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The Effect of Strength Training on the Quality of Life and Cognitive Functions of Elderly People

Ernesta Klimavičiūtė, Sandra Naujalė, Lina Mickevičienė, Erika Krasinskė, Margarita Drozdova – Statkevičienė, Vida Janina Česnaitienė
Lithuanian Sports University, Kaunas, Lithuania

ABSTRACT

Background: The evidence from research shows positive effects of physical exercise, both aerobic and resistance training, and their combination, on cognitive performance. Possible biological mechanisms that may underlie the effectiveness of physical exercise include increased blood flow in the brain, changes in neurotransmitter release, and the process of neurogenesis (Sumińska, 2021). However, there is still a lack of sufficient research on the relationship of physical exertion and aging, and their interaction. New research is looking for the best tools and methods to improve the quality of life of older people.

Methods: This study evaluated 65 non-exercising men over the age of 60. The participants were divided into groups of restricted blood flow training (BFRT), concentric training (MDRT) and control groups. Strength training in which leg pressing, leg bending and leg extension exercises were performed lasted 12 weeks. The short version of the World Health Organization (WHO 100) Quality of Life Questionnaire was used to assess quality of life, the subjects' physical abilities were evaluated using the Fullerton Test set, and ANAM4 cognitive function tests were used to assess cognitive functions.

Results: When comparing restricted blood flow, concentric training and control groups, the results of the functional test evaluation were improved statistically significantly: standing and walking, standing up from a chair ($p<.001$). The result of the hand grip test did not change significantly. The results of the quality of life assessment deteriorated statistically significantly in all the groups: in the areas of physical health, social relations and environment ($p <.001$), and in the area of psychological health ($p=0.001$). When evaluating cognitive functions we found that only inhibition function (Go/No Go) improved significantly ($p<.001$).

Conclusion: The study found that regardless of the type of strength training, the quality of life of elderly did not improve. Both types of training resulted in statistically significant improvements in cognitive inhibitory function in older adults.

Keywords: strength training, elderly, aging, cognitive function, life quality

INTRODUCTION

In recent decades we have witnessed a gradual aging of society. According to the data of the Lithuanian Statistics Department (2023), there were a quarter (25%) fewer children (0–14 years) than elderly people. It is believed that by 2050, there will be two million Lithuanian residents left, of which more than half a million over 65 years of age (Šurkienė, Stukas, Alekna & Melvidaitė, 2012).

Normal aging is usually associated with a decline in physical capacity and cognition. Cognitive functions that deteriorate with age include time and space oriention, attention, language, memory and executive function disorders (Molton & Jensen, 2010). The weakening of physical capacity and cognitive functions that most elderly people experience means not only a deterioration in the quality of life, but a decrease in the daily life possibilities, social and psychological difficulties as well. (Xu et al., 2023).

Physical exercise is said to improve cognitive function by promoting neurogenesis, angiogenesis, synaptic plasticity, reducing inflammatory processes, and reducing cellular damage due to oxidative stress. Many experiments and clinical trials have shown that physical exercise can improve cognitive function in older adults (Pedroli et al., 2018). Regular physical activity of elderly people can promote the maintenance, improvement or rehabilitation of biological processes, and slow down the decline of age-related cognitive functions (Xu et al., 2023). Evidence from research shows positive effects of physical exercise, both aerobic and resistance training, and their combination, on cognitive performance. Possible biological mechanisms that may underlie the effectiveness of physical exercise include increased blood flow in the brain, changes in neurotransmitter release, and the process of neurogenesis (Sumińska, 2021). However, there is still a lack of sufficient research on the relationship between exercise and aging. New research shall find the best tools and methods to improve the quality of life of older people.

Based on the analysis of scientific literature, we hypothesize that 12 weeks of training will improve the quality of life and cognitive functions of older men.

Objective: to determine the effects of strength training on quality of life and cognitive function in elderly people.

Tasks:

To determine and compare the effects of different types of strength training on the quality of life of older people.

