise participation at 26 months showed that active exercisers demonstrated a trend toward greater long-term response than either exercisers who had stopped lifting weights or controls ($p = .1$) (Figure 2).

The relative improvements in depression scores in the exercisers were 1.5 to 2.5 times greater than those in the controls at the end of Phase II. In contrasts performed within the exercise group for the BDI, all time points were significantly different from each other ($p < .05$) except for Weeks 10 and 20 (Figure 1). Thus, the decrease in depression appeared to be gradual and greatest between 0 and 10 weeks with benefit maintained up to 20 weeks during the period of unsupervised exercise.

Both psychological and somatic subscales of the BDI significantly improved with time. Compared with the control intervention, exercise significantly improved somatic symptoms in exercisers (6.2 ± 0.6 to 3.0 ± 0.7) versus controls (6.3 ± 0.8 to 4. ± 0.7; $p = .001$) for the time × treatment interaction, with a similar trend seen in psychological symptoms ($p = .09$).

At 20 weeks, 73% (11/15) of the group randomized to exercise were classified as nondepressed versus 36% of controls ($p = .02$), using a BDI of <9 to signify no depression.

There was a trend ($r = .20$, $p = .08$) toward a direct correlation between higher baseline depressive scores and absolute reduction in depression in the exercise group at 20 weeks. This relationship was significant with the exclusion of the outlier (Figure 3). This outlying subject did no exercise after 6 weeks in Phase I of the program. This relationship was not observed among controls. During Phase I of the trial strength increased 33% (±4%) in the exercise group and −2% (±2%) in controls ($p < .001$).

Self-efficacy and morale.—Self-efficacy for jogging improved significantly in the exercise group compared with the control group at 20 weeks (Figure 4). There was no significant effect of treatment assignment on the other physical self-efficacy perceptions (walking, climbing, lifting, push-ups). Total morale was significantly improved over time. Of the morale subscales, "attitude toward own aging" was significantly improved by exercise more than the control intervention, whereas the loneliness and agitation subscales were not significantly affected by group assignment (Table 4).

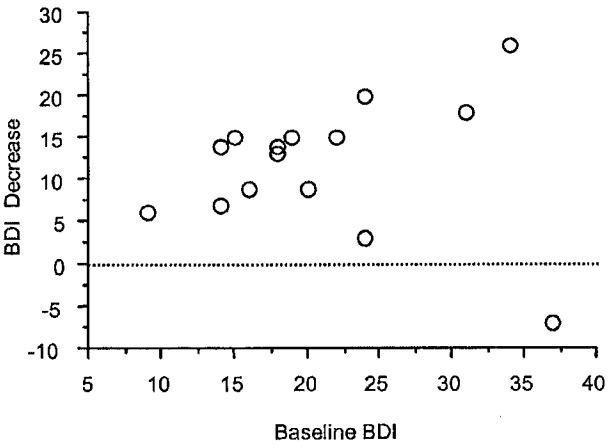

Figure 3. Decrease in the Beck Depression Inventory (BDI) score over 20 weeks related to the baseline BDI in the exercise group. With the removal of the subject who stopped training at 6 weeks (outlier), a significantly greater reduction in depressive symptoms was seen in patients with the most severe depression at baseline ($r = .64$, $p = .01$).

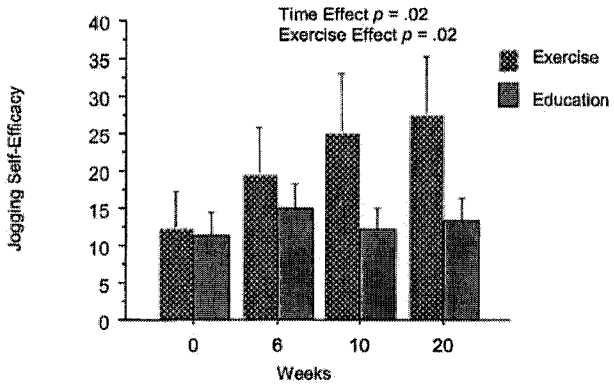

Figure 4. Changes in self-efficacy over the 20-week intervention period. Exercisers had a significant increase in self-efficacy for jogging compared with controls.

Discussion

Summary of Key Findings

The primary findings of this randomized controlled trial were that (i) the antidepressant effect of exercise is maintained over 20 weeks when laboratory-based supervised exercise is changed to unsupervised patient-directed weight lifting in gym or home settings; (ii) more than 2 years after randomization, patients randomized to the exercise treatment group were still significantly different from the controls in depressive symptom response; (iii) self-efficacy and morale in depressed patients continue to improve with exercise up to 20 weeks despite the withdrawal of supervision; and (iv) 26 months after the start of the intervention, one third of the depressed patients initially assigned to the experimental group were still actively exercising at target levels.

Efficacy of treatment.—Clinical depression had resolved in 73% of exercisers after 20 weeks of treatment, as compared with 36% of controls, an efficacy rate comparable to the best trials of antidepressants with psychological counseling in young or elderly individuals (1). Whereas there is a mood-elevating effect of even a single bout of exercise, the greatest decreases in depression have been seen in programs of 17 weeks or longer (4). This is the first controlled resistance training study of greater than 8 weeks duration in a depressed population, and the only such study in elderly persons. Exercise was associated with a significant reduction in depression at both 20 weeks and after 26 months, despite the removal of supervision, transport costs, and group setting at 10 weeks.

There are only three published randomized trials of the effect of exercise on clinically depressed subjects older than 60 years of age (8,10,11). In McNiel's study, subjects (mean age 72 years) were chosen by self-reported scores of >12 on the BDI and may or may not have fulfilled diagnostic psychiatric criteria for depression (8). Over a 6-week intervention of walking versus social contact versus wait list, the BDI was reduced approximately 33% in the walking group, not significantly different from the social contact group but significantly different from wait list. In our trial of clinically depressed elderly subjects older than 60 years of age (mean age 72 years), we demonstrated a reduction of 60% in both therapist- and self-rated scales of depression in comparison to 30% in the attention control group after 10 weeks of weight training (10). Blumenthal and colleagues studied a more severely depressed group with pure major depression who were significantly younger than our subjects, with a mean age of 57 ± 7 versus 71 ± 2. The 16-week study found that aerobic exercise at high intensity (70% to 80% of heart rate reserve) resulted in 60% of subjects being classified as nondepressed (11). On the basis of this current evidence, the two forms of exercise appear to be similar in efficacy for treating depression (10,11). A direct comparison of aerobic exercise versus weight lifting in a depressed older age group is awaited. The combination of high efficacy, high compliance, and low adverse event rates we and Blumenthal observed suggests that exercise may be a viable treatment alternative for similar groups of moderately clinically depressed elderly outpatients.

Depression is generally accepted to be a chronic, relapsing disorder, frequently not completely responsive to treatment and for which maintenance therapy is required and ef-

Table 4. Philadelphia Geriatric Center Morale Scale (PGMS)

PGMS	Timepoint (wk)	Exercise (n = 15)	Controls (n = 14)	Baseline p Value	Time p Value	Exercise × Time p Value
Total PGMS	0	6.1 ± 1.0	6.9 ± 0.1	.74	<.001	.11
	6	9.3 ± 1.1	8.4 ± 1.0			
	10	10.2 ± 1.0	8.4 ± 1.1			
	20	10.6 ± 1.1	9.6 ± 1.3			
Agitation subscale	0	2.8 ± 0.5	3.2 ± 0.6	.79	<.001	.30
	6	3.9 ± 0.5	3.6 ± 0.6			
	10	4.1 ± 0.4	3.7 ± 0.5			
	20	4.4 ± 0.5	4.0 ± 0.5			
Attitude toward aging subscale	0	0.8 ± 0.2	1.0 ± 0.4	.23	<.001	.05
	6	1.9 ± 0.4	1.3 ± 0.3			
	10	2.3 ± 0.4	1.0 ± 0.3			
	20	2.4 ± 0.4	1.6 ± 0.4			
Loneliness subscale	0	2.7 ± 0.5	2.5 ± 0.5	.50	<.001	.93
	6	3.8 ± 0.5	3.3 ± 0.5			
	10	4.0 ± 0.5	3.3 ± 0.5			
	20	4.0 ± 0.5	3.7 ± 0.6			

fective in reducing relapses (12). Therefore, feasibility, compliance, and long-term adoption of any effective treatment are issues of paramount importance. In our exercise group, 94% of subjects continued, without supervision, the same type of exercise as in Phase I. Compliance was high in whatever unsupervised setting subjects chose but was highest at home. Previous work in healthy elderly subjects has also found that home-based exercise is preferred by the majority of participants and has higher compliance than center-based exercise (16). There is no available data on compliance with other forms of unsupervised exercise in a clinically depressed elderly population. The surprisingly high rate of adoption and adherence in our study despite the advanced age, initial sedentary state, and depressive symptoms in our population may be due to the initial 10-week period of supervised training they received or to the potency of the effect of exercise on their target symptoms.

