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Effect of an exercise program on functional performance of institutionalized elderly

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Abstract—This study determined the effectiveness of a 6-month program of regular exercises for the improvement of functional performance of the elderly living in a nursing home. The 40 subjects aged 60 to 99 who took part in this trial were assigned either to a comparative group or an exercise group. The following variables were measured: functional performance with the use of an obstacle course, a lower-limb function test, and a 6-minute walk test (gait velocity); isometric strength of the knee extensors; proprioception of the lower limbs; mental status through the Mini-Mental State Examination (MMSE); and depression symptoms with the use of the Geriatric Depression Scale (GDS). In the exercise group, 19 subjects completed the program and attended an average of 32 (68%) sessions. At the end of the trial, the exercise subjects showed significant performance improvement in quantitative and qualitative obstacle course scores, lower-limb function test, gait velocity test, knee extensors strength, and the GDS, while the nonexercise subjects showed significant decrease in qualitative obstacle course score, lower-limb function, gait velocity, MMSE, and the GDS.

Key words: depression, elderly, exercise, functional performance, institutionalization, mental status, proprioception, strength.

INTRODUCTION

The elderly population has grown proportionally faster than any other age group in Brazil [1]. In 2020, when life expectancy will have reached 75.5 years, the Brazilian population will consist of an estimated 23.5 percent young people (aged 18 or younger) and 7.7 percent, an estimated 16.2 million, the elderly (aged 60 or older) [2]. As the population ages, a trend of health problems and functional disability increases [3], with a significant impact on rehabilitation service needs, such as home care and nursing homes, especially for those aged 85 and older [4]. In the United States, approximately 5 percent of the elderly are institutionalized, and this statistic is unlikely to decline in the coming years. As a result, the demand for long-term care institutions for the elderly will increase [5,6]. In Brazil, census information and research data on institutionalized elderly are scarce. In 1984, Jean Louis Hotê, a French sociologist, quoted the only study known. At the time, he believed that, in Brazil, around 0.6 to 1.3 percent of the elderly were institutionalized [7].

Abbreviations: GDS = Geriatric Depression Scale, IKES = isometric knee extensors strength, MMSE = Mini-Mental State Examination, OCQLS = obstacle course qualitative score, OCQTS = obstacle course quantitative score, 6-MIN = 6-minute walk test.

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The institutionalized elderly are high-risk patients. The loss of functional mobility has been shown to be associated with 50 percent mortality rate among nursing home patients within 6 to 12 months [8]. Evidence from several studies indicates that this decline in physical functionality as such is due only partly to the aging process, and to a large extent, it is due to the decrease in or lack of physical activity [9–11].

Exercise is an accessible form of prevention of physical decline. Several studies have found that adherence to a regular exercise program can improve muscle strength [9,12–19], reaction time [9,12], balance control [9,12,20], and gait velocity [21–23] significantly. Also some trial evidence has shown that exercise programs may enhance cognitive performance and effective states of the elderly as well [24–26], mainly of frail institutionalized elderly, given their lack of exercise and life stimuli [25,27].

Although sufficient evidence exists to recommend that older people should exercise and the findings just described suggest that exercise can increase function in the elderly, further studies are required to elucidate its role in improving function in institutionalized elderly patients. This research has important practical implications, since the primary goal of rehabilitating the elderly is to contribute to a better life quality by maintaining physical function [28–30].

In this study, we have attempted to address this issue by undertaking a long-term controlled exercise program trial with 40 elderly subjects living in a nursing home. Our aim was to assess the adherence of institutionalized elderly to an exercise program and to determine whether regular exercise has beneficial effects on their functional performance, muscle strength and proprioception of the lower limbs, and cognitive and affective status.

METHODS

Subjects

This study was conducted in a nursing home, which hosts 670 people. Of the residents, 85 percent are older than 60 years and among these, only 20 percent are independent.