To determine and compare the effects of different types of strength training on cognitive functions in elderly people.

METHODS

Research participants

The 65 participants were elderly, healthy, non-exercising men over the age of 60, who agreed to participate in the study. All the subjects' data were coded to preserve confidentiality. The subjects were divided into blood flow restricted training group (BFRT), concentric group (MDRT) and control group. The data of the subjects are presented in Table 1.

Table 1: **Distribution of subjects' data in groups**

	BFRT group	MDRT group	Control group
N	21	23	21
Age (mean ± SN)	66 ±5.4	67 ±4.1	66±3.1

RESEARCH METHODS

1. A computer program ANAM4™ TBI Battery (angl. Automated Neuropsychological Assessment Metric, version 4) was used to assess cognitive functions. Four tests were used from this package: for reaction time (2-Choice reaction time), for memory (Memory Search); to determine the ability to inhibit (Go/No Go), calculation skills, concentration and working memory index (Mathematical Processing). Test results were expressed in the number of correct answers.
2. To assess the quality of life, we used the World Health Organization Quality of Life Questionnaire (WHOQOL-BREF) which is a shortened version of the long WHOQOL-100 questionnaire. WHOQOL-BREF includes 26 questions that assess quality of life in the domains of physical health, mental health, social relationships, and environment.
3. The physical capacity of the elderly was assessed with functional tests. The hand grip test assessed absolute strength; with the "Timed Up and Go" test we evaluated coordination and walking speed; "Standing up from a chair" test was used for leg muscle strength evaluation; and body composition was analyzed with an analyzer Tanita TBF-300-A.

Statistical analysis. Research data analyses were performed using Microsoft Excel, IBM SPSS 29.0, and JASP 0.18.3. Means and differences before and after the intervention were calculated. The Repeated Measures ANOVA Test was used. Differences in results were considered statistically significant at the level of statistical significance ($p<0.05$).

STUDY DESIGN

This experimental study was conducted at the Lithuanian Sports University between October 2022 and December 2023. The study was approved by the regional bioethics committee (Nr.

2022-BE-10-0012.), signed and approved by each participant in the study.

The training lasted for 12 weeks and included leg press, leg curl and leg extension exercises. There were 2 training sessions per week, 60 minutes each for 12 weeks.

Figure 1: **Examples of exercises performed during the training**.

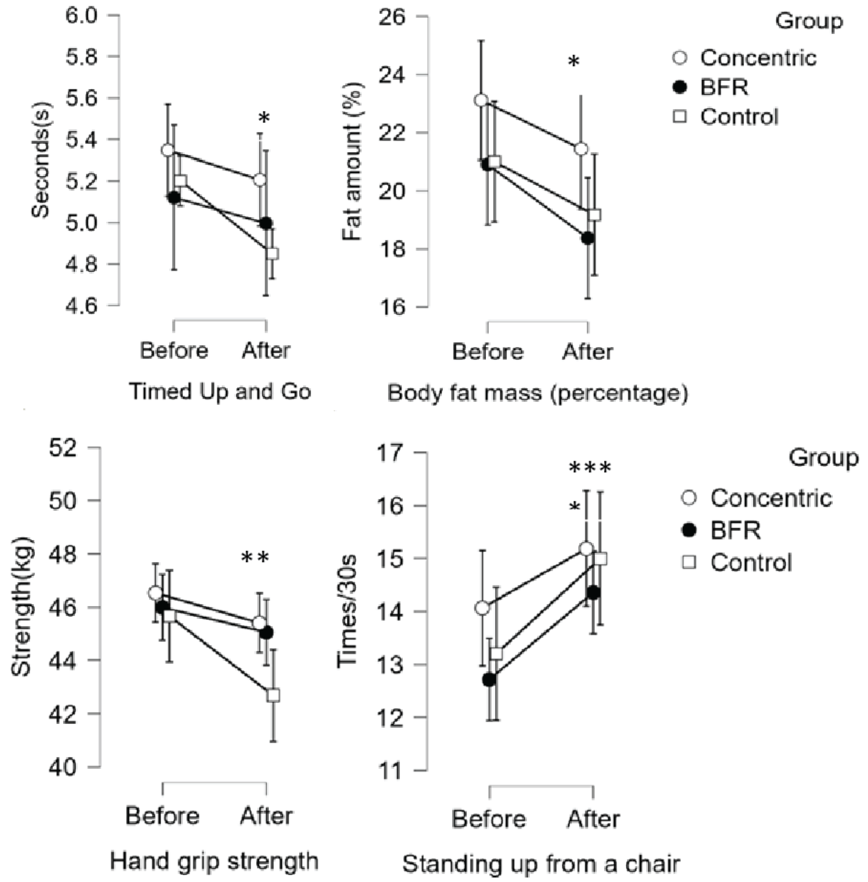
The first group was the BFRT strength training group. Each of the participants performed three strength training exercises with blood flow restriction at 40% of 1RM, with 30:15:15:15 repetition ratio, 30 seconds rest between sets and 5 minutes rest between exercises. The second was the MDRT strength training group. Every third workout, an eccentric overload of 120% of 1RM was performed with 4:4:4:4 repetition ratio, and regular concentric training was performed at 80% of 1RM with 6:6:6:6 repetitions, 2 minutes of rest between sets and 3 minutes between exercises. The third , the control group, did not perform any physical exercises and was physically inactive.

RESULTS

Effects of different types of training on the functional abilities of elderly men

The results of the research showed that the assessments of functional abilities of elderly men after the strength training were better than before the training cycle, with the exception of hand grip strength. The results of the functional test evaluation in the restricted blood flow training group, concentric training group and control group have improved statistically significantly: timed up and go, standing up from a chair ($p < 0.01$). The result of the hand grip functional test did not change significantly in the BFRT and concentric groups, except in the control group where the decrease was significant ($p < 0.01$). Fat body mass measurements changed statistically significantly in concentric and BFRT groups ($p < 0.01$). There were no significant differences between strength training groups.

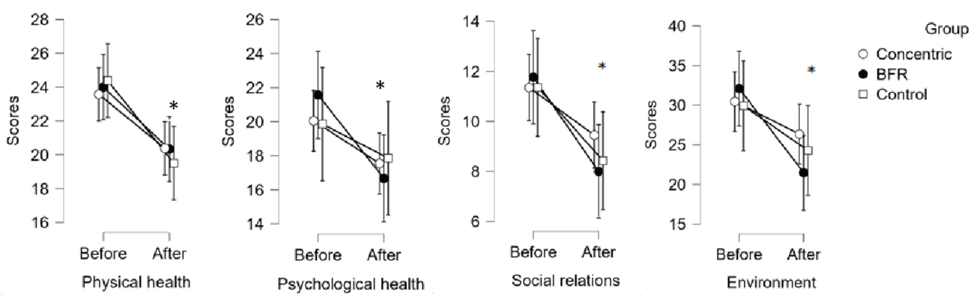
Figure 2: **Mean distribution of daily function assessment results of elderly men before and after 3 months strength training cycle. Note: * - p<0.05 compared to the pre-intervention results in all groups. ** - p<0.05 compared to the results before the intervention in the control group. *** - p<0.05 compared to the results before the intervention in the control and concentric group. **** - p<0.05 compared to the results before the intervention in the concentric and BFR group.**



Effects of different types of training on the quality of life on elderly men

Research results have shown that older men rated the quality of life as worsening after strength training compared to that before the training cycle. The restricted blood flow, the concentric strength training and the control group quality of life assessment results were statistically significantly worse: in the areas of physical health, social relationships and environment (p<.001), and in the area of psychological health (p=0.001).

Figure 3: **Mean distribution of the quality of life assessment result of older men (in points) before and after 3 months strength training cycle. Note: * - p<0.05 compared to the pre-intervention results. ***



Effects of different types of training on cognitive function indicators in elderly men using ANAM tests

ANAM tests were used to evaluate the effect of different types of training on the cognitive functions of older men. Only correct answers were counted in the results.

In the concentric strength training and control groups, there was a significant improvement in inhibitory function in the "Go/No Go" test (p<.001). We found no significant changes in memory, perception of space and reaction tests in all groups. There were also no significant differences between the groups.

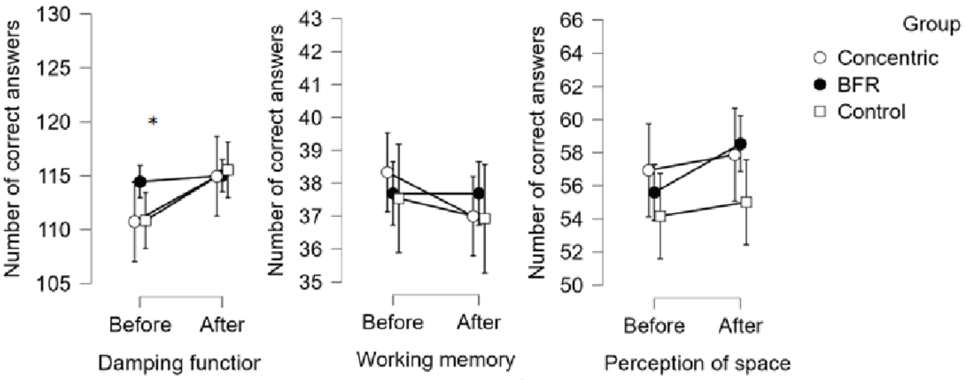


Figure 4: **Mean distribution of cognitive functions assessment results (number of correct answers) in elderly men before and after 3 month strength training cycle. Note: * - p<0.05 compared to the results before the intervention in the control and concentric groups.**

DISCUSSION

It is already known that the loss of muscle strength is one of the most prominent and problematic conditions in the elderly (Cannataro et al., 2022). 50–70 year olds lose about 8% of muscle mass per year (Larsson, 2019). A review of 29 randomized trials involving 1313 older adults over the age of 65 found that muscle strength improvement depended on the intensity of the weight training (McCormick & Vasilaki, 2018). High-intensity strength (resistance) training above 75 percent of maximal capacity was more effective at increasing strength, compared to that of moderate or low-intensity training (McCormick & Vasilaki, 2018). The results of the 13-month strength training study among two age groups, women over 65, and men over 60 years of age, showed significant gains in strength, although no differences were observed between the groups. (Marriott et al., 2021). Our study also showed no significant differences between strength training groups.

Physical activity, including strength training, has been shown to increase blood flow in the brain, improve neuroplasticity and reduce the inflammatory response (Li, 2018). These changes are important for maintaining cognitive function and may benefit older adults by reducing cognitive functions decline. In our study, the cognitive functions assessed by the ANAM tests show changes in cognitive functions: Go/No Go test, i.e., inhibition ability, there were detected significant differences after 3 months of training (except for the concentric group) (p<.001). No significant differences were found in memory, math (spatial awareness) and reaction tests. Amarya (2018) observed that the improvement in the executive function was greater after moderate load (70% iš 10RM) than after light load (40% iš 10RM). In our study, no significant differences were found between the BFRT and MDRT groups, regarding the evaluation of the cognitive functions before and after the training cycle. Therefore, although the improvement in cognitive function is not as obvious as the increase in physical capacity, it can still be assumed that strength training provides important benefits for brain health, supporting cognitive activity and reducing the risk of cognitive impairment. Nagamatsu et al., (2012) reported that 6 months of strength training improved memory in older adults with mild cognitive impairment (MCI). In yet another systematic review, researchers came to a conclusion that after a 16-week intervention with healthy older adults, reaction time on the Stroop test improves. And after 52 weeks of resistance training, older adults who did resistance exercise twice a week performed better on executive function tasks (i.e., Stroop test) than those who did balance and mobility exercises (Liu-Ambrose, Nagamatsu, Voss, Khan and Handy, 2012 m.). However, in the same study, no statistically significant differences were observed in the assessment of cognitive function before and after the training cycle between the resistance exercise group and the no-load movement group.

