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The effects of resistance training on well-being and memory in elderly volunteers

Pasqualina Perrig-Chiello, Walter J. Perrig, Rolf Ehrsam[1], Hannes B. Staehelin[2], Franziska Krings

Institute of Psychology, University of Berne, Muesmattstrasse 45, CH-3012 Bern, Switzerland
[1]Institute of Sports and [2]Geriatric Clinic, University of Basle, Basle, Switzerland

Address correspondence to: P. Perrig-Chiello. Fax: (+41) 61 331 7519. E-mail: pasqualina.perrigchiello@psy.unibe.ch

Abstract

Objective: to determine the short- and long-term effects of resistance training on muscle strength, psychological well-being, control-beliefs, cognitive speed and memory in normally active elderly people.
Methods: 46 elderly people (mean age 73.2 years; 18 women and 28 men), were randomly assigned to training and control groups ($n = 23$ each). Pre- and post-tests were administered 1 week before and 1 week after the 8-week training intervention. The training sessions, performed once a week, consisted of a 10 min warm-up phase and eight resistance exercises on machines.
Results: there was a significant increase in maximum dynamic strength in the training group. This training effect was associated with a significant decrease in self-attentiveness, which is known to enhance psychological well-being. No significant changes could be observed in control-beliefs. Modest effects on cognitive functioning occurred with the training procedure: although there were no changes in cognitive speed, significant pre/post-changes could be shown in free recall and recognition in the experimental group. A post-test comparison between the experimental group and control group showed a weak effect for recognition but no significant differences in free recall. Significant long-term effects were found in the training group for muscular strength and memory performance (free recall) 1 year later.
Conclusion: an 8-week programme of resistance training lessens anxiety and self-attentiveness and improves muscle strength.

Keywords: *cognitive function, elderly people, longitudinal study, memory, physical training*

Introduction

Physical exercise and resistance training may improve, or at least maintain health, physical and psychological well-being and cognitive functioning in elderly people. Although the benefits of physical exercise have been consistently shown for objective health measures (e.g. improvement of cardiorespiratory fitness, favourable physiological changes such as lower serum cholesterol concentrations and increase in bone mineral density [1]), benefits in well-being and cognition have been less consistently demonstrated. Some studies have indicated improvement in, or positive associations with, mood [2], self-esteem [3] and morale [4], and a lower occurrence of depressive symptoms [5, 6]. Others found that few psychological changes could be clearly attributed to a 4-month programme of aerobic exercise training with elderly subjects [1]: there was only a tendency for it to be associated with improved mood and reduced depression scores for men and lower anxiety scores for women.

The results on effects on cognitive performance are even more inconsistent [7-9]. Physical fitness seems to be related to higher attentiveness [10] and to lower reaction time [11-14]. Molloy *et al.* [15] found short-term improvement in cognitive functioning of older adults with memory complaints. In contrast, other researchers have found little if any effect of aerobic exercise on cognitive information processing [1, 4, 16].

Possible explanations for these discrepancies include:

1. Most are cross-sectional studies reporting correlational effects. From these data it is impossible to draw

causal conclusions about the relationships between physical activity and fitness and dependent variables such as well-being or cognitive functioning.

2. Experimental studies are not a guarantee of reliable and valid findings, since they may be only short-term in nature (e.g. due to temporary arousal).
3. Descriptions of variables depend mainly on subjective ratings.

The present study was designed to reduce these methodological shortcomings by using (i) an experimental design in which a group of elderly people who undergo resistance training is compared with a control group, (ii) objective measures (e.g. muscular strength, objective cognitive parameters, etc.) and (iii) longitudinal measures to gain a better understanding of short-term and long-term effects. We have based our rationale on the following assumptions:

1. Muscular strength shows an age-correlated decrease [17] and may result in loss of autonomy and increased disability [17, 18].
2. These more objective factors are associated with subjective perceptions and interpretations: feelings of increased weakness, more complaints, more self-centred thoughts and intensified feelings of depending on others.
3. In spite of inconsistent findings on the relationship between physical exercise and cognition, people engaged in strength training may develop more confidence in their own capacities, become more open to new experiences and social contacts and consequently keep themselves 'mentally fit'. There might be also an improvement of information processing, e.g. an increase in psychomotor speed, free recall and recognition due to better arousal and oxygen supply [7, 4].

