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RESISTANCE TRAINING, COGNITIVE FUNCTION AND THE ELDERLY: AN INTEGRATIVE REVIEW

Treinamento resistido, função cognitiva e idosos: revisão integrativa

Entrenamiento de resistência, función cognitiva y ancianos: revisión integrativa

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ABSTRACT:
Objective: to examine the effects of resistance training on cognitive function in elderly people. **Method:** this study is an integrative review conducted in the following databases Embase, PubMed, Scopus, Lilacs, Web of Science, and Google Scholar. **Results:** the initial search yielded 2525 records, which were screened by two independent reviewers using the Rayyan platform. After excluding duplicates and other results that did not meet the established eligibility criteria, seven studies were included in this review. **Conclusion:** it is concluded that resistance training is effective in improving cognitive function. The relationship between physical and cognitive function is noteworthy, and further studies are needed to clarify this matter by exploring additional modalities such as cardiorespiratory training, resistance training on unstable surfaces, and varying intervention periods.

DESCRIPTORS: Mental health; Self-destructive behavior; Suicide; Health science students; Suicide attempt; Student health;

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RESUMO:

Objetivo: investigar os efeitos do treinamento resistido sobre a função cognitiva de idosos. **Método:** o presente estudo se trata de uma revisão integrativa conduzida nas seguintes bases de dados Embase, Pubmed, Scopus, Lilacs, Web of Science e Google acadêmico. **Resultados:** a busca inicial resultou em 2525 registros e foram encaminhados à plataforma Rayyan, onde foram avaliados por dois revisores independentes. Após exclusão de duplicatas e outros resultados que não condiziam com os critérios de elegibilidade estabelecidos, sete estudos foram incluídos nessa revisão. **Conclusão:** conclui-se que, o treinamento de força tem sido eficiente em melhorar a função cognitiva. A relação entre as funções física e cognitiva é notória e mais estudos devem ser realizados para esclarecer o assunto, acrescentando outras modalidades como treinamento cardiorrespiratório, treinamento de força em superfícies instáveis, além de diferentes períodos de intervenção.

DESCRITORES: Idoso; Treinamento resistido; Treinamento de força; Cognição; Função cognitiva.

RESUMEN

Objetivo: investigar los efectos del entrenamiento de resistencia sobre la función cognitiva en adultos mayores. **Método:** el presente estudio es una revisión integrativa realizada en las siguientes bases de datos Embase, PubMed, Scopus, Lilacs, Web of Science y Google Académico. **Resultados:** la búsqueda inicial arrojó 2525 registros, los cuales fueron evaluados por dos revisores independientes utilizando la plataforma Rayyan. Tras excluir duplicados y otros resultados que no cumplían con los criterios de elegibilidad establecidos, se incluyeron siete estudios en esta revisión. **Conclusión:** se concluye que el entrenamiento de fuerza ha demostrado ser eficaz para mejorar la función cognitiva en adultos mayores. La relación entre las funciones física y cognitiva es notable y se requieren más estudios para esclarecer este tema, incorporando otras modalidades como el entrenamiento cardiorrespiratorio, el entrenamiento de fuerza en superficies inestables, y explorando diferentes períodos de intervención.

DESCRIPTORES: Anciano; Entrenamiento de resistencia; Entrenamiento de fuerza; Cognición; Función cognitiva.

INTRODUCTION

Aging is responsible for many relevant physiological changes and cognitive function is one of these physiological variables that decreases with age. This change, along with the loss of physical function, leads to functional dependency in the elderly and increases the likelihood of morbidity and mortality. The loss of cognitive function can lead to dementia, which has become common in the elderly, with an incurable case being discovered every 4 seconds.[1]

Cognitive function can be defined as a form of brain expression in which there is an interaction of the mind with the world. The authors also state that cognition expands from pregnancy to adulthood, and from the age of 60 the individual experiences a decline in this function.[2]

