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A Randomized Controlled Trial of Progressive Resistance Training in Depressed Elders

Nalin A. Singh,[1,2] Karen M. Clements,[3] and Maria A. Fiatarone[1,3,4]

[1]The Division on Aging, Harvard Medical School.
[2]Brockton/West Roxbury VA Medical Center.
[3]The Hebrew Rehabilitation Center for Aged, Roslindale, Massachusetts.
[4]The Jean Mayer U.S. Department of Agriculture Human Nutrition Research Center on Aging at Tufts University.

Background. Depression in elderly people may be contributed to by the multiple losses of aging. Exercise has the potential to positively impact many of these losses simultaneously. We tested the hypothesis that progressive resistance training (PRT) would reduce depression while improving physiologic capacity, quality of life, morale, function and self-efficacy without adverse events in an older, significantly depressed population.

Methods. We conducted a 10-week randomized controlled trial of volunteers aged 60 and above with major or minor depression or dysthymia. Subjects were randomized for 10 weeks to either a supervised PRT program three times a week or an attention-control group.

Results. A total of 32 subjects aged 60–84, mean age 71.3 ± 1.2 yr, were randomized and completed the study. No significant adverse events occurred. Median compliance was 95%. PRT significantly reduced all depression measures (Beck Depression Inventory in exercisers 21.3 ± 1.8 to 9.8 ± 2.4 versus controls 18.4 ± 1.7 to 13.8 ± 2, $p = .002$; Hamilton Rating Scale of Depression in exercisers 12.3 ± 0.9 to 5.3 ± 1.3 versus controls 11.4 ± 1.0 to 8.9 ± 1.3, $p = .008$). Quality of life subscales of bodily pain ($p = .001$), vitality ($p = .002$), social functioning ($p = .008$), and role emotional ($p = .02$) were all significantly improved by exercise compared to controls. Strength increased a mean of 33% ± 4% in exercisers and decreased 2% ± 2% in controls ($p < .0001$). In a multiple stepwise regression model, intensity of training was a significant independent predictor of decrease in depression scores ($r^2 = .617$, $p = .0002$).

Conclusions. PRT is an effective antidepressant in depressed elders, while also improving strength, morale, and quality of life.

THE multiple losses of health, function, loved ones, earning capacity, and social worth place the elderly at risk of depression. Response to various treatment modalities within the spectrum of depressive symptoms observed is not well defined in older individuals.

Current standard therapy for depression is drug treatment, the efficacy of which is not well documented in older adults (1). The depressed elderly have a higher risk of suicide (2), and approximately 30% are unable to comply with even the newer antidepressants because of side effects (3). Clinicians dealing with older patients must judge benefit of a treatment holistically, including the disease treated, effects on other comorbidities, functional outcomes, and quality of life. Antidepressant drugs do little to address these comorbidities, and in fact may place elders at higher risk for falls or delirium. Exercise has the potential to improve function and quality of life and avoid many of the adverse side-effect profiles of these drugs. In the elderly, therefore, the rationale for the use of exercise as an antidepressant is based on risk benefit advantage over standard therapy.

There are over 1,000 studies looking at the relationship of exercise to mood (4). In mildly depressed patients there are 11 experimental intervention studies (5,6) exploring the antidepressant effect of exercise in subjects less than 60 years of age, but few have used diagnostic criteria to define the subjects enrolled. All suggest that exercise (both aerobic and resistance training) is significantly better than no treatment and of comparable efficacy to various forms of psychotherapy.

While there is no conclusive evidence that one form of exercise is best in reducing depression, resistance training in the two published studies (7,8) had higher compliance and lower drop-out rates and possibly a larger antidepressant effect in a meta-analysis than aerobic exercise (9). There is no reported study of progressive resistance training (PRT) exercise in elderly depressed subjects.