This can be interpreted as a hint that continuous strength training preserves or significantly improves cognitive function only in people with mild or severe cognitive impairment (Nagamatsu, Handy, Hsu, Voss and Liu-Ambrose, 2012). Therefore, we assume that the fact that the subjects were in a good condition prevented the detection of significant differences in the study.

A 12-month twice-weekly resistance training program significantly improved ANAM test scores in healthy, non-cognitively impaired women aged 65–75 years. However, various studies have subsequently shown improvement after as little as six months of strength training in women aged 70 to 80 with possible mild cognitive impairment (Herold, Törpel, Schega, Notger, Müller, 2019). This shows that in a short-term perspective, in order to evaluate the effect of the intervention, subjects with a worse cognitive function are more sensitive to the study. To see a significant difference, subjects with a mild cognitive impairment are more sensitive to the study. Resistance training, performed twice a week for 26 weeks, showed a significant increase in gray matter thickness in the posterior cortex. It is in that area of the brain that greater activicty and increased thickness were associated with improved global cognitive performance and perception. (Suo et al., 2016). Since not all the results of the assessment of cognitive functions were statistically significantly changed in our study, we can only assume that the 3-month training cycle is too short to detect differences in the brain, which is responsible for cognitive functions.

Our study showed that leg muscle strength and dynamic balance improved significantly after a 12-week strength training cycle in older men. The exception was the hand grip strength test, which did not demonstrate any significant changes. This may be related to the fact that specific training of hand strength was not emphasized during training. Similar studies such as Liu, Shiroy, Jones and Clark, (2014), have shown that specific upper body strength training is necessary to achieve significant changes in hand grip strength in older adults.

Physical function tests “Timed Up and Go” and “Standing up from a chair” showed significant improvement (p >0.001). These results are similar to the findings of a study conducted by Liu, Shiroy, Jones and Clark, (2014) which found that this type of functional test was a good predictor of post-exercise changes in the physical performance of seniors, and at the same time, it could be concluded that strength training has a positive effect on seniors’ physical condition and helps maintain their independence.

When conducting the study, it was found that assessments of the quality of life significantly worsened: in the areas of physical health, social relations and environment (p<.001), and in the area of psychological health (p=0.001). This paradox may be related to the initial adaptation period to the new training routine, which may cause discomfort or even stress to the participants. In addition, it is important to mention that the aging process itself may be associated with changes in the perception of quality of life. Similar results were described by Hart & Buck, (2019), where the study found that despite the improvement in physical health, psychological adaptation to new life challenges may interfere with the perception of quality of life. Even though the study found that quality of life assessments got worse, it is important to take into account the possible nuances of filling out the questionnaire, which could have influenced the results. There is a possibility that the data of the quality of life questionnaire may be distorted due to the fact that the questionnaire was filled out in a negligent manner. Such filling of the questionnaire can be determined by various factors: mood, physical well-being, or inadequate briefing before filling out the questionnaire.

An important aspect is the possible multifaceted effect of strength training. But in order to achieve certain results, it is necessary to take into account the results of already conducted studies and their recommendations. When all the data are taken together, the different training groups (BFRT and MDRT) show similar results, which are not significantly different from each other. This suggests that various forms of strength training may benefit older adults. These results confirm that, even in older individuals, multi-strength training significantly increases muscle strength, which is closely related to daily functionality and may reduce age-related injury risk.

CONCLUSIONS

1. The study showed that regardless of the type of strength training, the quality of life

of older people did not improve. On the contrary, the quality of life evaluation indicators were statistically significantly worsened in all areas of life quality.

2. Both types of training statistically significantly improved cognitive inhibitory function in older adults. Memory and executive functions did not show significant change after the strength training cycle.

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