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Physical training in institutionalized elderly people with multiple diagnoses—a controlled pilot study

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Abstract

Reduction in muscle mass and physical function depends on a variety of interacting factors: age, physical activity level, nutritional state and the type and impact of disease. The aim of this study was to investigate the effect of an individualized moderate intensity physical training program on muscle strength, balance, mobility, ambulation and activities of daily living (ADL) in institutionalized elderly people aged 65 and over with multiple diagnoses. Baseline assessments consisted of strength, balance, mobility/ambulation, and ADL. Twenty-one subjects were included in the intervention program. A control group (21 subjects) was first matched in pairs according to gender, age, ADL and mobility, and then by balance, ambulation and strength. The intervention program was individualized and included strength, mobility, balance and endurance training. Follow-up measures were conducted directly after the intervention and 10 weeks later. After drop-out, 20 subjects in the intervention group and 15 subjects in the control group remained for analyses. Balance and mobility improved significantly in the intervention group while declining in the control group. This pilot study indicates that a physical training program may improve functional capacity for institutionalized elderly persons with multiple diagnoses.

Keywords: Frail elderly; Physical training; Motivation; Multiple diagnoses; Hospitalization; Controlled clinical trial

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1. Introduction

The effect of exercise on healthy elderly people has been extensively investigated and many studies report improvement in strength (Nelson et al., 1994; Hagerman et al., 2000; Rhodes et al., 2000), endurance (Lemura et al., 2000), balance (Lord et al., 1996) and functional capacity such as walking (Judge et al., 1993; Topp et al., 1996). Many studies highlight the importance of high intensity training to achieve good results especially concerning strength and endurance (Aniansson et al., 1980a,b; Lemura et al., 2000). There are also studies showing that significant effects on strength and endurance can be achieved even at low and moderate exercise intensity (Engels et al., 1998; Brown et al., 2000). Then again, other studies report that if the intensity is low the effects on strength will only be moderate (Aniansson and Gustafsson, 1981; Larsson, 1982).

Physical training is very important to minimize or delay functional decline that leads to dependence (Malbut-Shennan and Young, 1999). Reduction in muscle mass and function depends not only on age but also on life style factors such as physical activity (Grimby, 1995). Low physical activity may reduce VO_{2max} and in the end lead to a situation where quiet sitting requires approximately 35% of an 80-year-old female's VO_{2max}. This percentage of VO_{2max} is similar to that averaged over an 8 h shift for workers in heavy industry (Malbut-Shennan and Young, 1999).

There are several randomized controlled studies of physical training for nursing home patients, many of which report significant strength and mobility improvements (Sauvage et al., 1992; McMurdo and Rennie, 1993, 1994; Fiatarone et al., 1994; Mulrow et al., 1994; O'Hagan et al., 1994; Schnelle et al., 1995, 1996; Lazowski et al., 1999). The results of these studies have been summarized in a recent systematic review (Rydwik et al., 2004). Only one of the studies in the review reports significant improvement in balance (Lazowski et al., 1999). One study describes the intensity as high (Fiatarone et al., 1994), four describe it as moderate (Sauvage et al., 1992; Mulrow et al., 1994; Schnelle et al., 1996; Lazowski et al., 1999) and four as low (McMurdo and Rennie, 1993, 1994; O'Hagan et al., 1994; Schnelle et al., 1995, 1996). This suggests that even moderate and low intensity levels may be enough to gain significant effects from training, which has also been shown in healthy elderly people (Engels et al., 1998; Brown et al., 2000).

In a review, Rhodes et al. (1999) describe factors that might influence physical activity in the elderly. They conclude that education and exercise history are important factors among all age groups, while physical frailty and poor health may provide the greatest barriers to exercise for elderly people. A study in Finland shows that participating in competitive sports during childhood/youth is a significant predictor for maintaining activity in old age. The study also shows that participation in recreational sports for women aged 40–64 predicts activity in old age (Hirvensalo et al., 2000). Another study points to physical activity early in life as an important factor for the establishment of good activity habits—a prerequisite for activity patterns late in life (Frändin et al., 1995).

The aim of this study was to investigate the effect of an individualized moderate intensity physical training program on muscle strength, balance, mobility, ambulation and ADL in institutionalized elderly people aged 65 and more with multiple diagnoses.

2. Material and methods

2.1. Subjects

The study was performed in an institution for the elderly with multiple diagnoses in Sundbyberg, a suburb of Stockholm, Sweden. After giving informed consent (from relatives when needed) the 73 eligible residents underwent a clinical examination by a geriatrician and were screened for baseline measurements. The study has been approved by the Ethics Committee at the Karolinska Institute.

2.1.1. Criteria for exclusion

- Unable to stand without support
- Unable to understand instructions either by hearing or seeing

2.1.2. Criteria for inclusion in the intervention program

The residents were asked (assisted by relatives or staff as needed) to estimate their motivation to participate in a physical training program and to score their motivation for training on a four-graded scale (0: very low, 1: low, 2: fairly high, 3: very high). The 14 subjects who scored their motivation as "very high" ($n = 5$) or "fairly high" ($n = 9$) were invited to participate in an individualized physical training program (see below). Another two subjects were persuaded by relatives to participate and five subjects changed their motivation in a positive direction after the baseline measurements and were then also invited to participate in the physical training program. In summary, a total of 21 residents were included in the intervention group (IG).