Initially, among the nursing home residents who had been referred to the exercise program, 40 were selected to participate in this study after a personal interview. Subjects were assigned either to an exercise group, those who wanted to attend the exercise sessions, or to a comparative group, those who did not want to attend the exercise sessions but who volunteered to participate in the study. The subjects were consenting and informed volunteers, mentally capable of understanding and performing the tests proposed, and ambulatory with and without aids.

Inclusion criteria included the subjects being able to perform the functional “get-up and go” test described by Mathias and colleagues [31], without any evidence of risk of falling during the test or at any other time, as considered “normal” in the test’s scale. Performing the test also meant that they could follow commands.

Subjects were also medically examined by healthcare practitioners to identify any condition that precluded their participation in the exercise program, such as imminent fall risk, symptomatic coronary insufficiency, and uncontrolled chronic disease—diabetes, chronic obstructive pulmonary disease, congestive heart failure, hypertension. Exclusion criteria included not living in the institution, not meeting medical criteria, and unwillingness to participate in the study. The Ethics and Research Committee of the Medical School of the University of São Paulo approved this study.

Exercise Program

The experimental subjects participated in a 1-hour exercise session, twice a week for 6 months. The sessions consisted of mobility exercises involving ankles, knees, hips, spine, and shoulders. Subjects performed strengthening exercises with weights on the ankles and hands, closed-kinetic chain exercises (standing and sitting on a chair, climbing stairs), a 15-minute walk, and a 5- to 10-minute relaxation (cooldown) to simulate daily activities.

Exercises were undertaken in group activities, with emphasis on social interaction and enjoyment. The comparative subjects continued their daily nursing home routine, without participating in any organized physical activity.

Assessment Procedures

Assessments were made before subjects began the exercise program and after a 6-month period. Assessments included three functional performance tests: an obstacle course (based on an obstacle course quantitative score [OCQTS] and an obstacle course qualitative score [OCQLS]), a lower-limb function test, and a gait velocity test. Isometric knee extensors strength (IKES), lower-limb proprioception, depressive symptoms, and cognitive status were also measured. All tests were done in the same amount of time, with the exception of the obstacle course and the 6-minute walk test (6-MIN), which were done in a separate setting. Each subject test session took approximately 1 hour. The same person assessed all tests.

Obstacle Course

This test, validated in 1996, consists of a series of 12 stations at which functional tasks or simulations of common functional conditions encountered in and around the environment are presented. The three sections of the obstacle course included four stations with different floor textures, two ramps, two sets of stairs, and four discrete functional tasks (opening a door, rising from a chair, walking around, and stepping over obstacles) [32,33]. The course was set up in an existing physical therapy room (6.8 m × 15.0 m). The stations were set up within a different area from the one described, with minor variations in the obstacle course configuration and the corresponding interobstacle distances.

The subjects were asked to walk the course at a comfortable pace and the elapsed time was recorded based on OCQTSs. OCQLSs were assigned according to specific criteria. A physical therapist guided the test, and the subjects were not allowed to walk the course before the actual test.

Lower-Limb Function

We assessed lower-limb function by measuring standing balance, walking speed, and the ability to rise from a chair [34]. For standing balance tests, the subjects were asked to attempt to maintain their feet side-by-side, in semitandem (the heel of one foot beside the big toe of the other foot), and tandem (the heel of one foot directly in front of the other foot) positions for 10 s each. The subjects received a score of "1" if they could hold a side-by-side standing position for 10 s, but were unable to hold a semitandem position for 10 s; a score of "2" if they could hold a semitandem position for 10 s, but were unable to hold a full tandem position for more than 2 s; a score of "3" if they could stand in the full tandem position foot from 3 s to 9 s; and a score of "4" if they could stand in full tandem position for 10 s.

A 2.4 m walk at the subject's normal pace was timed, and the participants were scored according to quartiles for the time length required to complete the test. The time of the faster of two walks was used for scoring as follows: 5.7 s, a score of 1; 4.1 s to 5.6 s, a score of 2; 3.2 s to 4.0 s, a score of 3; and 3.1 s, a score of 4.

The subjects were asked to stand up from a chair and to sit down five times, as fast as possible. Quartiles for the length of time of this measure were used for scoring as follows: 16.7 s, a score of 1; 13.7 s to 16.6 s, a score of 2; 11.2 s to 13.6 s, a score of 3; and 11.1 s, a score of 4.