Methods

Sample

This is a part of an interdisciplinary longitudinal project, the Interdisciplinary Ageing (IDA) study which aims to investigate the physical, psychological and social predictors of healthy ageing [19]. The IDA study comprises 442 people aged between 65 and 95 years, whose medical data have been collected regularly since 1965. Of this sample, 46 people who expressed interest in planned resistance training were selected for the intervention study. These volunteers (18 women and 28 men; mean age 73.2 years) were randomly assigned to a training and a control group (23 participants each). There were no drop-outs. The purely medical aspects and training-specific effects of the intervention are described elsewhere [20]. Here, we focus on the short- and long-term non-specific psychological effects such as well-being and memory.

Design

Intervention and short-term effects

We used a two-group repeated measurement design. The pre- and post-test procedure was identical for the experimental and control groups.

The independent variables were: group membership (training *versus* control) and time of measurement (pre- *versus* post-training).

Dependent variables, which were assessed in the pre- and post-test procedure were: psychological and physical well-being, control beliefs and memory parameters (free recall, recognition and psycho-motor speed).

Long-term effects

One year after the intervention, we reassessed socio-psychological variables and the muscular strength of the intervention sample. This enabled us to compare the experimental and control groups with the rest of the IDA sample (268 participants) in terms of well-being, control beliefs and memory, which had been assessed 1 year before and 1 year after the intervention. Since these three groups did not differ from each other 1 year before the intervention on these variables, any differences found between the groups could be attributed to the resistance training.

Experimental procedure

Pre- and post-tests were administered 1 week before and 1 week after the 8-week training intervention. The training units, performed once a week, consisted of a warm-up lasting 10 min, followed by eight resistance exercises on machines (leg press, bench press, leg curls, seated row exercise, leg extension exercise, preacher curls, trunk curls and back extension [20]).

Operationalization of the variables

Psychological and physical well-being

To assess psychological well-being we used three subscales from a personality questionnaire [21]: meaning of life, self-attentiveness/self-preoccupation (having self-centred thoughts and being anxious and concerned about themselves and their future) and complaintlessness. Physical well-being was assessed by a 3-point subjective health rating scale.

Control beliefs

We used the four scales of a questionnaire on competence and control beliefs [22]: self-efficacy beliefs, internal control, social-external control and fatalistic-external control.

Memory and cognitive speed

We assessed immediate and delayed free recall by administering a word list (eight words containing two syllables) to the participants. An immediate and delayed recognition test was performed using the same word list, to which eight distractors were added. Cognitive speed was assessed using a digit-symbol test for elderly people (an adapted form of the WAIS subtest [2]), which aims to measure the visuo-motor co-ordination, attention and information processing speed.

Physical strength

A leg extensor power rig was used to determine leg extensor power before and after training [20].

Data analysis

For short-term effects, paired *t*-tests were calculated to determine whether the change between pre- and post-test means within both groups was significant. In addition, unpaired *t*-tests comparing the mean difference between pre- and post-test performance of the treatment and the control group were used.

For long-term effects, *F*-tests comparing the mean difference between the 1993 and 1995 performances of the three groups (treatment group, control group and IDA sample) were used.

Results

Neither group differed on the pre-test procedure on any of the measured variables (Table 1). In addition to a significant increase in muscular strength in the training group ($P < 0.02$; see also [19]), the post-test results showed non-specific short- and long-term training effects.

Short-term effects

Memory

No differences were noted between the groups in immediate and delayed free recall in the post-test comparison. The means and standard deviations of all cognitive pre- and post-test measures are shown in Table 2. The pre- and post-test comparison within groups showed a significant increase in the training group for the delayed free recall [t (22) = 3.33, $P <$ 0.01] and a marginal effect for immediate free recall [t (22) = 1.97, $P = 0.06$]. No significant increases were noted within the control group.