2.1.3. Matching a control group

After the initial baseline assessments (see below) each subject in the IG was paired with a control subject by gender, age, ADL and mobility and then by balance, ambulation and strength. A total of 42 subjects of the eligible 73 were assigned to the study, 21 subjects in the IG and 21 subjects in the matched control group (CG). A description of the subjects is shown in Table 1 (see Section 3).

2.2. Procedure

The study was conducted from November 2000 to September 2001. Baseline assessments were conducted from November 2000 to January 2001. The intervention program lasted 10 weeks, from the beginning of April to mid-June 2001. Follow-up measures were conducted directly after the intervention and 10 weeks later.

The subjects were asked to describe their history of physical activity. This information was used to divide the subjects into three categories. One category included subjects reporting regular physical activity of some kind (walking, gymnastics, etc.) during a major part of their lives. Another category included subjects reporting their major physical activity as heavy labor or heavy gardening for a major part of their lives. The last category included subjects reporting none or very little physical activity during a major part of their lives.

Table 1
Baseline characteristics for all examined residents

	Whole (n = 42)	Intervention (n = 21)	Control (n = 21)
Gender (w: women, m: men)	w = 32, m = 10	w = 16, m = 5	w = 16, m = 5
Mean age, years (*m*)	85.3 (7.2)	86.6 (5.5)	84.0 (8.6)
Length of stay, months (*md*)	28 (10–47)	33 (20–67)	20 (9–39)
History of physical activity			
Walking, gymnastics, bicycling	27 (64%)	14 (66%)	13 (62%)
Heavy labor, gardening	4 (9%)	2 (10%)	2 (10%)
No history of physical activities	11 (26%)	5 (24%)	6 (28%)
Walking aids (number of residents)			
No aid	2 (5%)	2	0
Stick	6 (14%)	1	5
Walker	21 (50%)	10	11
Walker + wheel-chair	8 (19%)	5	3
Wheel-chair	5 (12%)	3	2
Motivation score (number of residents)			
No motivation	16	3	13
Little motivation	12	4	8
Fair motivation	9	9	0
Much motivation	5	5	0

md: median (q1–q3), *m*: mean (standard deviation).

Average length of stay at the institution and type of walking aid was recorded. A physiotherapist administered the assessments and the intervention program.

2.3. Assessments

Isometric knee extensor strength was measured with a Nicholas manual muscle tester (model 01160), which has been shown to be a reliable device (Ottenbacher et al., 2002). The subjects sat on a quadriceps table with their thighs strapped with a band and had a hip and knee joint angle of 90°. The tester was placed on the lower leg 10 cm above the lateral malleolus. Both legs were tested three times and the best value of the strongest leg was noted and transformed to Newton meter (Nm).

Grip strength was tested with a Jamar hydraulic hand dynamometer, a valid and reliable instrument (Bellace et al., 2000; Peolsson et al., 2001). The subjects sat in an ordinary chair or wheelchair with their shoulders in a neutral position and the elbow in 90° flexion. The handgrip on the dynamometer was adjusted according to the size of their hands. Three measurements were conducted on both hands and the best result of the strongest hand was recorded (Hamilton et al., 1994).

Balance was assessed with Berg's balance scale where both static and dynamic balance are evaluated; the instrument is considered to be valid and reliable (Berg et al., 1992, 1995; Jensen et al., 1998). It consists of a 14-item scale from 0 to 4 points (max 56 p) where 4 indicates maximal accomplishment for each item.

Mobility/ambulation was measured with S-COVS, a Swedish translation of the clinical outcome variables (COVS), which measures different aspects of mobility (Hasselgren-

Nyberg et al., 1997). This instrument has been shown to be reliable and consists of 13 hierarchical ordinal scales from 1 to 7 points (max 91 p) representing ascending levels of functioning, from complete dependence (1 point) to independence or normal function with or without an assistive device (5–7 point) (Seaby and Torrance, 1989).

Ambulation was also tested with Timed Up and Go, shown to be a valid and reliable test for the frail elderly (Podsialdo and Richardson, 1991). The subjects were instructed to rise from a chair (height 42 cm) walk 3 m, turn around and walk back to be seated again. This activity was timed. The residents were allowed to use their usual walking aids. Maximal gait speed for 30 m indoors was measured.

ADL were evaluated by interviewing nursing staff, using the Katz index, which has been shown to be a valid and reliable scale (Katz and Apkom, 1976; Brorsson and Åsberg, 1984). The index rates from A to G, where A indicates independence and G indicates complete dependence.

2.4. Intervention

The training program included 45–60 min of moderate intensity group sessions twice a week for 10 weeks. It was individualized according to baseline assessments and performed in groups of 4–5 subjects. In total there were 20 separate physical training sessions.

The program started with a warm-up session of 6–7 min including range of motion, functional motions such as hand in neck (HIN), hand in back (HIB) and reaching down from a sitting position as well as circulatory movements in sitting and standing.

The physical training program consisted of the following four stations:

- dynamic strength training (knee-extension, elbow-extension, shoulder-extension);
- mobility training (sitting down/standing, toe-raise, step-up),
- balance training (static balance, dynamic balance),
- endurance training (stationary bicycle or arm and leg ergometer and/or walking).