We created a performance score profile by adding the three test scores. The subjects were allowed to use their aids if necessary.

6-Minute Walk Test

The subjects were instructed to walk for 6 minutes in the space determined, from one side to the other, and to try to cover as much ground as possible, continuously if possible, but without being concerned if they felt an urge to slow down or to stop. A physical therapist accompanied the subjects and measured the time, giving encouragement as necessary [35]. The distance covered was then measured in meters, with the use of a tape measure.

Isometric Knee Extensors Strength

The modified sphygmomanometer was used to measure the IKES [36]. It consists of a sphygmomanometer folded bladder inside a sewn bag, as described by Helewa et al. [37]. The sphygmomanometer was inflated to a baseline reading on the aneroid scale (20 mmHg). The tester placed the sphygmomanometer on the subject's leg, and the subject was asked to attempt to induce movement by exerting force against the tester. A "break" in movement or a tremor indicated maximal isometric contraction. Measurements were made in triplicate and the greatest force was recorded (mmHg).

Proprioception

Proprioception was measured with the use of an apparatus modified by Lord et al. [38]. This test measured the subject's ability to match the position of the lower limbs. The subjects attempted to simultaneously place the right big toe on the right side of a sheet and the left big toe on the corresponding position on the left side of the sheet in an orthostatic position, without looking to the feet. Error in matching the two toes was measured with a protractor. The test score was the mean error.

Mini-Mental State Examination

The Mini-Mental State Examination (MMSE) was administered to assess the subject's cognitive level in items related to orientation, capability of registration, attention and calculation, recall, and language [39].

The maximum score possible is 30. A score below 24, which indicates cognitive impairment, is not considered normal for older people. A score of 21 implies mild intellectual impairment, a score from 16 to 20 reflects moderate impairment, and a score below 15 is considered severe impairment. No adjustment for subject characteristics was made because MMSE was not used as an exclusion criterion, and only the means of the differences obtained by subtracting the baseline from the follow-up values was compared across groups.

Geriatric Depression Scale

We used the GDS to measure depressive symptoms. It includes 30 questions to which subjects answer “yes” or “no” [40], such as—

- “Are you basically satisfied with your life?”
- “Do you frequently feel like crying?”
- “Do you often feel helpless?”

Statistical Analysis

All variables were considered continuous because measurements varied within a certain scale. Baseline differences in group characteristics were analyzed with the use of an unpaired two-tailed *t*-test for age and with the Mann-Whitney *U*-test for institutionalization time. Pearson correlation coefficients were calculated comparing data from different variables at baseline. We used the one-tailed *t*-test, Wilcoxon test, and Mann-Whitney test to assess differences between the exercise and nonexercise group means, and after the trial, we subtracted the baseline value from the follow-up value and compared the means. In addition, improvement in the performances of the subjects with and without chronic conditions in the exercise group was compared with the Wilcoxon test. A *p*-value < 0.05 was considered statistically significant.

RESULTS

Of the 40 subjects initially recruited into the study, 3 failed to complete the program: 1 from the exercise group, due to medical conditions that caused discontinuation of participation in the exercise class and 2 from the nonexercise group (1 who died and another who left the institution). The characteristics of the study group are described in **Table 1**. Chronic conditions considered were those found to compromise the performance of the subjects in the physical function tests.

No significant difference was found between the groups at baseline in relation to age. But compared to the exercise group, the nonexercise group had a significantly longer institutionalization time.

The total number of sessions in the 6-month period was 47. The mean number of sessions attended by the 19 subjects who adhered to the exercise program was 32 (68%), in the range of 20 to 47 sessions (43% to 100%); 16 subjects (84%) attended 30 (64%) or more sessions. The mean number of subjects per session was 14 (74%), in the range of 8 to 19 subjects (42% to 100%); over 10 (53%) subjects attended 46 (98%) of the sessions.