The between-group comparison for immediate and delayed recognition showed slightly, although not significantly higher, mean differences [t (42) = 1.83, $P = 0.07$; t (43) = 1.77, $P = 0.08$, respectively] in favour of the training group. However, paired *t*-test results revealed a significant pre/post-test increase only for the training group—immediate recognition, t (20) = 3.16,

Table 1. Pre-test measurements

	Mean (and SD), by group		
	Training	Control	*P*
Memory			
Free recall			
Immediate	5.5 (1.4)	5.7 (1.8)	0.676
Delayed	5.0 (1.4)	4.9 (2.2)	0.855
Recognition			
Immediate	6.9 (1.2)	7.1 (1.1)	0.559
Delayed	6.9 (1.1)	6.9 (1.1)	1.000
Cognitive speed	39.4 (16.7)	39.7 (12.7)	0.946
Well-being			
Sense of well-being	17.7 (2.8)	18.1 (3.6)	0.676
Self-forgetfulness[a]	17.6 (2.8)	16.7 (2.8)	0.282
Lack of complaining	17.2 (3.5)	18.4 (3.5)	0.251
Subjective health	4.1 (0.6)	4.0 (0.6)	0.575
Control beliefs			
Internality	35.7 (5.0)	33.9 (6.5)	0.298
Powerful others	27.0 (6.8)	25.8 (6.6)	0.547
Chance	27.0 (5.5)	26.3 (7.2)	0.713
Muscular strength (leg extensor power)	63.3 (19.7)	62.6 (18.3)	0.943

[a]Lack of self-attentiveness/self-preoccupation.

Table 2. Memory variables: pre/post-test comparisons within the training and control groups

	Mean (and SD), by group			
	Training		Control	
	Pre	Post	Pre	Post
Free recall				
Immediate	5.5 (1.4)	6.1 (1.4)	5.7 (1.8)	5.9 (1.8)
Delayed	5.0 (1.4)	5.8 (1.3)[a]	4.9 (2.2)	5.4 (2.4)
Recognition				
Immediate	6.9 (1.2)	7.5 (1.0)[a]	7.1 (1.1)	7.2 (1.2)
Delayed	6.9 (1.1)	7.7 (0.7)[a]	6.9 (1.1)	7.2 (1.1)
Cognitive speed	39.4 (16.7)	44.1 (15.5)	39.7 (12.7)	42.3 (13.6)

[a] $P < 0.01$.

$P < 0.01$; delayed recognition, t (22) = 3.30, $P < 0.01$ (Table 2).

For the cognitive speed test (WAIS-NAI) no significant differences were found within groups or between the experimental and control group (see Table 2).

Well-being

No significant pre/post-test changes between or within groups could be observed for the subtest 'sense of well-being'. However a significant increase in 'self-forgetfulness' (lack of self-attentiveness/self-preoccupation) was registered in the training group [t (22) = 2.83, $P < 0.01$] but not in the control group. This result has been confirmed by an additional unpaired t-test: the pre/post-test mean difference for the training group was significantly higher than that of the control group [t (44) = 2.16, $P < 0.05$; Table 3].

For the scale of 'lack of complaints', a marginal effect was found for the training group [t(22) = 1.88, P = 0.07]. At the end of the intervention those who were enrolled in the training group tended to feel physically better than at the beginning. Unpaired t-tests, however, showed no significant differences between the experimental and control groups (Table 3).

The within- and between-group comparisons did not show any effects for subjective health ratings nor for the four scales measuring control beliefs.

Long-term effects

To analyse the long-term effects of resistance training we compared the following variables 1 year before and 1 year after the experimental intervention: muscular strength, subjective health rating, reported sports activity (assessed by the questions: 'Do you regularly perform strenuous exercise' and, if yes, 'Do you perform strenuous exercise at least 3 times a week?'), psychological well-being, control beliefs and memory performance (free recall).

Table 3. Well-being and control beliefs: pre/post-test comparisons within training and control groups

	Mean (and SD), by group			
	Training		Control	
	Pre	Post	Pre	Post
Well-being				
Sense of well-being	17.7 (2.8)	16.9 (3.3)	18.1 (3.6)	18.7 (4.3)
Self-forgetfulness[b]	17.6 (2.8)	16.6 (2.3)[a]	16.7 (2.8)	17.0 (3.1)
Lack of complaining	17.2 (3.5)	16.4 (2.7)	18.4 (3.5)	18.4 (3.2)
Subjective health	4.1 (0.6)	4.2 (0.5)	4.0 (0.6)	4.0 (0.6)
Control beliefs				
Internality	35.7 (5.0)	33.9 (3.8)	33.9 (6.5)	33.5 (7.7)
Powerful others	27.0 (6.8)	25.5 (5.7)	25.8 (6.6)	23.7 (6.2)
Chance	27.0 (5.5)	25.7 (6.0)	26.3 (7.2)	26.0 (7.4)

[a] $P < 0.01$.
[b] Lack of self-attentiveness/self-preoccupation.

The size of the training group increased to 33 in 1997, as 10 more people from the waiting control group completed the training programme (which occurred 8 weeks after the end of the experimental intervention of the first training group). The control group now comprised 19 (13 remaining from the original waiting control group plus six new people interested in the training program). These two groups were compared with the rest of the longitudinal sample ($n = 268$).

The results of the ANOVA show striking long-term effects: those who had been engaged in resistance training still had significantly greater muscular strength 1 year after the intervention than the controls and the total IDA sample [$F = 5.48$ (2,300), $P < 0.0001$]. One year before the intervention, no significant group differences were found [$F = 2.09$ (2,394), $P = 0.13$].

In 1993 the three groups did not differ in the amount of sport undertaken. In 1995, the training group and control group reported significantly more activities than the IDA group [$F = 3.45$ (2,264), $P = 0.03$; Figure 1]. No significant changes could be registered for subjective health ratings, psychological well-being or control beliefs. However, high mean differences were found for free recall. The training group showed higher mean differences between 1993 and 1995 than the control group and the IDA group [$F = 2.90$ (2,303), $P = 0.05$; Figure 2].

Discussion

Elderly people enrolled in an 8-week resistance training programme show a significant increase in muscular strength directly after the intervention and 1 year later. This effect cannot be attributed to the training group being involved in more sports activity. One year after the intervention, it was the control group who reported the highest sports activity (1 year before the intervention the training group, control group and IDA sample did not differ from each other). It might be that the training group had learned to engage in sports in a much more efficient manner, which does not necessarily mean they engaged in sports more often. Since our study group was selected from the members of a larger study population on the basis of their interest in the programme, the effects might represent motivational bias, which has to be taken into account when interpreting our data.

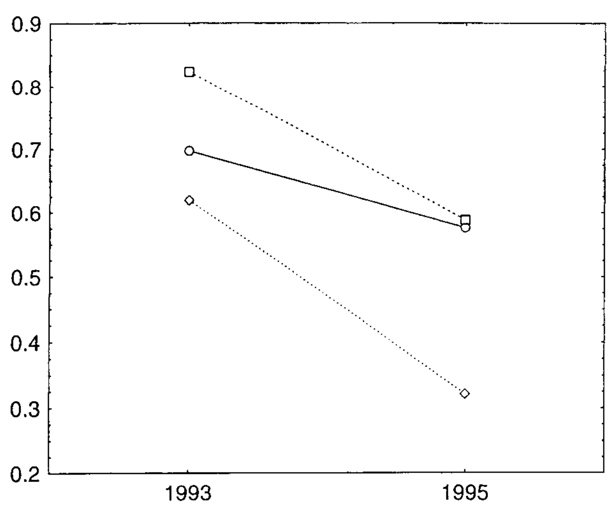

Figure 1. Exercise frequency (frequency score) in 1993 and 1995 for the training (○) and control (□) groups and in the whole Interdisciplinary Ageing Study population (◇).