The subjects circulated among these stations spending approximately 25% of the training session at each station. The level of exercise was checked every other week to see if training progress was possible in terms of increasing load (strength and endurance), number of repetitions (strength and mobility), exercise duration (endurance) and difficulty of balance-training (changing base and quality of support, displacement of the center of mass, etc.).

The control group received regular physical and occupational therapy when needed and the nursing staff was instructed to try to achieve a higher level of activity among all the residents living in the institution.

2.5. Statistical analysis

A proportional odds logistic regression analysis for ordinal data and a generalized linear model for repeated measurements for continuous data, were used to analyze a 1–1 matched study (Brown and Prescott, 1999). The models were set up as a repeated measures design. The data contained missing values, supposed to be at random. The major aim was to analyze the treatment effect after accounting for background factors. The data were also analyzed for a systematic trend over time. The analysis also included interaction effects between background factors and time as well as that between time and the treatment effect. The models were reduced, certain background factors and interaction terms were deleted, and a robust model was obtained and found relevant to the data.

The scores of Berg's balance scale and S-COVS were sorted into four categories according to the lower quartile, median and the upper quartile. ADL was sorted into three categories according to the lower quartile and the upper quartile.

The ordinal data were analyzed in PROC GENMOD in SAS. The data were assumed to be multinomial distributions and cumulative logits were used as a link function in the analysis (Stokes et al., 2000).

Continuous data such as gait speed, handgrip strength, knee-extensor strength and TUG were analyzed in PROC MIXED in SAS. The covariance structure for the within matched-pair-effects was assumed to be compound symmetry (Littell et al., 1996).

3. Results

3.1. Baseline characteristics

Table 1 shows the baseline characteristics for the whole group and for the IG and CG, respectively. The subjects in the IG were on average two years older than those in the CG (86 versus 84 years) and had lived in the institution longer than the CG (33 versus 20 months). The differences between the IG and CG at baseline have been accounted for in the statistical model (see Section 2.5). As planned, the IG had a much higher motivation score than the CG. The subjects that scored "0" and "1" in the IG expressed a motivation to participate in the physical training program after baseline assessments, but were not asked to score their motivation again.

3.2. Drop-out

There was a successive reduction of subjects (Fig. 1). At the first follow-up at the end of the 10-week training period, one subject in the IG refused to take part because of loss of initial motivation. In the CG three subjects had died and three subjects refused assessment because of sickness, grief or lack of motivation. All subjects completed the physical training program and 17 subjects (81%) completed both follow-ups.

3.3. Compliance with the intervention program

The 21 subjects in the IG had different compliance rates during the intervention program; the average compliance rate was 65% (range 5–100%). Nine subjects participated in ≥75% of the training sessions, eight ≥50%, and four <50%. One subject refused to participate after the first occasion because of muscle soreness following the first exercise session, but completed all follow-ups. Reasons for not participating were otherwise sickness, lack of motivation, hospital visits and on five occasions because the nursing staff forgot about the sessions so that the subjects were showering or still in bed. Two subjects had a compliance rate of 100%; one of them scored the initial motivation as fairly low.

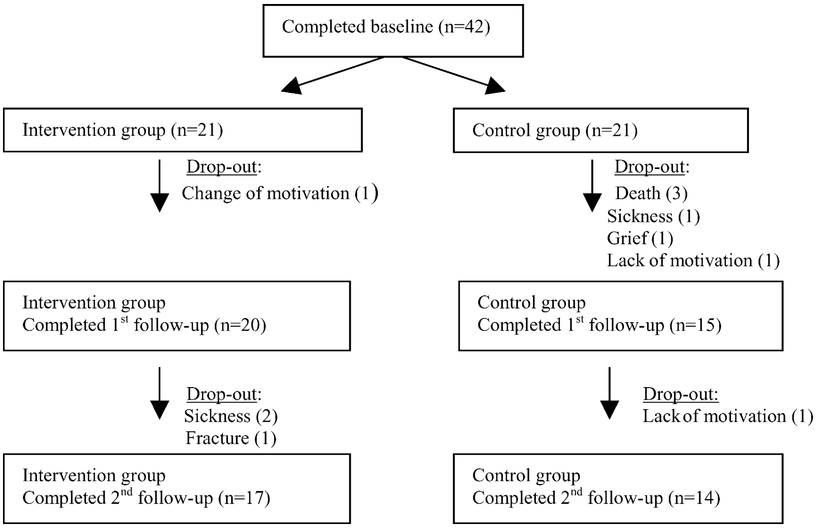

Fig. 1. Graphic illustration of drop-out from the intervention study.

3.4. *Effect of the intervention program*

Table 2 shows the result of the seven assessments at baseline, and the first and second follow-ups. Table 3 shows the effect of the intervention of the tests assessed at baseline and at the first follow-up. The table shows the effect of the intervention in terms of estimated odds ratio (ordinal data) and estimated effect of the intervention (continuous data), and the effect of prognostic (background) factors. The first quartile was used as a base in the statistical model for the estimation of odds ratio. The prognostic factors accounted for were baseline values in each assessment variable, length of stay, age and baseline ADL. These prognostic factors were chosen with reference to clinical experience (see Sections 4.3 and 4.6). The prognostic factors that affected the results are shown in Table 3.