Mean values and standard deviations of test measures before and after trial are shown in **Table 2**. The comparison of these values reveals that the exercise group performed significantly better in functional tests (OCQTS and OCQLS), lower-limb function, gait velocity, strength, and the GDS. The nonexercise group had a significantly diminished functional performance (only OCQLS), lower-limb function, gait velocity, MMSE, and the GDS.

The correlation between baseline variables is shown in **Table 3**. The highest coefficients were found among functional tests. The proprioception test, MMSE, and GDS had a weak correlation with the remaining tests, except for a moderate correlation between MMSE and lower-limb function tests.

Table 1.
Characteristics of study group at baseline.

Characteristic	Exercise Group (*n* = 19)	Nonexercise Group (*n* = 18)	*p*-Value
Mean Age (y)	76.78 (60.42–99.33)	80.25 (60.83–91.33)	0.322
Female, *n* (%)	14 (73.7)	14 (77.8)	—
Male, *n* (%)	5 (26.3)	4 (22.2)	—
Chronic Conditions*	6	4	—
Mean Institutionalization Time (y)	10.88 (0.75–31.92)	15.25 (1.08–36.17)	0.037

*Including Parkinson’s disease, stroke, osteoarthritis, and poliomyelitis sequela.

Table 2.
Mean ± standard deviations of test measures—baseline and 6-month follow-up.

Test	Exercise Group (*n* = 19)			Nonexercise Group (*n* = 18)		
	Baseline	Follow-Up	*p*-Value	Baseline	Follow-Up	*p*-Value
OCQTS (s)	333.39 ± 168.67	263.56 ± 136.51*	0.000	367.62 ± 117.12	405.52 ± 180.51	0.080
OCQLS	27.47 ± 7.88	29.95 ± 6.59†	0.001	24.22 ± 7.45	22.94 ± 7.63*	0.017
LLF	6.68 ± 2.79	7.79 ± 2.97*	0.000	6.28 ± 2.02	5.33 ± 2.37*	0.007
6-MIN (s)	204.06 ± 77.62	220.53 ± 86.52*	0.001	175.68 ± 55.97	165.68 ± 60.24*	0.001
IKES (mmHg)	95.89 ± 28.06	122.21 ± 28.90*	0.000	105.78 ± 24.78	104.06 ± 24.85	0.072
Proprioc. (°)	10.95 ± 8.14	11.79 ± 7.52	0.132	10.33 ± 5.75	12.00 ± 6.17	0.977
MMSE	19.17 ± 7.53	19.72 ± 7.55	0.177	20.94 ± 6. 83	19.22 ± 6.26*	0.000
GDS	13.78 ± 6.34	9.89 ± 4.57*	0.000	12.78 ± 4.69	14.06 ± 5.48*	0.046

*Student *t*-tests: $p < 0.05$
†Wilcoxon test: $p < 0.05$
OCQTS = obstacle course quantitative score
OCQLS = obstacle course qualitative score
LLF = lower-limb function
6-MIN = 6-minute walk test
IKES = isometric knee extensor strength
Proprioc. = proprioception (distance in matching toes)
MMSE = Mini-Mental State Examination
GDS = Geriatric Depression Scale

Table 3.
Pearson correlation coefficients (*r*) of different baseline variables.

	OCQLS	LLF	6-MIN	IKES	Proprioc.	MMSE	GDS
OCQTS (s) (*p*-Value)	–0.8063* (0.000)	–0.6853† (0.000)	–0.6860† (0.000)	–0.4210† (0.007)	0.3416 (0.031)	–0.2776 (0.087)	0.1230 (0.466)
OCQLS (*p*-Value)	—	0.7149* (0.000)	0.7426* (0.000)	0.3892 (0.013)	–0.3708 (0.019)	0.3030 (0.061)	–0.1324 (0.422)
LLF (*p*-Value)	—	—	0.6685† (0.000)	0.4128† (0.008)	–0.3625 (0.022)	0.4142† (0.009)	–0.0713 (0.666)
6-MIN (s) (*p*-Value)	—	—	—	0.5166† (0.001)	–0.3241 (0.041)	0.3428 (0.033)	–0.0357 (0.829)
IKES (mmHg) (*p*-Value)	—	—	—	—	–0.0539 (0.741)	0.3763 (0.018)	–0.1239 (0.452)
Proprioc. (°) (*p*-Value)	—	—	—	—	—	–0.0999 (0.5450)	0.1134 (0.492)
MMSE (*p*-Value)	—	—	—	—	—	—	0.2105 (0.198)