Considerations of Mechanism

Efficacy of treatment.—The mechanism for the potent antidepressant effect of weight lifting exercise we observed is not yet known, but age does not appear to attenuate the response to this mode of exercise, which has also been shown to be therapeutic in younger depressed patients (17).

Exercise is postulated to exert an antidepressant effect via a variety of mechanisms including biological, cognitive, and behavioral. Distraction or social contact is one of the proposed cognitive behavioral mechanisms. The social contact of supervised exercise is an integral part of such programs, and its effect on psychological outcomes is difficult to control and quantify. However, our results clearly demonstrate that the withdrawal of staff interaction and direct supervision as well a group setting does not result in a relapse of depressive symptoms; in fact self-efficacy and morale improve even further under such conditions.

Additional support for the specificity of exercise as a treatment for depression in elderly patients is provided by the fact that there was a greater benefit of exercise in patients with more severe depression, whereas those with milder depression benefited equally from exercise or attention-control (health lecture) activities over the initial 20-week period. This finding is again contrary to a common perception that exercise acts as a "placebo" or "diversion" and by contrast suggests its potency in the realm of therapeutic options, such as combined medication and psychological counseling (12). Although weight lifting has yet to be compared directly with pharmacological management in depression in elderly persons, the recent study by Blumenthal and colleagues (11) suggests that aerobic exercise is approximately equipotent to medication management. Future studies need to address both the relative efficacy and feasibility of aerobic versus resistive exercise as well as resistive exercise versus standard therapy in depressed elderly patients.

The observed improvements in specific morale and self-efficacy subscales may shed light on some of the mechanisms associated with the antidepressant effect of exercise in elderly subjects. Exercisers developed a more positive attitude toward their own aging, in contrast to controls, yet ratings of loneliness and agitation did not differ between the groups. Depression in old age is thought to be multi-factorial, but an important etiologic factor is the multitude of losses the older person must endure. Thus a more optimistic view of the aging process may help to minimize depressive reactions to such changes and events as they occur. Increase in self-efficacy is postulated as a way of interrupting the maladaptive cognitive processes of depressed persons. Self-efficacy has been shown to increase in resistance-trained cardiac patients as well as depressed elderly patients treated with aerobic exercise or medication (11,18). Our results of improved self-efficacy in jogging in exercisers may be explained by the fact that jogging was perceived as the most difficult of the physical tasks assessed. Lifting weights is generally perceived as a novel and difficult task, especially for elderly persons. If PRT led to an increase in their perceived ability to perform tasks seen as difficult, the effect may first be generalized to the most difficult of tasks, which was jogging in our subjects. Such an increase in self-efficacy may mean that they were better equipped psychologically to face challenges. Confidence in one's physical competence induced by exercise training may then generalize to other areas of life (19). Thus, our data lend support to the self-efficacy theory of exercise and depression as well.

Limitations

There are two important limitations to our study. First, our results are applicable to clinically depressed elderly outpatients who were volunteers for a research study, which may make them different in some ways from nonresearch patients. Second, sample sizes were not estimated to allow differentiation of response rates between depressive diagnostic categories. Larger studies will need to specifically target subgroups, such as major depressives, to fully define clinical utility in various clinical settings.

Clinical and Research Implications

Direct comparisons in randomized controlled trials are needed to evaluate the potency of PRT in relation to standard care (pharmacologic and counselling), as well as other modes of exercise in depressed elderly patients.

Identification of depressive subgroups for whom exercise is most effective would be helpful for targeting and cost-effective use of resources as well as shortening the period of disability and suffering that accompanies serious depression. More information is needed on its efficacy in maintenance (prevention of recurrent episodes), treatment-resistant depression, bipolar disorder, frailty, and cognitive impairment, among others. Behavioral methods that will optimally enhance adherence to exercise over the long term in depressed patients need to be tested. It should be remembered that in antidepressant drug trials at least one third of the subjects are unable to take the medication and that little is known about compliance rates among elderly subjects (9). The overall effectiveness of therapies needs to be considered in light of both response rate and patient acceptance of treatment.

In conclusion, progressive resistance training exercise has been demonstrated in an unsupervised setting to be safe and feasible, maintaining an antidepressant effect over the

long term in outpatient depressed elderly patients. The benefits of treatment were most pronounced in those with more severe depression and persisted despite the withdrawal of personal supervision and group training in the first phase of this trial. This study lays the foundation for future research, including direct comparisons with more established treatments for depression in both the acute and maintenance phases of this disabling disorder.

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