There were no significant effects of either treatment or prognostic factors on *knee extensor strength* and *grip strength*, thus the statistical model was not significant (NS). They are therefore not included in Table 3.

Balance increased significantly in the IG at the first follow-up compared to the CG ($P < 0.003$) (Fig. 2). The odds ratio for moving up to a higher quartile as a result of treatment was 10.4 for all individuals in the IG. Baseline ADL ($P < 0.05$) and initial balance baseline values ($P < 0.01$) also affected the outcome of balance (Table 3).

Mobility/ambulation showed significant changes concerning S-COVS ($P < 0.05$) (Fig. 3). The odds ratio for moving up to a higher quartile as a result of treatment was 3.6 (Table 3). Baseline values were also significantly important to the outcome ($P < 0.006$). On a group level the improvements were very modest.

Maximal gait speed and TUG showed no significant changes concerning treatment effect. However, the result was affected by the initial baseline values ($P < 0.001$) (Table 3).

Table 2
Result of the seven assessments conducted at baseline and follow-up in the intervention group (IG) and the control group (CG)

Functional measurements	Baseline		First follow-up		Second follow-up	
	IG ($n = 21$)	CG ($n = 21$)	IG ($n = 20$)	CG ($n = 15$)	IG ($n = 17$)	CG ($n = 14$)
Isometric knee-extension strength, Nm (*m*)	39 (18)	27 (15)	41 (17)	30 (18)	40 (11)	27 (14)
Handgrip strength, kg (*m*)	17 (6)	15 (8)	15 (6)	13 (8)	15 (6)	13 (6)
Berg's balance scale, points (*md*)	27 (0–50)	34 (5–48)	31 (18–40)	21 (9–39)	37 (16–41)	27 (9–39)
S-COVS, points (*md*)	71 (30–81)	68 p (47–81)	72 (64–77)	66 (57–71)	72 (62–76)	68 (56–70)
Max gait speed 30 m, m/s (*m*)	0.8 (0.3) ($n = 14$)	0.5 (0.1) ($n = 17$)	0.7 (0.3) ($n = 14$)	0.4 (0.1) ($n = 10$)	0.7 (0.3) ($n = 12$)	0.5 (0.2) ($n = 9$)
Timed Up and Go, s (*m*)	28 (13) ($n = 15$)	33 (22) ($n = 18$)	30 (16) ($n = 13$)	34 (13) ($n = 11$)	33 (15) ($n = 12$)	31 (8) ($n = 10$)
Katz (*md*) (range)	C (A–F)	C (A–G)	C (A–F)	C (A–F)	C (A–F)	D (A–F)

m: mean (standard deviation), *md*: median (q1–q3).

Table 3
The effects of the intervention and the influence of prognostic factors

Variable	Estimated intervention oddsratio (OR)	Confidence interval (OR)	*P*-value	Prognostic factor 1	Estimated (OR)	Confidence interval (OR)	*P*-value	Prognostic factor 2	Confidence interval (OR)	*P*-value
Ordinal data										
Balance	10.4	2.48–43.75	<0.003	Baseline ADL	9.6	1.1–80.6	<0.05	Baseline balance	3.48–156.04	<0.01
S-COVS	3.6	1.16–11.3	<0.05	None				Baseline S-COVS	3.2–60	<0.006
ADL	0.92	0.18–4.64	0.93	None				Baseline ADL	3.55–194	<0.004

Variable	Estimated intervention effect	Confidence interval	*P*-value	Prognostic factor 1				Prognostic factor 2	Confidence interval	*P*-value
Continuous data										
Gait speed	0.094	−0.012–0.2	<0.08	None				Baseline gait speed	0.52–0.99	<0.001
TUG	3.65	−1.25–8.54	0.13	None				Baseline TUG	14.49–30.71	<0.001

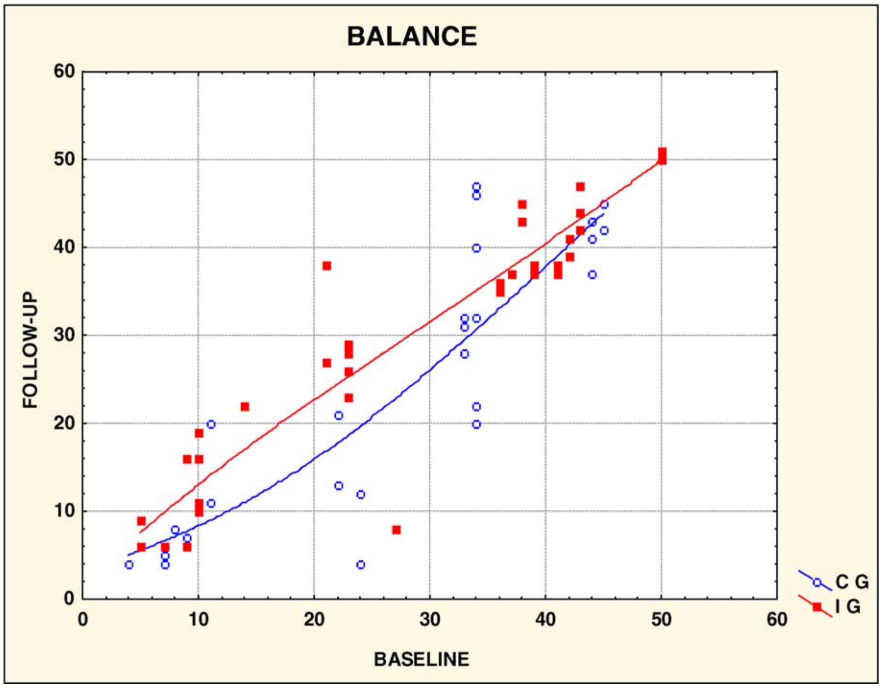

Fig. 2. Individual result of the Berg's balance scale at baseline and follow-up in the intervention group (IG) and the control group (CG).