Therefore we undertook this study from a holistic perspective by measuring not only depression, but also quality of life, function, medical illness, physiology, adverse events, and compliance outcomes. We tested the following hypotheses:

(a) PRT would decrease depressive symptoms in depressed elders by both therapist- and self-rated scales when compared to an attention control group.

(b) PRT would concomitantly improve strength, function, morale, self-efficacy, and quality of life in depressed elders without adverse effects.

Methods

Study design. — This was a randomized, controlled 10-week clinical trial in which depressed subjects received

either a progressive resistance training program or a health education program. Randomization followed baseline assessment and was by computer-generated list in blocks of five. The study was approved by the Human Investigations Review Committee at the New England Medical Center, and written informed consent was obtained from each subject.

Study population. — Volunteers were recruited from the community through two volunteer databases, the Jean Mayer USDA Human Nutrition Research Center on Aging (HNRC) and the Harvard Cooperative on Aging. Volunteers over age 60 were sent a letter and a Beck Depression Inventory (BDI) to complete and return. Subjects were not informed of the investigators' hypotheses. Subjects with a score of >12 on the Beck Depression Inventory (10), which is the lower boundary for mild depression, were then contacted by phone.

Subjects included in the study were aged ≥60 and fulfilled DSM-IV (*Diagnostic and Statistical Manual of Mental Disorders*) diagnostic criteria (11) for either unipolar major or minor depression or dysthymia.

Subjects were excluded if demented clinically by DSM-IV criteria or if their Folstein Mini-Mental State (12) score was <23, if they were suffering with unstable diseases, bipolar disorder, active psychosis, or suicidal plans. They were also excluded if currently seeing a psychiatrist, on antidepressant drugs within the last 3 months, or participating in any progressive resistance training or in aerobic exercise more than twice a week in the previous month.

Intervention. — Subjects assigned to exercise training underwent a regimen of high-intensity progressive resistance training of the large muscle groups, 3 days per week for 10 weeks. These exercises, chosen for their importance in functional activities, included the chest press, lat (lattisimus dorsi) pulldown, leg press, knee extension, and knee flexion (Keiser Sports Health Equipment, Fresno, CA). For each machine, the resistance was set at 80% of the one repetition maximum (the maximal load that could be lifted fully one time only) (13). To maintain the intensity of the stimulus, the load was increased at each session as tolerated by the subjects. Strength testing was repeated at 4 weeks to establish a new baseline value. Subjects performed 3 sets of 8 repetitions on each machine. Each session lasted approximately 45 minutes and was followed by 5 minutes of stretching. All sessions were supervised, 90% by the principal investigator (N.A.S.), with one to eight subjects being trained simultaneously. Discussion of depression was minimized.

Control group. — Control subjects engaged in an interactive health education program of lectures and videos followed by discussion. Topics included general nutrition, vitamins, heart disease, first aid, falls, home safety, incontinence, medical ethics, eye and ear disease, etc. The group (from one to nine subjects) met two days a week for one hour. All sessions were supervised, 86% by the principal investigator, and discussion of depression was minimized.

Subjects in both groups were asked not to commence any new exercise regimen, other than what had been prescribed within the study. Transportation costs were provided for all subjects.

Outcome measures. — All outcome measures with the exception of strength and medical and psychiatric history were performed by a blinded assessor (K.M.C.) at baseline and at 10 weeks. All questionnaires were interviewer-administered except the BDI, which was self-administered.

Depression. — The primary self-rated measure of depression was the BDI (score 0–63). It was chosen because it is valid and reliable in older adults (14,15), it measures intensity of symptoms, and contains both psychological (score 0–42) and somatic (score 0–21) components. The 17-item Hamilton Rating Scale of Depression [HRSD; score 0–52; (16)], was the therapist-rated measure and was chosen to allow comparison with prior published work in exercise and clinically depressed populations (1,3,8). The Geriatric Depression Scale (GDS; 30 items, score 0–30) was also administered due to its documented specificity in the elderly (17). DSM-IV symptoms and psychiatric diagnoses were assessed by structured clinician interview, according to the DSM-IV manual (11).