*Strong correlation 0.7 < /*r*/ < 1.0
†Moderate correlation 0.4 < /*r*/ < 0
OCQTS = obstacle course quantitative score
OCQLS = obstacle course qualitative score
LLF = lower-limb function
6-MIN = 6-minute walk test
IKES = isometric knee extensor strength
Proprioc. = proprioception (distance in matching toes)
MMSE = Mini-Mental State Examination

When comparing the means of the differences obtained subtracting baseline from follow-up values of the exercise and nonexercise groups, we found that the exercise group performed significantly better in all the tests, except for the proprioception one, as shown in **Table 4**.

DISCUSSION

This study evaluated the effectiveness of an exercise program on functional performance, mental status, and depressive symptoms in the institutionalized elderly. Strength and balance measurements were included

Table 4.
Mean ± standard deviations of differences between baseline and follow-up values for exercise and nonexercise groups.

Test	Exercise Group (n = 19)	Nonexercise Group (n = 18)	p-Value
OCQTS (s)	–69.82 ± 48.5486	37.90 ± 109.5877*	0.000
OCQLS	2.4737 ± 2.6950	–1.2778 ± 2.3466†	0.000
LLF	1.1053 ± 1.0485	–0.9444 ± 1.4742†	0.000
6-MIN (s)	16.4763 ± 20.8125	–10.0083 ± 10.7530†	0.000
IKES (mmHg)	26.3158 ± 12.0418	–1.7222 ± 4.7627†	0.000
Proprioc. (°)	0.8421 ± 3.1844	1.6667 ± 3.2899	0.778
MMSE	0.5556 ± 2.7273	–1.7222 ± 1.8087†	0.001
GDS	–3.8889 ± 3.8484	1.2778 ± 3.1957†	0.000

*Mann-Whitney test: $p < 0.05$
†Student t-tests: $p < 0.05$
OCQTS = obstacle course quantitative score
OCQLS = obstacle course qualitative score
LLF = lower-limb function
6-MIN = 6-minute walk test
IKES = isometric knee extensor strength
Proprioc. = proprioception (distance in matching toes)
MMSE = Mini-Mental State Examination
GDS = Geriatric Depression Scale

because they are prerequisites for successful functional activity performance [41,42]. Proprioception assessment, joint position sense, was used as an indirect balance evaluation [43]. The finding that proprioception was not significantly better in the exercisers compared with the nonexercisers is consistent with a previous study by Lord et al. [44]. They reported that their subjects showed negligible effects on proprioception after a 12-month exercise intervention, suggesting that exercising may have minimal effect on peripheral sensory systems.

According to Rogers and Evans [45], the very old and frail elderly experience skeletal muscle atrophy of Type II fibers as a result of disuse, disease, undernutrition, and the effects of aging per se. However, several studies have shown that elderly men and women retain the capacity to adapt to progressive resistive exercise training with significant and clinically relevant muscle hypertrophy and increased muscle strength [46–49]. Our study supports this finding, showing a significant performance improvement in the strength test in the exercise group compared to the nonexercise group.

Few other studies that addressed adaptation to resistance training in the institutionalized elderly reported improvement in strength, irrespective of the use of a high-intensity resistance program [14], a combination of isometric training and low-intensity weight-lifting exercises [50,51], seated resistance exercises [18,26], and rowing exercises for restrained nursing home residents [52]. Although high-intensity exercise clearly may elicit sizable gains in strength [14], less strenuous programs (similar to the one described in this study) have demonstrated significant gain in muscle strength [53,54].