In some studies, it is possible to verify the link between physical and cognitive functions, in which when one declines, the other also has some negative impact. It is possible to verify that the loss of cognitive function has a negative effect on physical function, as there is a prediction of a reduction in gait speed when there is a decrease in cognition1. A systematic review found that high levels of physical fitness may be associated with the prevention of cognitive and neural decay.[3]

These negative effects of aging are explained by relevant changes in the structure and function of the brain that affect cognitive function. Shrinkage of the hippocampus and white and gray matter are the structural changes that explain the decline in memory and processing speed, causing difficulties in performing basic tasks such as driving and remembering things.[3,4]

Physical activity has been strongly recommended to delay the adverse effects of aging, particularly on cognitive function. Resistance training is emerging as one of the viable training options for minimizing the effects of aging, although studies of resistance training interventions have been less frequent.[5]

In view of these arguments and the importance of the topic for public health, it is relevant to research effective intervention approaches to reduce the negative effects caused by the decline in cognitive function during the aging process.

The aim of the present study was to investigate the effects of resistance training on cognitive function in elderly people and to verify the efficacy of this intervention in this population.

METHOD

This study consists of an integrative review conducted in four main methodological stages: formulation of the research question, literature search, selection of studies, and data extraction/synthesis. In the first stage, the topic and research question were defined: "Does resistance training promote improvement in cognitive function in healthy elderly people?". During the second phase, which took place between June and July 2024, the databases Embase, Pubmed, Scopus, Lilacs, Web of Science, and Google Scholar were consulted.

To guide the search strategy, the acronym PICO was used with the following components: P (population: healthy elderly people), I (intervention: resistance or strength training), C (comparison: not applicable), and O (outcome: improvement in cognitive function). Inclusion criteria included studies with healthy elderly, randomized controlled trials (RCTs), interventions with resistance training, published between 2019 and 2024, without language restriction. Exclusion criteria included studies with elderly with any health impairment, literature reviews, pilot studies, prevalence studies, cohort studies, combined interventions, studies with outcomes unrelated to cognitive function improvement, and restricted articles.

In the third stage, studies were selected using the Rayyan - Intelligent Systematic Review platform.[6] This involved two independent reviewers who were responsible for screening the articles by title and abstract. Conflicts were resolved by consensus or, if necessary, by a third reviewer.

The final step involved data extraction and synthesis, which was performed using the LibreOffice spreadsheet software Calc, version 24.2.1.2. The extracted data included information such as bibliographic reference, sample characteristics, intervention site and protocol, objectives and results of the selected studies. This study adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.[7] Due to the methodological nature of the research, it was not submitted for evaluation by a research ethics committee.[7]

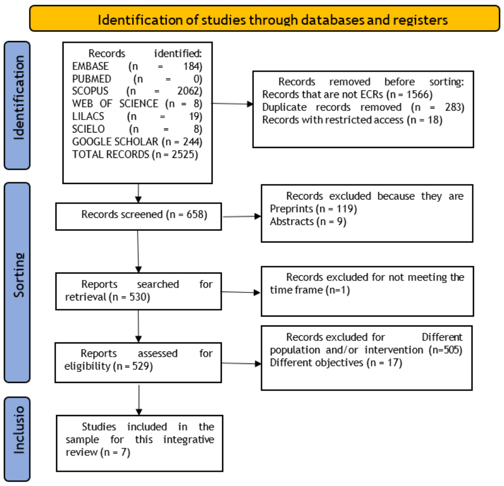
Table 1 – Search strategy carried out in the databases. Rio de Janeiro, RJ, Brazil 2024 - Dates

Database	Search strategy
EMBASE	'aged'/exp OR elderly AND ('resistance training' OR strenght) AND training AND ('cognition' OR cognitions OR cognitive) AND function AND (2019:py OR 2020:py OR 2021:py OR 2022:py OR 2023:py OR 2024:py) AND 'article'/it
PUBMED	Aged OR Elderly and Resistance training OR Training, Resistance OR Strength Training OR Training, Strength OR Weight-Lifting Strengthening Program OR Strengthening Programs, Weight-Lifting OR Strengthening Program, Weight-Lifting OR Weight Lifting Strengthening Program OR Weight-Lifting Strengthening Programs OR Weight-Lifting Exercise Program OR Exercise Programs, Weight-Lifting OR Exercise Program, Weight-Lifting OR Weight Lifting Exercise Program OR Weight-Lifting Exercise Programs OR Weight-Bearing Strengthening Program OR Strengthening Programs, Weight-Bearing OR Strengthening Program, Weight-Bearing OR Weight Bearing Strengthening Program OR Weight-Bearing Strengthening Programs OR Weight-Bearing Exercise Program OR Exercise Programs, Weight-Bearing OR Exercise Program, Weight-Bearing OR Weight Bearing Exercise Program OR Weight-Bearing Exercise Programs AND COGNITION OR Cognitions OR Cognitive Function OR Cognitive Functions OR Function, Cognitive OR Functions, Cognitive
SCOPUS	TITLE-ABS-KEY (aged) OR (elderly) AND {resistance training} OR {strenght training} AND (cognition) OR (cognitions) OR {cognitive Function} AND PUBYEAR > 2018 AND PUBYEAR < 2025 AND {randomized controlled trial} AND (LIMIT-TO (DOCTYPE , "ar"))
WEB OF SCIENCE	"Aged" OR (Elderly) (Title) AND "Resistance Training" OR (Strength Training) (Title) AND "cognition" OR cognitions OR Cognitive Function (Title)
LILACS	(idosos) OR (ancianos) AND (treinamento resistido) OR (treinamento de força) OR (entrenamiento de fuerza) AND (função cognitiva) OR (cognición) AND (db:("LILACS") AND type_of_study:("clinical_trials")) AND (year_cluster:[2019 TO 2024])
SCIELO	((Idosos) OR (ancianos)) AND (treinamento de força) OR (treinamento resistido) OR (entrenamiento de fuerza) AND (função cognitiva) OR (cognición)
GOOGLE SCHOLAR	"Idosos", "Treinamento de força", "Função cognitiva"

RESULTS

The sample of this study consisted of seven randomized controlled trials (RCTs) after the search strategy identified 2525 records in the databases. The studies had a time frame from 2019 to 2024, with the aim of selecting more recent records and examining the effects of strength training interventions on cognitive function in elderly people. Figure 1 shows the process of identifying, screening, and including these studies in this integrative review.

Figura 1 – Flowchart for the selection of studies analyzed. Rio de Janeiro, RJ, Brazil, 2024



Source: Adapted from Page et al.[7]

Tabela 2 – Study characteristics. Rio de Janeiro, RJ, Brazil, 2024

Reference	Sample	Place
Bento-Torres et al. (2019)8	47 elderly (sex not specified) divided into 3 groups: ST group (n=14; 71.7 ± 4.6 years) Sedentary group (n=19; 70.9 ± 5.2 years) Water exercise group (n=14; 71.2 ± 4.4 years)	Brazil (State/ Municipality N/I)
Cavalcante et al. (2020)9	67 Elderly divided into 3 groups: ST group (n=23; 18F and 5M; 71 ± 6 years; 3 dropouts), STI group (n=22; 17F and 5M; 71 ± 6 years; 5 dropouts) and CG (n=22; 17F and 5M; 71 ± 6 years; 5 dropouts).	Petrolina (PE), Brazil
Eckardt; Braun; Kibele (2020)10	68 elderly (aged 65 to 79 years) divided into 3 groups: ST group, (n=24; 16F and 8M; 69.5 ± 3.8 years), STI group, (n=21; 12F and 9M; 71.3 ± 3.9 years) ASTHA group, (n=23; 13F and 10M; 69.9 ± 3.9 years)	Kassel, Ger-many
Huang et al. (2020)11	415 elderly (aged from 65 to 85 years; 220M and 195F; 72.3 ± 4.6 ye-ars) divided into 4 groups: AT group (n=104; 55M and 49F; 72.3 ± 4.6 ye-ars), ST group (n=102; 53M and 49F; 72.3 ± 4.8 years), AT+ST group (n=104; 61M and 43F; 72.3 ± 4.8 years) and CG (n=105; 54F and 51M; 72.1 ± 4.6 years).	Toyota, Japan.

Santos et al. (2020)12	50 elderly (mean age 67 years, about 60% women) divided into 2 groups: ST group (n=24; 64% F and 36% M; 66 ± 5 years) and CG group (n=25; 60% F and 40% M; 68 ± 6 years)	N/I
Castillo-Quezada et al. (2021)13	113 elderly women (69.39 ± 6.48 years) divided into 3 groups: ST group (n=14), AT group (n=15) and CG (n=15))	Talcahuano, Chile
Coelho-Júnior; Uchida (2021)14	60 elderly (32 pre-frail aged 60 to 76 years; 31F and 2M; 65 ± 3.2 years and 28 frail aged 66 to 99 years; 18F and 10M; 76 ± 7.2 years) divided in 3 groups: LSST group (n=19), HSST group (n=22) and CG group (n=19).	Poá (SP), Brazil.

Fonte: dados dos autores

ST: strength training; STI: strength training with instability; LSST: low-speed strength training; HSST: high-speed strength training; AT: aerobic training; ASTHA: abduction strength training and hip adduction; CG: control group; N/I: not informed.

Tabela 3 – Applications of Instruments for the Assessment of Cognitive Function. Rio de Janeiro, RJ, Brazil, 2024

Instrument	Purpose
Rapid Visual Processing (RVP)	Assesses sustained visual attention and working memory. Evaluates fronto-parietal functions.
Reaction Time (RTI)	Evaluates the speed of reaction and movement after the presentation of a visual stimulus.
Pair Learning Associations (PAL)	Assesses learning ability and visual memory. Evaluates frontal, temporal and cingulate lobe functions.
Spatial Working Memory (SWM)	Assesses working memory and therefore frontal lobe function.
Mini-Mental State Examination-Folstein (MMSE)	Assesses cognitive deficit.
Montreal Cognitive Assessment (MoCA)	Assesses the status of cognitive function.
Computerized STROOP Color Task	Assesses selective attention and conflict resolution.

Tracking Tests A and B (TTB-TTA)	TTA: Evaluates processing speed and visual attention; TTB: Evaluates processing speed and visual attention, it also evaluates cognitive flexibility.
Digital Span Backward Less Right Test	Evaluates working memory.
Coding Test	Assesses cognitive processing speed.
Semantic and Phonological Verbal Fluency Test	Evaluates verbal fluency.
Logical Memory Test	Assesses episodic memory capacity, especially memory for verbal information or stories.
Wechsler Memory Scale IV (WMS-IV)	Assesses verbal, visual and auditory memory, both short and long term.
Clock Design Test (CDT)	Assesses visuocons-tructive and visuospatial skills and executive function.
Rey's Auditory Verbal Learning Test (RAVLT)	Assesses episodic verbal me-mory, the ability to remember and recall specific verbal in-formation after a period of time.
FAB-D = Frontal Evaluation Battery, German Version	Assesses executive and frontal functions of the brain.
Digit Symbol Test	Evaluates processing speed.

Tabela 4 – Aims and results of the studies. Rio de Janeiro, RJ, Brazil, 2024

Reference	Objective	Results
Bento-Torres et al. (2019)8	To examine the effects of water ae-robics and resistance training on cognitive performance in he-althy elderly people and to identify the test that may be most sensitive to di-fferences in cognitive function.	Study participants scored a mean of 28.50 ±1.70 points on the MMSE, with a mean response time of 649.04 ±146.53mms on the PVR test and 9.50 ±2.65 points on the PAL test. No significant differences were found between the active and sedentary groups on RVP, learning, visual and working me-mory (SWM) tests.
Cavalcante et al. (2020)9	To examine the effects of unstable versus traditional resistance training compared to a heal-th education control group on cognitive function in elderly people with cogniti-ve complaints.	No significant diffe-rences were found between the groups in the combined global cognitive score for both types of exercise compa-red to CG (STI-CG: 1.42, 95% CI: [-0.70, 3.55], p = 0.186; CG-ST: -0.78, 95% CI: [-2.88, 1.31], p = 0.458). There were no significant improvements in any of the cognitive domains assessed (executive function, processing speed, and memory func-tion) compared to the CG.

Eckardt; Braun; kibele (2020)10	To test the effects of unstable versus stable resistance exercise on executive function.	The STI group showed a significant 11% increase in working memory compared to the ST group (d=0.32). In the digital symbol substitution test, the STI group showed an improvement of 19% versus 4.5% in the ST group (d=0.73). In the STROOP test, there were no significant differences between the groups (d=0.42), but there was a mean advantage of the STI group over the ST group (d=0.55), resulting in an increase of 8% for the STI group and 3% for the ST group.
Huang et al. (2020)11	To examine the effects of physical activity on intrinsic capacity in community-dwelling elderly with subjective memory-related problems.	In the unadjusted model, the ST group had a significant increase of 0.18 (95% CI 0.07-0.30) in the global cognitive z-score. In the fully adjusted model for age, sex, and BMI, the ST group still showed an increase in global z-score of 0.17 (95% CI 0.05 to 0.28) compared to the CG group. However, this improvement was reduced by week 52, and no significant differences in cognitive Z-score were observed between the ST and CG groups at weeks 26 and 52. After excluding individuals with mild cognitive impairment (MCI), the ST group showed an increase in cognitive function Z-score of 0.17 at week 26. In addition, at week 26, the ST group showed a significant increase in the vitality z-score (95% CI 0.06 to 0.47), while at week 52, there was a 0.23 (95% CI 0.01 to 0.45) increase in the mobility z-score.

Santos et al. (2020)12	To analyze the effects of resistance training (RT) on cognitive and physical function in elderly people.	ST showed significant improvement in reducing declines in performance on selective attention and conflict resolution (STROOP test: -494.6; 95% CI: -883.1 to -106.1) and promoting significant improvements in working memory (direct digital span: -0.6; 95% CI: -1.0 to -0.1 and direct digital span minus reverse: -0.9; 95% CI: -1.6 to -0.2) and verbal fluency (animal naming: +1.4; 95% CI: 0.3 to 2.5). There were no significant differences between the groups on other cognitive measures.
Castillo-Quezada et al. (2021)13	To determine the effects of two types of exercise training on functional characteristics associated with cognitive status and the effect on a physiological growth hormone mediator (IGF-1) in elderly women.	The results indicate improvements in cognitive status and IGF-1 concentration. Significant differences (p ≤ 0.05) were found between the groups, with a large effect size for the ST group (ES = 1.0). The authors related improvements in physical function to cognitive function.
Coelho-Júnior; Uchida (2021)14	To investigate the effects of low-velocity and high-velocity resistance training on frailty status, physical performance, cognitive function, and blood pressure in pre-frail and frail elderly.	No statistically significant differences were found between the prefrail groups on the MMSE, CDT, and STROOP tests. However, the LSST and HSST resulted in a significant improvement in verbal learning compared to the CG. In the frail group, no statistically significant differences were found in the results of the MMSE and STROOP tests, but an improvement in performance on the RAVLT was observed after the HSST (p = 0.01).

Source: The Authors.

ST: Strength training; STI: Strength training with instability; LSST: Low-speed strength training; HSST: High-speed strength training; AT: Aerobic training; ASTHA: Abduction strength training and hip adduction; CG: Control group; BMI: Body Mass Index; IC: Intrinsic Capacity; MMSE: Mini-Mental State Examination; CI: Confidence Interval; N/I: Not informed; DWT: Design of Watch Test; STROOP: Color Task; RAVLT: Rey's Auditory Verbal Learning Test.

Of the studies analyzed, 820 elderly participated in the interventions as volunteers or as part of the control groups. The interventions took place in Brazil (n=3), Chile (n=1), Germany (n=1), Japan (n=1), and in one case the intervention site was not specified. After analyzing the studies, we found that five studies (71.4%) showed improvements in cognitive function in the elderly.

In two studies, ST interventions were performed in a different way from the traditional way practiced in gyms and other conditioning centers. Traditional ST was compared with strength training on unstable surfaces (STI). In one of these studies, there was an improvement in the cognitive function of the elderly.

In another scenario, ST was compared to muscle power training in one of the studies in this review and showed similar results, as there were no significant differences between the two methods.

DISCUSSION

The reviewed studies compared cognitive function between different methods. One study compared the results of strength training (ST) with exercises performed in an aquatic environment. The authors found that aquatic exercise provided significant improvements in muscle strength, cardiorespiratory fitness, and functional mobility in healthy elderly people, suggesting that this modality is more effective in promoting these benefits. They also highlighted the relationship between cognition and quadriceps femoris muscle strength, emphasizing the importance of muscle-strengthening exercises in improving cognitive function. The best results observed in reaction time during aquatic exercise were attributed to the peripheral neuromuscular adaptations promoted by ST. However, improved cardiorespiratory capacity has been associated with better cognitive performance, giving aquatic exercise an additional advantage.[8]

The differences found in reaction time were not observed in sustained visual attention, learning capacity, and visual memory functions, which the authors report as a consequence of the aging process causing deterioration of white matter in the brain and affecting processing speed.[8]

As previously reported, there is an association between cognitive function and good cardiorespiratory fitness, however, both strength and aerobic training must be performed to create protection against cognitive decline and diseases such as dementia.[13] The efficiency of these two types of physical exercises is also confirmed in a systematic review, in which the authors also mention dance and other modalities that develop the "mind-body" relationship.[15]

ST was also performed on different surfaces to see if there were significant differences between them. Two interventions were performed with the ST, one on a stable surface (ST) and one on an unstable surface (STI). The authors attribute the results of the interventions to the short intervention time of 12 weeks. However, they report that this relationship between intervention time and outcomes is still unclear, as other studies have shown significant improvements in cognitive function with short interventions. Although the STI showed superior results to the traditional ST on global cognitive function and memory, the authors analyze this result with caution.[9]

Another study also compared these two methods of ST and found significant differences between the groups, with an advantage for STI on tests of working memory, processing speed, and response inhibition, and similarity between the groups on the Trail Making test, although they consider the results of this test inconclusive due to the use of a more easily adapted version. The short duration of the intervention was a factor cited by the authors as a reason for the lack of significant effects in the ST groups on a stable surface. In addition, the greater effort and duration of the STI seem to justify its results.[10]

Also, when comparing between methods, it was found that both ST and muscle power training produced improvements in verbal memory that differed from other studies in terms of global cognition, medium-term memory, inhibitory capacity, and attention. These results are explained by the authors as possible discrepancies in the sample, the state of cognitive function, different types of mobility of the participants, the use of different cognitive assessment tools, and non-standardized ST programs.[2]

When a combined training protocol (aerobic and resistance training) was performed, it was found that there was no improvement in the CIN (Composite Index) in the elderly with combined aerobic and ST training. For the authors, the explanation is that the sample of their study consisted of elderly people with subjective memory complaints, which may have affected the results. In addition, the fact that the exercises were performed at home and without professional supervision may have affected the quality of the execution of these movements. Other factors analyzed by the authors were the rest interval and the transition time between the methods (AT and ST), which may have also contributed to reducing the actual training time. The authors also state that the inclusion of other strategies, such as the involvement of community leaders, group activities, as well as increasing motivation in a personalized way, the inclusion of multidisciplinary interventions, including physical training, cognitive stimulation, nutritional guidance, could maximize the positive effects. