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PHYSICAL FUNCTION PREDICTS IMPROVEMENT IN QUALITY OF LIFE IN ELDERLY ICELANDERS AFTER 12 WEEKS OF RESISTANCE EXERCISE

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Abstract: *Background:* Little is known about the effects of resistance training on health related quality of life (HRQL) in the elderly. *Aim:* The main purpose of the study was to investigate the effects of resistance training on strength, body composition, functional capacity and HRQL in independent living elderly people. We hypothesised that resistance training would improve lean mass, muscle strength, physical function and HRQL. *Methods:* Subjects (N = 237, 73.7±5.7yrs, 58.2% female) participated in a 12-week resistance exercise program (3 times/week; 3 sets, 6-8 repetitions at 75-80% of the 1-repetition maximum) designed to increase strength and muscle mass of major muscle groups. Body composition, quadriceps- and grip strength, timed up and go test (TUG), six minute walk for distance (6MW) and HRQL were measured at baseline and endpoint. *Results:* Two hundred-and-four participants completed the study. Although the increase in lean mass was small (+0.8 kg, P<0.01), quadriceps strength (+53.5N), grip strength (+3.0lb), TUG (-0.6sec), 6MW (+33.6m) and HRQL (+1.2 t-score) improved significantly (all P<0.01). Changes in 6MW predicted improvement in HRQL after 12 weeks. *Conclusions:* Our study shows that a 12-week resistance exercise program significantly improves lean mass, muscle strength, physical function and HRQL in elderly individuals, and that improvements in physical function predict improvements in HRQL. Our study indicates that resistance training should be promoted for the elderly as it has the potential to improve physical performance, thereby prolonging healthy, independent aging.

Key words: Health related quality of life (HRQL), resistance exercise, elderly people, function, 6 minute walking distance.

Background

Health related quality of life (HRQL) measures have been denoted as measures that assess well-being and wellness associated with different medical diseases and conditions that impair function or cause symptoms (1).

Physical function is associated with HRQL where functional performance affects mobility, usual daily activities and self-care (2). The main factor in the loss of functional performance in the elderly is the progressive loss of skeletal muscle mass that naturally occurs with aging (3, 4). The loss of muscle mass is escalated with inactivity and malnutrition and is accelerated after the age of sixty (5). These changes in muscle mass may have adverse consequences such as functional impairments, loss of independence, frailty and ultimately death (6-9). Muscle weakness appears to be an independent risk factor for falls in older adults and falls are a growing public health concern due to high healthcare costs associated with their treatment and secondary complications (10). The population of elderly people aged 65 and over, started to rise sharply in the latter part of the 20th century (11), which has a major financial impact on our healthcare system (12). In order to maintain an independent lifestyle it is essential for elderly people to preserve muscle mass and strength.

There is evidence that resistance training can increase muscle mass and strength, reduce the difficulty of performing daily tasks and promote participation in spontaneous physical activity (13, 14).

Previous studies have investigated the effects of resistance training on strength and lean mass (15). However, little is known about the effects of resistance training on HRQL in the elderly. It is particularly important to evaluate the effects of resistance exercise on HRQL of healthy elderly individuals, as it has been proposed that high priority should be given to the development of strategies to preserve and enhance muscle power in older adults (16). The main purpose of the study was therefore to investigate the effects of resistance training on strength, body composition, functional capacity and HRQL in healthy elderly people. We hypothesised that resistance training would improve lean mass and muscle strength which would in turn increase physical function and result in improved HRQL.

Methods

Subjects

Participants (n= 238) were 65 years and older (range 65-92 years old) and were recruited by advertisements posted in the Reykjavik area. Exclusion criteria were low cognitive function (Mini-Mental State Examination (MMSE) <19 points), (17) evidence of uncontrolled coronary heart disease (CHD), major orthopaedic disease, and pharmacological interventions with exogenous testosterone or other drugs known to influence muscle mass. Furthermore, participants had to be free of any musculoskeletal disorders or other disorders that could affect their ability to complete the training and testing. Enrolled subjects were apparently healthy, although some had milder forms of hypertension, hyperlipemia, diabetes type 2 or other

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diseases which often are associated with older age. When cardiovascular symptoms were detected during screening, the participant was encouraged to contact their physician to verify whether they were allowed to participate or not. The study was approved by the Icelandic National Bioethics Committee (VSNb2008060007/03-15) and informed written consent was obtained from all participants.

Study design and intervention

The subjects participated in a 12-week resistance exercise intervention program which was designed to increase strength and muscle mass of all major muscle groups. All data were obtained at baseline and again at the end of the study period.

Subjects exercised for three non-consecutive days per week for 12 weeks in groups of 20-30 individuals. The first week was used to teach correct exercise techniques at lower loads (60% of 1-repetition maximum (RM)). Thereafter, resistance training involved 3 sets, where each exercise was repeated 6-8 times, at 75-80% of their 1-RM. The training load was systematically increased by 5-10% each week in order to keep the number of repetitions per set between six and eight. Each exercise session started with a 10-15 minute warm up after which resistance training with weights on all major muscle groups was performed. Stretching exercises were performed at the end of each session. Each session was supervised by study staff, an athletic trainer, and occasionally a physical therapist.

Body composition

Body composition was assessed by dual energy x-ray absorptiometer (DXA, Hologic QDR-2000 plus®, Hologic Inc., Waltham, MA, USA). The DXA measurements were conducted at the Icelandic Heart Association, Kopavogur, Iceland.

Body weight was measured in light underwear on a calibrated scale (model no. 708, Seca, Hamburg, Germany). The subjects' height was measured with a calibrated stadiometer (model no. 206; Seca, Hamburg, Germany). Body mass index (BMI) was calculated from height and weight [kg/m^2].

Physical function

Subjects underwent pre- and post-intervention testing of physical function, including the timed up and go (TUG) test in seconds and a six minute walk for distance (6MW) in meters. To evaluate muscle strength, grip strength and knee extensor muscle strength were measured.

Grip strength was measured with a hydraulic hand dynamometer (Baseline ® Baseline Evaluations Corporation) and the maximal grip strength of three trials was registered as the subject's grip force in pounds (lbs).

Quadriceps strength (maximum voluntary isometric contraction (MVIC)) was tested with an isokinetic dynamometer (Kin-Com ® 500H Chattanooga). The subjects performed three submaximal trials and then performed four MVIC tests for five seconds each, with a 50 second rest between tests. The greatest output was recorded as the peak torque expressed in Newton's (N).

Physical activity was assessed by self-reports as total minutes per week and by a yes/no question; "Do you practice regular physical activity?"

Health related quality of life

The HRQL questionnaire has 12 domains that cover a range of psychological and physical functions; functional status, vitality, social function, physical pain, emotions, general health and mental health. The domains are summarized into a single general score; quality of life. Each sub-scale in the instrument is calculated for men and women in different age groups and is converted to a T-score (T-score norm is 50 ± 10). The HRQL questionnaire was developed based on several questionnaires that were intended to measure health related quality of life. An Icelandic translation of these questionnaires was presented to 147 individuals, following a detailed cluster analyses of the answers it was decided to develop the instrument, (18) later two questions concerning memory and concentration were added later. This new version of the questionnaire has been tested for the Icelandic population, and used to assess HRQL (19).

Statistical analysis

The data were entered into the SPSS statistical package, version 18.0 (SPSS, Chicago, IL, USA). Data are described as a mean ± standard deviation (SD). Differences between individuals who dropped out and those who completed the study were calculated using the independent-samples T test and Mann-Whitney test.

The paired t-test was used to compare baseline and endpoint variables and the Wilcoxon test was used to analyse differences between baseline and endpoint variables within the HRQL test and other non-parametric variables. The one-sample Wilcoxon signed ranks test was used to compare baseline HRQL with normal values for gender and age matched Icelanders.

Pearson's and Spearman's correlations were carried out to assess the non-adjusted relationship between HRQL, lean mass, strength and function.

Hierarchical regression analyses were performed to determine the explained variance of the endpoint HRQL. In the hierarchical regression analyses, baseline HRQL was entered as a first block, background variables, i.e. age and gender, as a second block, habitual physical activity at baseline as a third block, change in lean mass as fourth block, change in strength as fifth block, and change in function as a sixth block. Standardized regression coefficients (Beta) are given for each scale. For each step in the model, the adjusted variance and the change of variance are given. The unstandardized coefficients B from the final hierarchical regression model were used to predict the change in HRQL during the intervention (Figure 2). The significance niveau was set at $P \leq 0.05$.

Table 1
Characteristics of the participants (All values are in mean ± standard devition)

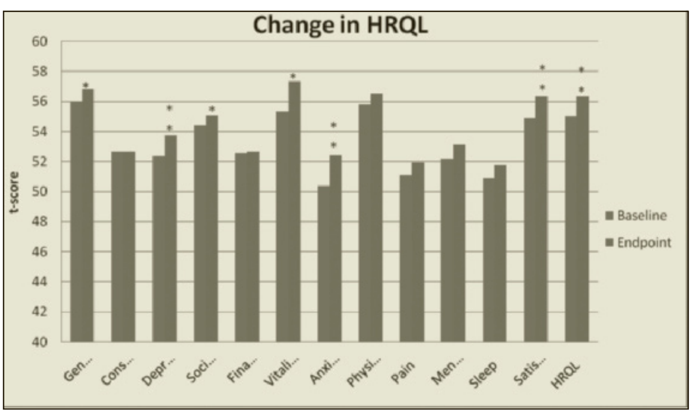
Age (years)	All (n = 237) 73.7 ± 5.7			Men (n = 99) 74.8 ± 5.9			Women (n = 138) 72.9 ± 5.4		
	Baseline	**Endpoint**	**P†**	**Baseline**	**Endpoint**	**P†**	**Baseline**	**Endpoint**	**P†**
BMI	28.8 ± 4.8	28.9 ± 4.8	< 0.001	29.6 ± 4.6	29.8 ± 4.6	0.001	28.2 ± 4.9	28.2 ± 4.8	0.079
Lean mass (kg)	48.1 ± 9.9	48.9 ± 10.1	< 0.001	57.0 ± 7.6	58.3 ± 7.3	< 0.001	41.2 ± 4.6	41.7 ± 4.3	0.013
Quadriceps strength (N)	467.1 ± 123.2	520.6 ± 130.8	< 0.001	544.9 ± 122.1	600.0 ± 130.8	< 0.001	411.1 ± 89.1	463.5 ± 97.0	< 0.001
Grip strength (lb)	62.9 ± 18.9	65.9 ± 19.5	< 0.001	77.5 ± 17.7	80.5 ± 18.7	< 0.001	52.3 ± 11.0	55.3 ± 11.8	< 0.001
6MW *(m)	462.5 ± 73.1	496.1 ± 75.5	< 0.001	466.9 ± 76.9	498.2 ± 85.5	< 0.001	459.1 ± 70.2	494.8 ± 66.9	< 0.001
TUG§(sec)	7.7 ± 1.7	7.1 ± 1.7	< 0.001	7.8 ± 1.7	7.2 ± 1.6	< 0.001	7.6 ± 1.7	7.0 ± 1.7	< 0.001
HRQL	55.0 ± 6. 3	56.2 ± 5.6	< 0.001	55.2 ± 6.2	55.8 ± 5.7	0.076	54.9 ± 6.4	56.4 ± 5.5	< 0.001

§TUG = Timed up and go test is weighed negatively ie. lower time is better; *6MW = Six minute walking distance; †P-value = Paired t-test between endpoint and baseline. Statistical significant are considered when P < 0.05

Results

At baseline 237 participants started the 12 weeks program and 204 participants completed the study. Subjects' characteristics are listed in Table 1. The majority (82%) of the participants reported regular physical activity at baseline and two-thirds reached the recommended level of 30 minutes per day (20). Baseline HRQL was higher than the Icelandic norm matched for age and gender (Δ = 5.0, P < 0.001).

Figure 1
Change in HRQL domains and total HRQL after the intervention

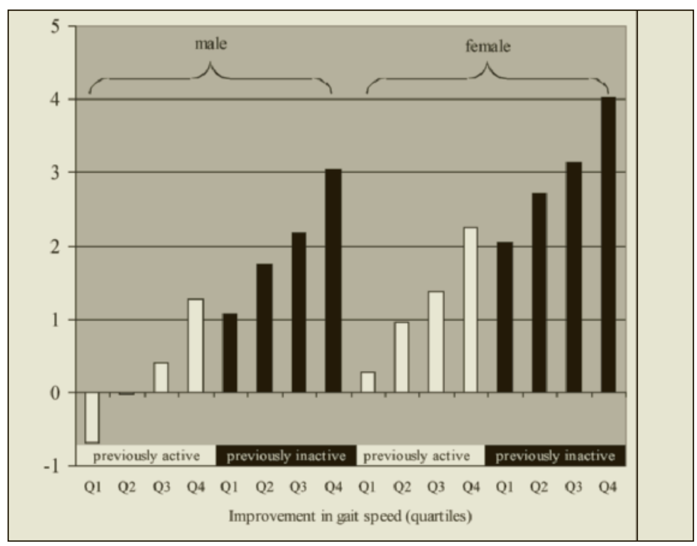


*P < 0.05; ** P < 0.001

Reasons for dropping out were illness and falls at home (n = 22), some participants didn't like the program (n = 8) while others had to quit because of previously diagnosed musculoskeletal problems (n = 3). At baseline drop outs were significantly older (P = 0.001), had less quadriceps strength (P = 0.002) and grip strength (P = 0.016). Drop outs had less 6MW-distance (P = 0.006), slower TUG-test (P = 0.003), and a lower HRQL-score (P = 0.037). No gender difference was found for drop outs.

On average, all outcome parameters, i.e. lean mass, strength, physical performance parameters and HRQL (Figure 1), improved significantly both for men and women taken together after the 12 weeks period of intervention (Table 1). Figure one shows changes in HRQL domains before and after the intervention.

Figure 2
Predicted changes in HRQL separately shown by gender, baseline physical activity and improvement in 6MW distance



The regression model (Table 2) explained 70.7% of the variance in endpoint HRQL. The background factors of the model as well as functional change contributed significantly to the variance in endpoint HRQL although change in lean mass and strength did not contribute significantly to the explanation.

The predicted changes in HRQL, shown by gender, baseline physical activity and improvement in 6MW distance (in quartiles), can be seen in Figure 2. The figure shows that lower baseline physical activity and higher increase in 6MW distance were associated with greater improvement in HRQL.

Table 2
Hierarchical regression model explaining the variance in HRQL

	Block 1		Block 2		Block 3		Block 4		Block 5		Block 6	
	Beta	P-value	Beta	P-value	Beta	P-value	Beta	P-value	Beta	P-value	Beta	P-value
Baseline HRQL	0.810	< 0.001	0.815	< 0.001	0.841	< 0.001	0.848	< 0.001	0.851	< 0.001	0.845	< 0.001
Gender (male)			-0.084	0.068	-0.089	0.050	-0.100	0.030	-0.101	0.029	-0.096	0.034
Age (years)			-0.067	0.142	-0.076	0.093	-0.074	0.100	-0.063	0.176	-0.053	0.250
Physical activity					-0.123	0.008	-0.125	0.007	-0.124	0.007	-0.121	0.008
Change in lean mass							0.056	0.216	0.055	0.233	0.048	0.283
Change in quadriceps									0.015	0.746	-0.002	0.961
Change in grip									0.040	0.377	0.057	0.207
Change in 6MW											0.137	0.003
Change in TUG											0.045	0.334
Adjusted R^2	0.657		0.670		0.678		0.676		0.689		0.689	
R^2 change	0.657	< 0.001	0.013	0.039	0.014	0.008	0.016	0.216	0.002	0.624	0.017	0.013

Discussion

In the present study we investigated the effects of resistance training on physical performance and HRQL among healthy elderly. As hypothesized, lean mass, physical strength, physical function and HRQL improved after 12 weeks of resistance exercise. Changes in function and habitual physical inactivity at baseline explained a significant portion of the variance in endpoint HRQL while changes in muscle mass and strength did not.

The most important finding in this study is that improved physical function, i.e., 6MW distance predicts the improvement in HRQL after 12 weeks of resistance exercise. The average increase in 6MW distance in this study was 33.8 ± 34.8 meters and Holland et. al (21) reported that minimal important differences for chronic obstructive pulmonary disease (COPD) patients to experience more fitness were 25 m in 6MW distance test which is in agreement with our results. Previous studies have shown that physical fitness is associated with HRQL and that resistance training improves muscle strength and gait speed in elderly (22, 23). However, it has not been demonstrated before that resistance exercise increases HRQL and that this improvement is partly mediated by increased physical function. This study shows that increased HRQL score was in association with increased 6MW distance in quartiles. In order to visualize the association between HRQL and function, Figure 2 shows the predicted change in HRQL, dependent on the improvement in 6MW distance. The highest quartiles for 6MW change increased more than the lowest quartiles. This 2 unit difference was not affected by physical activity at baseline or gender.

Older adults who have low levels of physical activity are likely to have declined cardio respiratory fitness and muscle strength which may reach levels that are incompatible with some aspects of functional independence (24). Thus, it is important to maintain fitness and muscle strength to manage activities of daily living and preserve independence.

The predicted changes in HRQL scores are also affected by habitual physical activity at baseline, where inactive participants increased their HRQL more after the intervention than participants who were physically active at baseline. One explanation is that physically active and well functioning participants already had a high HRQL score and gait speed at baseline. This could have introduced a ceiling effect, thereby making it difficult for them to further improve performance and HRQL (25).

Although the mean changes in HRQL were small, Figure 2 shows that certain individuals (e.g., women, physically inactive individuals) benefit more than others from such an intervention. It is difficult to evaluate the clinical relevance of the magnitude of HRQL changes in apparently healthy elderly people. However, in comparison, a study comparing pre- to post-treatment HRQL scores of patients undergoing coronary catheterization showed a smaller effect on HRQL (26).

Although statistically significant, the changes in lean body mass (2%) were small compared to the substantial increase seen in quadriceps strength (12%) and no correlation was seen between the two (results not shown), which is consistent with previous reports (27). Strength gains without associated alterations in body composition but better functional status as seen in the present study reflect enhanced neural adaptation in the early stages of training (28).

Not all domains of the HRQL questionnaire improved equally after the intervention. Significant changes were observed for several mental and physical domains which have been previously shown in studies investigating exercise and quality of life (29, 30) and these are in accordance with known effects of exercise on mild depressive symptoms (31) and anxiety symptoms (32).

Limitation

There was no control group in this study. However, a group of elderly people would not be expected to spontaneously increase their muscle mass, strength or function without intervention over a 12 week period.

The participants' mean baseline HRQL score was significantly higher than the norm of elderly Icelanders, which may have introduced a ceiling effect with respect to improvements over time, particularly among those participants who were most physically fit at the beginning of the study period. Significant effects were nonetheless found.

Conclusion

Our study shows that a 12-week resistance exercise program significantly improves lean mass, muscle strength, physical function and HRQL, and that improvements in physical function predict improvements in HRQL.

The ability of resistance exercise to prevent and postpone muscle weakness is likely an important factor in maintaining independence of the elderly and prolonging healthy aging.

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Competing interests: The authors declare that they have no competing interest. All authors are responsible for the reported research. O.G.G. worked on the statistical analysis and wrote the first draft of the manuscript. A.A., K.B. and A.R. participated in the designing the study and project planning. A.R. participated in the data analysis. K.T. is author of HRQL questionnaire and participated in final work of manuscript. I.T. was the project leader and participated in all part of the work. All authors provided critical revision of the paper, and read and approved the final manuscript.

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