Self-efficacy and morale. — The Philadelphia Geriatric Morale Scale (PGMS; 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 (18). An increase in self-efficacy has been proposed as one mechanism of improving mood following exercise training, and Ewart's Scale of Self-Efficacy [ESSE; 0–100 with higher scores indicating higher self-efficacy; (19)], was chosen for its specificity for physical functioning.

Function. — The physical function subscale of the Sickness Impact Profile [SIP; (20)], validated in an older population and sensitive to change, was used to measure function (score 0–100; higher scores reflect more impairment) as was the Katz scale of activities of daily living [(21); score 6–18] and instrumental activities of daily living (IADL) by the Lawton Brody Scale [(22); score 0–24].

Quality of life was measured by Medical Outcomes Survey Short Form (SF-36). This measures eight domains each ranging from 0–100, with higher scores reflecting better quality of life. It is a reliable and valid measure in community-dwelling elderly (23).

Physiologic measures. — The one repetition maximum (1RM) was used to determine muscle strength. This is defined as the maximum weight that could be lifted correctly for one repetition within 5 degrees of full range of motion (13). To minimize improvement related to repeat testing, the better of two measures taken at least 48 hours apart was used as the baseline value. Strength is reported as summation of all five exercises in Newtons. Intensity of exercise training was calculated by taking the training force in Newtons on each machine in the session prior to 1RM testing at 4 and 10 weeks. These forces were then divided by 1RM at 4 and 10 weeks and averaged to give a percentage of 1RM trained at

during the study. Habitual gait velocity was measured to the nearest .01 second as the mean of two trials by an ultrasonic gait speed monitor (Ultratimer, DCPB Electronics, Glasgow, Scotland). The chair rise was performed in a standard chair, and the fastest of three trials was recorded. Five chair stand time was also measured. The maximal distance walked in 6 minutes was recorded to the nearest foot by a rolling measuring wheel (Redi Measure, Redington, Windsor).

Monitoring. — Each week subjects were monitored by the principal investigator for chest pain, musculoskeletal pain, medication change, intercurrent illness, hospitalization, visits to a health professional, and worsening of suicidality.

Statistical analysis. — Sample size calculations were based on an 80% power to discern a 25% difference in depression outcomes between groups at a $p = .05$. Based on previous literature for the BDI in exercise trials, we estimated that we required 20 subjects to disprove the null hypothesis. All data were analyzed with Statview (Abacus Concepts, 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, except for quality of life measures which are presented as mean (standard deviation) to allow comparison with reported normal values. 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. A repeated measures ANOVA was used to analyze the effect of time, treatment, and time × treatment interactions for all outcome variables at baseline and 10 weeks. Relationships between variables of interest were analyzed by simple and multiple regression models as appropriate. A two-sided *p*-value less than or equal to .05 was considered to indicate statistical significance.

RESULTS

Recruitment. — We sent 2,953 letters and Beck Depression Inventories (BDI) as a result of mailing lists and response to local advertising and received 884 replies. Seven percent (216) had a BDI score >12, used as the lower boundary for telephone screening; 210 were contacted, of whom 50 were potentially eligible. The major reasons for ineligibility were depression not fulfilling a diagnostic category, or subjects' objections to the time commitment or location of the study. Of the 41 who attended screening, 32 were eligible and enrolled, which was approximately 1% of the mailed letters. Baseline characteristics are summarized in Table 1. There were no significant differences at baseline in any variables measured.

Table 1. Baseline Characteristics

Variable	Exercise (n = 17)	Control (n = 15)	p-value
Age (years)	70 (1.5)*	72 (2.0)	.34
Range	61–82	60–84	
Gender			
Male	5	7	.71
Female	12	8	
Marital Status			
Married	9	7	.76
Widowed	3	5	
Divorced	2	2	
Never married	2	1	
Income Annually			
<$10,000	4	3	.95
$10,000–30,000	7	6	
>$30,000	6	6	
Residence			
House	13	12	.63
Apartment	4	3	
Employment			
Full time	3	0	.63
Part time	4	4	
Unemployed	10	11	
Education (years)	14.6 (0.8)*	14.1 (0.7)	.65
Smoking			
Lifelong nonsmoking	13	11	.78
Past smoker, noncurrent	4	4	
Current smoker	0	0	
Ethanol (avg daily intake in gms in last month)	4.8 (1.4)*	7.4 (4.7)	.34
Medications per day (no.)	4.5 (0.6)*	3.7 (0.6)	.36
Chronic diseases (no.)	2.9 (0.3)*	2.1 (0.3)	.10
Mini-Mental State Exam score (0–30)	28.4 (0.3)*	28.6 (0.4)	.70
DSM-IV diagnosis			
Minor depression	7	10	.40
Major depression mild	7	2	
Major depression moderate	2	2	
Dysthymia	1	1	
Duration since onset of any depressive symptoms (months)	24 (10)*	36 (18)	.45
Previous Psychiatric Treatment			
Psychiatrist	8	4	.23
Antidepressant drugs	8	5	.43
Hospitalization for depression	2	1	.62

*Means and (*SD*).

Compliance and adverse events. — All randomized subjects completed the 10-week study. One subject in the control group had the final assessment at home due to reluctance to travel after recent hospitalization, limiting physical performance measures. One exerciser was referred to her psychologist due to increasing suicidality at 6 weeks. She was not placed on antidepressant drugs and completed her final assessment. She also experienced a flare of her Paget's disease at this time and did no further exercise on medical advice. Musculoskeletal symptoms required transient adjustment in training regimen in two subjects. Median compliance in the exercise group was 93%, with a range of 45–100%, and 95% in the control group, with a range of 44–100%. Major reasons for missed sessions were illness (43%), illness in a family member (8%), holidays (18%), appointments (15%), and miscellaneous (16%). Results of weekly monitoring for adverse events are shown in Table 2.

Primary Outcomes

Depression. — Exercise significantly improved both self- (BDI, GDS) and therapist-(HRSD, DSM-IV symptoms) rated depression compared to the control intervention (see Table 3). The relative improvements in depression scores in the exercisers were 2 to 3 times greater than those of the controls. We also analyzed our results using a 50% reduction in HRSD score to indicate a clinically meaningful response to treatment, as this is how response is commonly defined in the literature (1). In this analysis, a total of 59% of the exercise group had a response to treatment vs 26% of controls ($p = .067$).

As an additional way of judging the clinical significance of our results, we used a change in diagnostic category as a criterion of success. In the minor depression group 6/7 exercisers no longer met criteria vs 4/10 in the control group, $p = .06$. In the major depression group 8/9 exercisers no longer met criteria for major depression at 10 weeks vs 2/4 controls, $p = .12$.

In the subscales of the BDI, somatic symptoms improved significantly with a trend toward significance in the psychological ($p = .07$).

In diagnostic subgroup analysis of our primary outcomes (BDI and HRSD), the magnitude of improvement in major depression was twice that of controls and reached significance on the HRSD. In minor depression the effect was larger and reached significance on the BDI (see Table 4). In an analysis excluding the one exerciser who saw a psychologist and stopped exercising at the 6-week point of the trial, the magnitude of the antidepressant effect of exercise was increased for all depression measures: BDI 20.3 (1.6) to 7.8 (1.3), $p < .0001$; HRSD 12.0 (0.9) to 4.4 (0.9), $p < .002$.

Table 2. Adverse Events*

Variable	Exercise ($n = 17$)	Control ($n = 15$)	p-value
Visits to a health professional per 10 weeks	2.1 (0.4)	2.0 (0.5)	.90
Minor illness per 10 weeks	0.65 (0.2)	0.47 (0.2)	.50
Hospital days per 10 weeks	0.24 (0.2)	0.53 (0.4)	.40
Musculoskeletal pain (no. of weeks reported)	5.4 (0.7)	5.6 (0.7)	.80
Worsening of suicidal ideation (no. persons)	1	1	

*Means and *SD* unless otherwise noted.

Quality of life. — The baseline subscale scores of the subjects in this study were in general lower than in an age-matched normal population (24), as shown in Table 5.

Physical functioning, vitality, social functioning, role emotional, and mental health subscale scores were improved over time in both groups.

Vitality, bodily pain, role emotional, and social functioning were significantly improved by exercise compared to the control condition. General health showed a trend ($p = .06$) toward improvement in the exercise group. At the end

Table 3. Depression Outcomes

Variable	Exercise ($n = 17$)	Control ($n = 15$)	Baseline p-value	Time p-value	Group × Time p-value
BDI (total)					
Pre	21.3 (1.8)*	18.4 (1.7)	.84	<.0001	.002
Post	9.8 (2.4)	13.8 (2.0)			
% reduction	59 (7)	29 (6)			
BDI (psychological subscale)					
Pre	13 (1.4)	11.9 (1)	.80	<.0001	.07
Post	6.3 (2.0)	8.5 (1.6)			
BDI (somatic subscale)					
Pre	8.2 (0.6)	6.5 (0.4)	.98	<.0001	<.0001
Post	3.5 (0.7)	5.5 (0.8)			
HRSD					
Pre	12.3 (0.9)	11.4 (1.0)	.30	<.001	.008
Post	5.3 (1.3)	8.9 (1.3)			
% reduction	59 (8)	20 (9)			
GDS					
Pre	16.9 (1.6)	13.9 (1.4)	.90	<.0001	.0004
Post	8.6 (1.8)	12.0 (1.8)			
% reduction	53 (8)	15 (8)			
DSM-IV Symptoms					
Pre	5.2 (0.4)	4.6 (0.4)	.63	<.001	.0003
Post	2.0 (0.4)	3.3 (0.6)			
% reduction	66 (8)	34 (8)			

Notes: BDI = Beck Depression Inventory; HRSD = Hamilton Rating Scale of Depression; GDS = Geriatric Depression Scale; DSM-IV = *Diagnostic and Statistical Manual of Mental Disorders* (4th ed.).

*Means and (*SD*).

Table 4. Minor and Major Depression Outcomes by Diagnostic Group

Variable	Exercise	Control	Baseline *p*-value	Time *p*-value	Group × Time *p*-value
Minor Depression					
BDI					
Pre	16.7 (1.7)*	15.6 (1.0)	.13	<.0001	.001
Post	3.7 (1.3)	11.3 (1.9)			
HRSD					
Pre	9.3 (0.9)	10.6 (1.0)	.03	.0004	.19
Post	2.7 (0.8)	7.0 (1.3)			
Major Depression					
BDI					
Pre	24.6 (2.6)	21.5 (3.8)	.87	.002	.34
Post	14.9 (3.8)	16.3 (4.7)			
HRSD					
Pre	14.8 (0.8)	13.6 (2.9)	.34	.003	.04
Post	7.2 (2.2)	13.5 (2.5)			

Notes: Minor depression: 7 exercise and 10 control subjects; Major depression: 9 exercise and 4 control subjects. BDI = Beck Depression Inventory; HRSD = Hamilton Rating Scale of Depression.

*Means and (*SD*).

Table 5. Quality of Life Outcomes

Variable	Normal Values (65–74 yr)	Exercise (n = 17)	Control (n = 15)	Baseline *p*-value	Time *p*-value	Group × Time *p*-value
Physical Functioning						
Pre	69.4 (26.3)*	65.9 (23.5)	64.3 (24.9)	.34	.01	.22
Post		82.6 (18.4)	70.3 (27.8)			
Role Physical						
Pre	65.4 (41.3)	52.9 (34.0)	63.3 (44.2)	.95	.20	.16
Post		73.5 (42.8)	61.7 (44.2)			
Bodily Pain						
Pre	68.5 (26.4)	56.8 (26.9)	72.3 (31.0)	.98	.51	.001
Post		74.2 (19.0)	58.5 (28.6)			
General Health						
Pre	62.6 (22.4)	54.0 (17.5)	64.9 (24.8)	.49	.12	.06
Post		63.9 (26.5)	63.5 (23.9)			
Vitality						
Pre	59.9 (22.1)	37.6 (17.9)	45.3 (24)	.73	.0001	.002
Post		61.7 (25.3)	48.7 (27.5)			
Social Functioning						
Pre	80.6 (25.6)	51.5 (25.0)	69.2 (26.2)	.66	.002	.008
Post		82.4 (19.3)	70.8 (26.2)			
Role Emotional						
Pre	81.4 (34.6)	43.1 (35)	60.0 (42.2)	.91	.007	.02
Post		76.5 (32.8)	62.2 (43.4)			
Mental Health						
Pre	76.9 (18)	55.5 (20.3)	57.0 (18.7)	.80	.0002	.24
Post		71.8 (26.5)	66.1 (22.6)			

*Means and (*SD*).

of the intervention, control subjects still scored below normal reference ranges on most subscales, whereas exercisers approximated or exceeded age-matched normal scores on all subscales.

Self-efficacy and morale. — No measures of self-efficacy changed significantly with time or intervention. Total morale was significantly improved over time and by the exercise intervention. Of the morale subscales, attitude toward one's own aging was significantly improved by exercise more than the control intervention (see Table 6).

Function and performance-based tests. — Strength increased significantly with the exercise intervention. There were no significant effects of the exercise intervention on ADLs, IADLs, or the physical subscales of the SIP, as summarized in Table 7. Mean gait speed and 6-minute walk distance improved with time, but there was no significant effect of exercise. Change in chair rise time with exercise approached significance ($p = .06$).

Mean intensity of training for the exercise group was 78% ($SD = 24$) of the 1RM (range 45–87%). Excluding the one subject who had less than 50% compliance and did not train in the 10th week, mean intensity was 80% ($SD = 10$) of the 1RM (range 70–87%).

As shown in Figure 1, the relative decrease in BDI correlated significantly with increasing intensity of training ($r = -.786$, $p = .0002$), as well as with increasing compliance ($r = -.589$, $p = .013$), and with lower baseline BDI score ($r = .500$, $p = .04$). In a backward stepwise multiple regression model of these three variables, only intensity of training remained a significant independent predictor of the decrease in depression scores ($r^2 = .617$, $p = .0002$).

Discussion

To our knowledge, this is the first published trial of the use of PRT as an antidepressant in depressed elderly people. The intervention worked with clinically meaningful reductions in depression on all self-rated and therapist-rated scales, with almost 60% of exercisers achieving a greater than 50% reduction in HRSD score and 14 out of 16 exercisers no longer meeting criteria for depression at 10 weeks. Improvements in both minor and major depression diagnostic groups were significant.

McNeil et al.'s study (25) is the only other randomized exercise trial in older adults. Their subjects (mean age 72,

Table 6. Self-efficacy and Morale

Variable	Exercise ($n = 17$)	Control ($n = 15$)	Baseline p-value	Time p-value	Group × Time p-value
Self-efficacy					
Lifting					
Pre	46.1 (4.4)*	57.8 (6.7)	.18	.08	.59
Post	51.9 (4.9)	60.9 (7.0)			
Climbing					
Pre	50.7 (5.7)	50.2 (6.3)	.78	.9	.63
Post	51.4 (5.0)	47.4 (5.8)			
Pushups					
Pre	19.8 (4.8)	15.3 (4.6)	.31	.23	.48
Post	25.1 (5.7)	16.6 (3.7)			
Jogging					
Pre	13.0 (4.3)	11.5 (2.8)	.41	.13	.25
Post	20.9 (6.8)	12.4 (2.7)			
Walking					
Pre	51.3 (6.6)	63.9 (7.3)	.51	.21	.14
Post	51.9 (7.8)	51.4 (6.0)			
Morale					
Philadelphia Geriatric Morale Scale					
Pre	5.8 (0.9)	6.9 (0.8)	.85	<.0001	.03
Post	9.9 (1.1)	8.3 (1.0)			
Agitation					
Pre	2.7 (0.4)	3.4 (0.5)	.78	.002	.17
Post	4.2 (0.5)	3.9 (0.5)			
Attitude Toward Aging					
Pre	0.7 (0.2)	0.9 (0.3)	.32	.003	.04
Post	2.1 (0.4)	1.1 (0.3)			
Loneliness					
Pre	2.4 (0.5)	2.6 (0.5)	.91	.001	.30
Post	3.6 (0.5)	3.3 (0.5)			

*Means and (*SD*).

Table 7. Function and Performance-Based Tests

Variable	Exercise (n = 17)	Control (n = 14)	Baseline p-value	Time p-value	Group × Time p-value
ADL					
Pre	6.3 (0.8)*	6.2 (0.1)	.76	.04	.36
Post	6.1 (0.8)	6.1 (0.9)			
IADL					
Pre	23.4 (0.3)	23.9 (0.1)	.15	.80	.80
Post	23.4 (0.4)	23.9 (0.1)			
SIP Total					
Pre	6.4 (1.8)	7.4 (2.7)	.66	.002	.84
Post	3.3 (1.5)	4.7 (1.8)			
Gait Speed (meters/second)					
Pre	1.10 (.06)	1.1 (.06)	.60	.04	.32
Post	1.2 (.06)	1.1 (.06)			
6-minute Walk (feet)					
Pre	1455 (76)	1500 (87)	.94	.03	.36
Post	1580 (94)	1552 (122)			
Chair Rise Single (sec)					
Pre	1.78 (0.3)	1.67 (0.2)	.39	.83	.06
Post	1.35 (0.1)	2.1 (0.5)			
Chair Rise 5 Times (sec)					
Pre	18.4 (2.4)	17.2 (1.4)	.73	.9	.10
Post	16.2 (1.0)	19.4 (3.1)			
Strength (newtons)					
Pre	2469 (165)	2823 (349)	.85	<.0001	<.0001
Post	3241 (191)	2756 (334)			
% change	33 (4)	−2 (2)			

*Means and (*SD*).

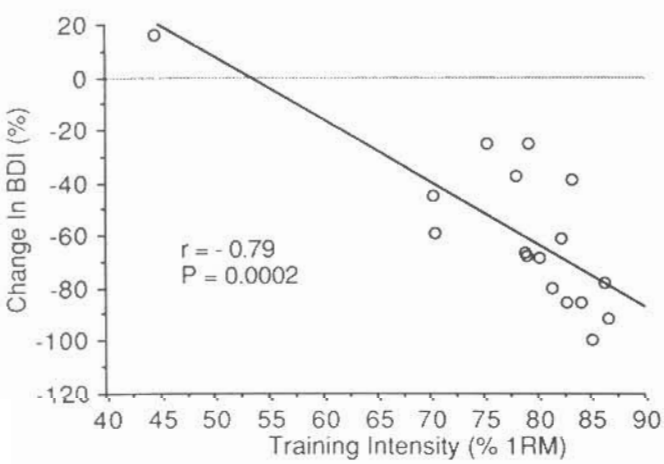

Figure 1. Relative change in Beck Depression Inventory score related to the training intensity in the exercise group (n = 17). There was a significant correlation between these variables by simple regression. Excluding the one subject whose depression did not improve, this relationship remained significant.

SD = 6 years) were chosen by self-reported scores of >12 on BDI and may or may not have fulfilled diagnostic criteria for depression. Over a 6-week intervention of walking vs social contact vs wait list, the BDI was reduced approximately 33% in the walking group, not significantly different from the social contact group, and similar to our control group response (29%).

Two other reports of resistance training and depression have been published. In a younger population of mixed major and minor depression, in a comparison of aerobic to resistance exercise to wait list, a similar magnitude of reduction in HRSD and BDI scores as in our study was demonstrated (8). In the only other study of resistance training and depression (7), it was compared to aerobic exercise with no control group and found equally efficacious. Thus, our study and previous literature would support the efficacy of both resistance and aerobic training for the treatment of depression. Determination of whether resistance training is superior to aerobic training in the elderly would require a direct comparison of these two interventions in the same study.

We found that subjects were able to be trained at the intended high intensity (mean 78, *SD* = 24, of the 1RM). Within this range of intensity we found a significant relationship between increased intensity and percent reduction in depression scores, whether the outlier (see Figure 1) was included or not. We included this subject in the analyses, as her results were felt to represent true clinical variability in psychological response to the intervention and not measurement error. No strength gains or training intensities have previously been reported in resistance training studies of depression (7,8). However, Martinsen et al. (26) found in men with major depression a positive correlation between

increased aerobic capacity and reduction in depression scores in a randomized trial. Subsequent larger studies (7,8) found no such dose response to aerobic exercise, so the generalizability of our findings in this regard is not yet clear.

The mechanisms by which exercise is theorized to reduce depression include biological (27,28) and cognitive behavioral (29,30,31). Biological changes are most likely to be altered by increased intensity of exercise, as are relief of somatic symptoms, improved health, and function. Our results included changes in both somatic and psychological measures of depression, strength, and quality of life with no change in self-efficacy. These in conjunction with a significant correlation between intensity of training and reduction in depression suggest the mechanism may be a combination of physical and health improvements rather than a purely cognitive mechanism operating in relief of depression.

Importantly, quality of life measures showed significant improvement with exercise. Baseline scores were similar to the published norms for clinically depressed samples of mean age 41.6 with 6% of the sample over 65, and they are all below the age-matched normals (24). Quality of life scores after the experimental intervention approximated or exceeded those of age-matched normals, while controls remained below these values.

Self-efficacy has been shown to increase in resistance-trained cardiac patients (32). We hypothesized that an increase in self-efficacy would be associated with improvement in depression. Our negative results suggest that either a different mechanism is in operation, or our physical-based measure of self-efficacy was not sensitive to potential changes in other domains of self-efficacy. The total morale scale and attitude toward one's own aging subscale did significantly improve after training and may be part of the way in which exercise addresses the multiple losses of aging that contribute to depression.

In older individuals, PRT has been previously demonstrated to be safe and feasible (33). For the first time in an aged population selected for depression, PRT has now been shown to be efficacious, feasible, and safe. Importantly, it has fewer contraindications than aerobic exercise and addresses many of the concerns of the depressed elderly including drug side effects, declining functional and health status, and poor quality of life.

In conclusion, this study demonstrates the efficacy of PRT as an antidepressant in depressed community-dwelling elders, with improvements in depressive symptoms, strength, morale, and quality of life. Future research is required to determine the duration of the antidepressant effect, its efficacy in an unsupervised setting, its applicability to different subtypes of depression in larger samples, and its risks and benefits in comparison to drug treatment among aged individuals.

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Dr. Singh is now at the Department of Geriatrics, Royal Prince Alfred Hospital, Sydney, Australia. Ms. Clements is at Massachusetts General Hospital.

Address correspondence to Dr. Maria A. Fiatarone, Chief, Physiology Laboratory, Jean Mayer USDA Human Nutrition Research Center on Aging at Tufts University, 711 Washington Street, Boston, MA 02111. E-mail: fiatarone_ex@hnrc.tufts.edu

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