ADL showed no significant changes concerning treatment effect; however, the result was affected by the initial baseline values ($P < 0.005$) (Table 3).

4. Discussion

There is a lack of evidence concerning the effect of physical training on balance for institutionalized elderly people (Rydwik et al., 2004), however this pilot study shows that a physical training program can significantly improve balance and mobility in a group of institutionalized elderly people. The clinical significance concerning mobility (S-COVS) is, however, questionable. The differences between the IG and CG are probably too small to be of functional relevance.

There are several limitations of the study that could have affected the outcome.

4.1. Heterogeneity

The subjects exhibited a very heterogeneous mix of functional impairments. These large differences made it necessary to design individual training programs that varied substantially in both quality and quantity (workload).

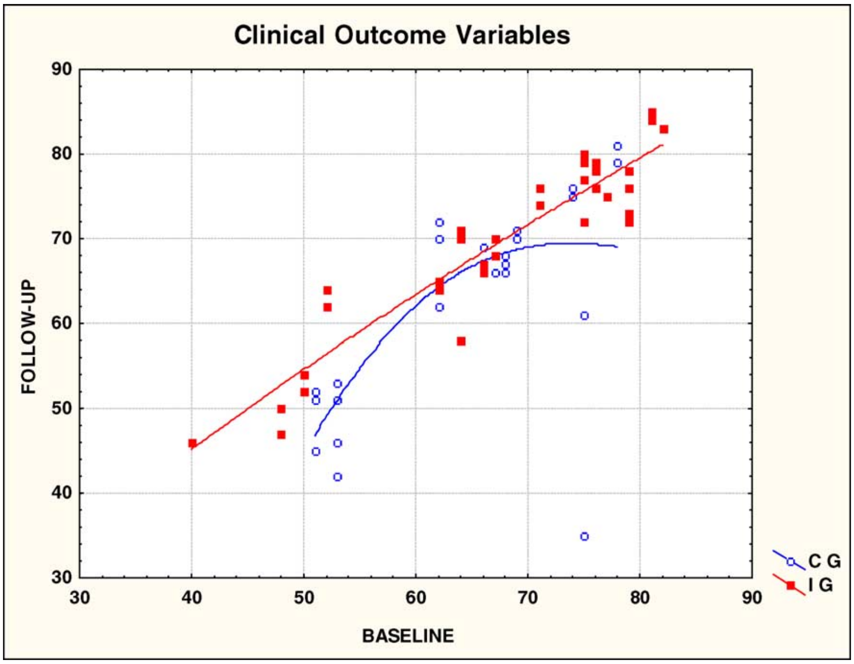

Fig. 3. Individual result of the S-COVS at baseline and follow-up in the intervention group (IG) and the control group (CG).

However, some of the subjects with low scores in Berg's balance scale and S-COVS gained more than others from the physical training program. This is in line with another study where the subjects that were most dependent in ADL gained the most from the exercise intervention (Meuleman et al., 2000). The lack of increase in muscle strength may explain the lack of improvement concerning TUG and gait speed. The relationship between knee extensor strength and gait speed is linear over the entire range of strength (Ferrucci et al., 1997).

4.2. Motivation and Compliance

Motivation is a complex area to define and to measure. Physical and psychological barriers as well as self-efficacy have been shown to affect motivation for life style changes (Taylor, 1999). We cannot say that we, by the question asked, have defined participants with high or low motivation. For example, one of the subjects who scored "low" had 100-percentage participation compliance. Maybe several of the subjects in the CG would have had a high compliance rate if they had been participants in the IG. Therefore the groups could be comparable. To our knowledge there is no available motivation scale for elderly people.

Compliance to exercise sessions was widely spread despite the fact that most of the subjects had estimated their motivation as high or fairly high. Two of the subjects hesitated to participate but relatives persuaded them to do so, therefore their motivation for physical training was questionable. One of them participated on fewer than 50% of the occasions. Three of the highly motivated subjects could not participate as much as they wanted due to illness. Motivation during physical training sessions is another factor that can affect the outcome. Some of the subjects worked really hard during sessions, while others were more reluctant and in need of more encouragement to complete each session. Some of the subjects in the IG were not able to perform at their maximal level during the physical training sessions due to pain.

4.3. Hospitalization

It is difficult to change the habits of people living in an institution, where they are accustomed to receiving help and the nursing staff is accustomed to delivering help, in many cases to save time. This might have affected ADL and mobility assessments. This is also described by Simmons et al. (1995) where the staff wheeled the residents at mealtime because it was more efficient than letting the residents propel their wheelchairs by themselves. One may argue that the effect of a physical training program most likely will yield good results if the staff actively supports the idea of physical activity and avoids unnecessary help to the residents. This is discussed in other articles about nursing home residents. Morris et al. (1999) included education for the nursing staff as one intervention, and "the staff were consistently taught how to break the cycle of dependence." It has been shown that it is important to let the residents make personal decisions to avoid feelings of poor self-esteem and powerlessness. Such feelings can lead to decreased functional performance and increased assistance from the nursing staff (Przybylski et al., 1996).