Some studies have considered changes in functional ability in older people after training [19,21,26,51,55–58]. In our study, we found significant improvement in the three functional indicators used. It is important to point out their strong correlation shown by the Pearson correlation coefficients, which corroborate their validity.

When considering relevant improvements in functional tasks, one should consider the type of training exercises used. Skelton et al. [59], in a study with task independent training exercises (i.e., training exercises specific to increase strength of major muscle groups) and avoidance of those that mimic functional tasks, reported only minimal improvements in 2 out of 12 functional ability tests, despite significant increase in strength and muscle power. In contrast, Skelton and MacLaghlin [21] found significant improvements in chair-rise, timed-up-and-go, stair-climbing time, and floor rise-time tests, in an 8-week study, with a training program mirroring daily activities. They concluded that it might be more beneficial to train using movements that closely mirror daily activities rather than to train to increase strength and the power of individual muscle groups per se.

Rantanen et al. have also suggested that usual daily activities may represent a large proportion of maximal strength for older individuals and, therefore, be an adequate overload [60]. In accordance with that, Schnelle et al. reported a study in which nurses in a nursing home bladder/bowel training program spent an extra 6 minutes helping extremely frail residents exercise every time they got the residents up to toilet [61]. The residents would push their wheelchairs, do sit-to-stands, or try to walk a couple of extra minutes. After 8 weeks, their levels of daily living activity improved significantly; they could walk and propel their wheelchairs further and stand up more easily, which showed that even simple interventions can translate into physical benefits.

The psychological effects of exercise, described elsewhere [62,63], have been confirmed in this study by GDS improvements. Nevertheless, the issue of whether or not exercise affects cognitive function remains controversial [19,25,26,64–66]. In our study, the exercisers showed no significant effect on MMSE performance improvement by the end of the program. However, we would like to note that the comparative group showed a significant decrease in MMSE after the 6-month period.

The mechanism underlying the connection between exercise and mental health is still unknown, but many theories have been proposed to try to explain it [25,67]. There is evidence that exercise enhances the activity of monoamines in the brain; stimulates the release of endorphins, especially in the elderly population; and increases oxygen transport capacity, blood circulation, and energy supply to different parts of the body, including the brain. This last effect has been emphasized in relation to cognitive changes. Powell suggested that the deterioration of cognitive processes among psychogeriatric patients hospitalized for many years may result from disuse or disinterest and that exercise therapy may lead to a revitalization of those mental activities, or at least to the maintenance of cognitive level [68]. According to Barry and Eathorne [69], the social interaction offered by an exercise program provides mental and intellectual stimulation that is often missing. In this study, the lack of association between MMSE and GDS with the remaining tests implies that the psychological and cognitive level of the subjects in this sample had no influence on the physical tests.

Some methodological problems relevant to the evaluation of the effects of an exercise program have not been considered in this study. First, owing to resource limitations, a blind observer did not assess the exercise group, and therefore, observer bias possibly may have intervened. However, poststudy measurements were made without reference to baseline values. Additionally, according to Morgan [70], it is necessary to distinguish between effects caused by exercising and confounding effects caused by social or personal consequences of participating in supervised activities. In practical terms, a need exists to include control interventions, which mimic the exercise program as close as possible, except for the exercise program itself. In this particular study, a control group with an intervention that mimics the exercise program only in the social aspects was not accomplished. McMurdo and Rennie studied a group of elderly who exercised in comparison to those who participated in reminiscence sessions [19]. Those in the exercise group demonstrated significantly better strength scores, but cognitive status declined in both groups. Even though the decline was larger in the reminiscence group, it was not statistically significant.

This study had an interesting finding, despite the initial difficulty to motivate the subjects to attend the exercise program sessions during the subject selection step. This finding was that the subjects' enthusiasm for the exercise sessions was apparent from their expressed hope for continuation of the program.

CONCLUSION

Our results suggest that an exercise program can produce benefits with regard to functional improvement, reduction of depressive symptoms, and prevention of decline in mental status in the institutionalized elderly, thus contributing to a better quality of life. However, to conclusively confirm these benefits, investigators need to conduct randomized controlled studies with large subject samples and better assessment conditions.

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