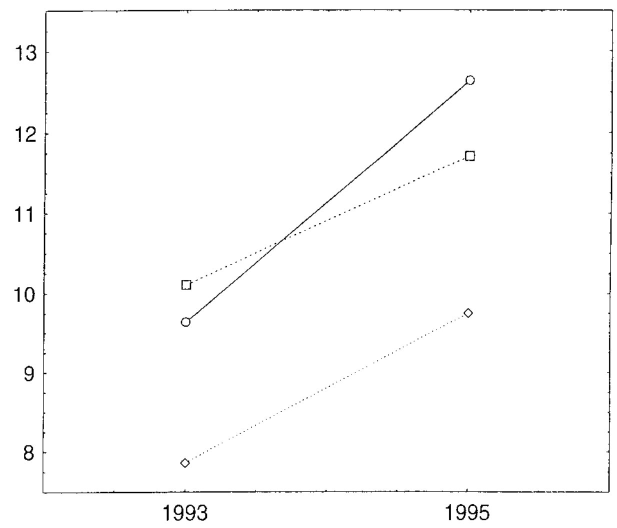

Figure 2. Free recall (word remembered) in 1993 and 1995 for the training (○) and control (□) groups and in the whole Interdisciplinary Ageing Study population (◇).

The specific training effect (increased muscular strength) was associated with such non-specific short-term effects as a decrease in self-attentiveness, which enhances psychological well-being. Contrary to our expectations, the increase in muscular strength was not associated with better subjective health ratings, fewer complaints, greater sense of well-being or improved control belief pattern in either the short or the long term.

The only well-being variable with a significant change was self-attentiveness. Participants from the training group had less self-centred thoughts and were less anxious and concerned about themselves and about their future. According to Safran and Segal [24], people who are less self-centred are more open to new experiences. Perhaps the resistance training, which was performed in a fitness studio equipped with modern and complicated machines, had the side-effect of giving elderly subjects the opportunity of experiencing new and challenging situations. This might have lead to a decrease in anxiety about new experiences.

Subjective health rating and the degree of complaining did not change after the treatment. This may be due to a ceiling effect, since, from the beginning, both training and control groups had had very good subjective health ratings and a high level of non-complaining.

No significant changes were found for the psychological well-being dimension 'sense of well-being' or for the control beliefs. According to McCrae and Costa [25] and Lachman and Burack [26], these variables represent stable personality traits rather than variable states. It might be that our intervention programme was too short to show measurable changes in these personality dimensions.

Our study supports others which have found positive relationships between physical exercise and cognitive function. Even although no training effects were found for psychomotor speed (WAIS digit-symbol) there is empirical evidence that different memory functions are influenced by exercise. We found significant pre/post-test changes in free-recall and recognition in the training group. One year after the intervention, the performance of the training group in free-recall still significantly exceeded that of the control group. Our data do not allow us to make causal explanations of this phenomenon: we cannot state that resistance training *per se* is responsible for the increased memory performance of the training group. It is quite unlikely that our resistance training would have had a monodirectional and ubiquitous effect on memory performance. Intervening variables might also have a modifying effect.

The action of making changes to their habits to create a new situation and the experiences of adhering to a new regime and mastering the new situation might have enhanced participants' motivation to seek new challenges. This openness and self-confidence could be responsible for participants staying physically, socially and mentally active and being self-reliant, all of which are prerequisites for optimal cognitive functioning.

Besides inducing the specific short- and long-term adaptations in muscular strength, resistance training has effects on self-attentiveness and memory functioning. Additional work is needed to explain the mechanisms involved and develop an integrated model of exercise, well-being and cognition.

Key points

- Resistance training in elderly volunteers results in short and long-term increased muscular strength.
- This increase in muscle strength was associated with a lessening of anxiety and self-attentiveness/self-preoccupation.
- There was no corresponding increase in subjective health, well-being or memory in the exercise group.

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