The subjects were also accustomed to technical aids of various kinds. Fear of falling among the subjects, as well as among the nursing staff and relatives, could be another reason for not being able to change such things as walking assistance.

4.4. Method sensitivity

The sensitivities of the assessment methods are vital for the interpretation of the results. As mentioned above, the residents exhibited large variations in functional capacities and to our knowledge there are no evaluation forms available that are sensitive to such different levels of capacities. This study showed that subjects in the IG who scored high in Katz, Berg's balance scale and S-COVS at baseline, did not improve in functional skills, even though in some cases they improved in strength measurements. The reason for this may be a so-called "ceiling effect".

One repetition maximum (1RM) was planned to be tested during the first physical training session, but this turned out to be impossible due to lack of time and assistance. Therefore the initial muscle strength-training load was estimated according to the isometric baseline values. 1RM should have been tested as a part of the baseline assessment to describe the intensity during practice and also to ensure the effectiveness of strength training.

We chose to evaluate isometric strength with a handheld dynamometer both for its simplicity and the fact that studies have shown that isometric strength correlates with dynamic strength, such as climbing capacity (Aniansson et al., 1980a,b). On the other hand other studies show that significant changes after an exercise intervention could be seen, when the muscle group was tested dynamically with 1RM (Brown et al., 1990) or by CAT scanning (showing hypertrophy) of the muscle (Sale et al., 1992), but not when tested isometrically. The effect of strength training is initially caused by neural adaptation (e.g. activation of more motor units and increasing firing rates) and therefore the specificity between training and assessment is vital (Sale, 1988). This could be another reason for not testing isometrically, when training dynamically.

4.5. Study design

For various administrative reasons there was a gap of 3–5 months between baseline assessments and the start of the intervention period that could have left us with false baseline values. This was mainly a problem for the IG. Baseline values might have been lower if baseline assessment had been conducted closer to the intervention.

For different administrative and economic reasons, we could not have a blind evaluator and therefore the same person performed both assessments and intervention.

The assessment and the physical training program were conducted in a specially equipped room within the institution. This may increase the possibility to implement the results in other institutions for elderly people, rather than if the study had been conducted in a laboratory environment. Disadvantages with conducting a study within an institution could be that there is a lack of eligible subjects (57% of the eligible subjects took part in the study) and that the researchers are dependent on the assistance and attitudes among the nursing staff. This could have affected the results. However, we believe that it is necessary to conduct studies like this in a clinical authentic environment to increase the possibilities of implementation.

4.6. Insufficient matching

There was a difference between the groups concerning median length of stay at baseline. The IG had lived longer in the institution than the CG and for an extended time been accustomed to receiving help from the nursing staff. This can partly explain the fact that there was no difference in ADL between the groups at follow-up. However, the insufficient matching has been accounted for since we have included prognostic factors and baseline values in the statistical analysis.

4.7. Sample size

The small group of 31 individuals remaining after drop-out was most likely too small to enable further detection of significant changes at the group-level.

A possible weakness was that the IG consisted primarily of subjects who were motivated to take part in a physical training program. To avoid this bias it would have been more appropriate to randomize the motivated subjects to different groups. If that had been the procedure, the groups would have been even smaller from the start. Considering the drop-out rate there would have been even fewer subjects left for analysis and it would have been impossible to draw conclusions.

We included all subjects in the analysis regardless of compliance to exercise classes. This was done in order to maintain as high a number of subjects as possible.

5. Conclusion

This pilot study indicates that a physical training program partly improves balance and mobility for institutionalized elderly people with multiple diagnoses. There is a big need for further controlled studies with larger randomized groups to analyze the extent to which physical training can benefit the institutionalized elderly. There is also a need for nursing staff education to avoid hospitalization to successfully implement this kind of exercise intervention in institutions for the elderly.

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References

Aniansson, A., Gustafsson, E., 1981. Physical training in elderly men with special reference to quadriceps muscle strength and morphology. Clin. Physiol. 1, 87–98.

Aniansson, A., Grimby, G., Rundgren, Å., 1980a. Isometric and isokinetic quadriceps strength in 79-year-old men and women. Scand. J. Rehab. Med. 12, 161–168.

Aniansson, A., Rundgren, Å., Sperling, L., 1980b. Evaluation of functional capacity in activities of daily living in 70-year-old men and women. Scand. J. Rehabil. Med. 12, 145–154.

Bellace, J.V., Healy, D., Besser, M.P., Byron, T., Hohman, L., 2000. Validity of the Dexter evaluation system‘s Jamar dynamometer attachment for assessment of handgrip strength in a normal population. J. Hand Ther. 13, 46–51.

Berg, K.O., Wood-Dauphinee, S.L., Williams, J.L., Maki, B., 1992. Measuring balance in the elderly: validation of an instrument. Can. J. Public Health 83 (Suppl. 2), S7–S11.

Berg, K., Wood-Dauphinee, S., Williams, J.I., 1995. The balance scale: reliability assessment with elderly residents and patients with an acute stroke. Scand. J. Rehabil. Med. 27, 27–36.

Brorsson, B., Åsberg, K.H., 1984. Katz index of independence in ADL: reliability and validity in short-term care. Scand. J. Rehabil. Med. 16, 125–132.

Brown, H., Prescott, R., 1999. Applied Mixed Models in Medicine. Wiley Chichester, UK.

Brown, A.B., McCartney, N., Sale, D.G., 1990. Positive adaptations to weight-lifting training in the elderly. J. Appl. Physiol. 69, 1725–1733.

Brown, M., Sinacore, D.R., Ehsani, A.A., Binder, E.F., Holloszy, J.O., Kohrt, W.M., 2000. Low-intensity exercise as a modifier of physical frailty in older adults. Arch. Phys. Med. Rehabil. 81, 960–965.

Engels, H.J., Drouin, J., Zhu, W., Kazmierski, J.F., 1998. Effects of low-impact, moderate-intensity exercise training with and without wrist weights on functional capacities and mood states in older adults. Gerontology 44, 239–244.

Ferrucci, L., Guralnik, J.M., Buchner, D., Kasper, J., Lamb, S.E., Simonsick, E.M., Corti, M.C., Bandeen-Roche, K., Fried, L.P.,. For the WHAS Research Group 1997. Departures from the linearity in the relationship between measures of muscular strength and physical performance of the lower extremities: the women;s health and aging study. J. Gerontol. Med. Sci. A 52, M275–M285.

Fiatarone, M.A., O'Neill, E.F., Doyle Ryan, N., Clements, K.M., Solares, G.R., Nelson, M.E., Roberts, S.B., Kehayias, J.J., Lipsitz, L.A., Evans, W.J., 1994. Exercise training and nutritional supplementation for physical frailty in very elderly people. N. Engl. J. Med. 330, 1769–1775.

Frändin, K., Mellström, D., Sundh, V., Grimby, G., 1995. A life span perspective on patterns of physical activity and functional performance at the age of 76. Gerontology 41, 109–120.

Grimby, G., 1995. Muscle performance and structure in the elderly as studied cross-sectionally and longitudinally. J. Gerontol. A. Biol. Sci. Med. Sci. 50 Spec. No., 17–22.

Hagerman, F.C., Walsh, S.J., Staron, R.S., Hikida, R.S., Gilders, R.M., Murray, T.F., Toma, K., Ragg, K.E., 2000. Effects of high-intensity resistance training on untrained older men. I. Strength, cardiovascular, and metabolic responses. J. Gerontol. A. Biol. Sci. Med. Sci. 55, B336–B346.

Hamilton, A., Balnave, R., Adams, R., 1994. Grip strength testing reliability. J. Hand Ther. 7, 163–170.

Hasselgren-Nyberg, L., Omgren, M., Nyberg, L., Gustafsson, Y., 1997. S-COVS: den svenska versionen av physiotherapy clinical outcome variables. Nordisk Fysioterapi 1, 109–113 (in Swedish).

Hirvensalo, M., Lintunen, T., Rantanen, T., 2000. The continuity of physical activity—a retrospective and prospective study among older people. Scand. Med. Sci. Sports 10, 37–41.

Jensen, J., Lundin-Olsson, L., Lindmark, B., Nillbrand, A., Gustafsson, Y., 1998. Bergs balansskala: Prövning av interbedömarreliabilitet. Nordisk Fysioterapi 2, 3–8 (in Swedish).

Judge, J.O., Underwood, M., Gennosa, T., 1993. Exercise to improve gait velocity in older persons. Arch. Phys. Med. Rehabil. 74, 400–406.

Katz, S., Apkom, C.A., 1976. A measure of primary sociobiological functions. Int. J. Health Serv. 6, 493–507.

Larsson, L., 1982. Physical training effects on muscle morphology in sedentary males at different ages. Med. Sci. Sports Exer. 14, 203–206.

Lazowski, D.A., Ecclestone, N.A., Myers, A.M., Paterson, D.H., Tudor-Locke, C., Fitzgerald, C., Jones, G., Shima, N., Cunningham, D.A., 1999. A randomized outcome evaluation of group exercise programs in long-term care institutions. J. Gerontol. A. Biol. Sci. Med. Sci. 54, M621–M628.

Lemura, L.M., von Duvillard, S.P., Mookerjee, S., 2000. The effects of physical training of functional capacity in adults—ages 46 to 90: a meta-analysis. J. Sports Med. Phys. Fitness 49, 1–10.

Littell, R.C., Milliken, G.A., Stroup, W.W., Wolfinger, R.D., 1996. SAS System for Mixed Models. SAS Institute, Cary, North Carolina, USA.

Lord, S.R., Ward, J.A., Williams, P., 1996. Exercise effect on dynamic stability in older women: a randomized controlled trial. Arch. Phys. Med. Rehabil. 77, 232–236.

Malbut-Shennan, K., Young, A., 1999. The physiology of physical performance and training in old age. Coron. Artery Dis. 10, 37–42.

McMurdo, M.E.T., Rennie, L., 1993. A controlled trial of exercise by residents of old people's homes. Age Ageing 22, 11–15.

McMurdo, M.E.T., Rennie, L., 1994. Improvements in quadriceps strength with regular seated exercise in the institutionalized elderly. Arch. Phys. Med. Rehabil. 75, 600–603.

Meuleman, J.R., Brechue, W.F., Kubilis, P.S., Lowenthal, D.T., 2000. Exercise training in the debilitated aged: strength and functional outcomes. Arch. Phys. Med. Rehabil. 81, 312–318.

Morris, J.N., Fiatarone, M., Kiely, D.K., Belleville-Taylor, P., Murphy, K., Littlehale, S., Ooi, W.L., O'Neill, E., Doyle, N., 1999. Nursing rehabilitation and exercise strategies in the nursing home. J. Gerontol. A. Biol. A. Sci. Med. Sci. 54, M494–M500.

Mulrow, C.D., Gerety, M.B., Kanten, D., Cornell, J.H., DeNino, L.A., Chiodo, L., Aguilar, C., O'Neill, M.B., Rosenberg, J., Solis, R.M., 1994. A randomized trial of physical rehabilitation for very frail nursing home residents. J. Am. Med. Assoc. 271, 519–524.

Nelson, M.E., Fiatarone, M.A., Morganti, C.M., Trice, I., Greenberg, R.A., Evans, W.J., 1994. Effects of high-intensity strength training on multiple risk factors for osteoporotic fractures. J. Am. Med. Assoc. 272, 1909–1914.

O'Hagan, C.M., Smith, D.M., Pileggi, K.L., 1994. Exercise classes in rest homes: effect on physical function. N.Z. Med. J. 107, 39–40.

Ottenbacher, K.J., Branch, L.G., Ray, L., Gonzales, V.A., Peek, M.K., Hinman, M.R., 2002. The reliability of upper- and lower-extremity strength testing in a community survey of older adults. Arch. Phys. Med. Rehabil. 83, 1423–1427.

Peolsson, A., Hedlund, R., Oberg, B., 2001. Intra- and inter-tester reliability and reference values for handgrip strength. J. Rehabil. Med. 33, 36–41.

Podsialdo, D., Richardson, S., 1991. The Timed Up and Go: a test of basic functional mobility for frail elderly persons. J. Am. Geriatr. Soc. 39, 142–148.

Przybylski, B.R., Dumont, D.E., Watkins, M.E., Warren, S.A., Beaulne, P.A., Lier, D.A., 1996. Outcomes of enhanced physical and occupational therapy service in a nursing home setting. Arch. Phys. Med. Rehabil. 70, 554–561.

Rhodes, R.E., Martin, D.A., Taunton, J.E., Rhodes, E.C., Donelly, M., Elliot, J., 1999. Factors associated with exercise adherence among older adults: an individual perspective. Sports Med. 28, 397–411.

Rhodes, E.C., Martin, A.D., Taunton, J.E., Donelly, M., Warren, J., Elliot, J., 2000. Effects of one year of resistance training on the relation between muscular strength and bone density in elderly women. Br. J. Sports Med. 34, 18–22.

Rydwik, E., Frändin, K., Akner, G., 2004. Effects of physical training on physical performance in institutionalised elderly patients (70+) with multiple diagnoses—a systematic review. Age Ageing 33, 1–11.

Sale, D.G., 1988. Neural adaptation to resistance training. Med. Sci. Sports Exerc. 20 (Suppl. 5), S132–S145.

Sale, D.G., Martin, J.E., Moroz, D.E., 1992. Hypertrophy without increased isometric strength after weight training. Eur. J. Appl. Physiol. Occup. Physiol. 64, 51–55.

Sauvage, L.R., Myklebust, B.M., Crow-Pan, J., Novak, S., Millington, P., Hoffman, M.D., Hartz, A.J., Rudman, D., 1992. A clinical trial of strengthening and aerobic exercise to improve gait and balance in elderly male nursing home residents. Am. J. Phys. Med. Rehabil. 71, 333–342.

Schnelle, J.F., MacRae, P.G., Ouslander, J.G., Simmons, S.F., Nitta, M., 1995. Functional incidental training, mobility performance and incontinence care with nursing home residents. J. Am. Geriatr. Soc. 43, 1356–1362.

Schnelle, J.F., Mac Rae, P.G., Giacobassi, K., MacRae, H.S., Ouslander, J.G., 1996. Exercise with physically restrained nursing home residents: maximizing benefits of restraint reduction. J. Am. Geriatr. Soc. 44, 507–512.

Seaby, L., Torrance, G., 1989. Reliability of a physiotherapy functional assessment used in a rehabilitation setting. Physiother. Can. 41, 264–270.

Simmons, S.F., Schnelle, J.F., MacRae, P.G., Ouslander, J.G., 1995. Wheelchairs as mobility restraints: predictors of wheelchair activity in non-ambulatory nursing home residents. J. Am. Geriatr. Soc. 43, 384–388.

Stokes, M.E., Davis, C.S., Koch, D.G., 2000. Categorical Data Analysis Using the SAS System, 2nd ed. SAS Institute, Cary, North Carolina, USA.

Taylor, S.E., 1999. Health Psychology. 4th ed. McGraw-Hill, Singapore.

Topp, R., Mikesky, A., Dayhoff, N.E., Holt, W., 1996. Effect of resistance training on strength, postural control, and gait velocity among older adults. Clin. Nurs. Res. 5, 407–427.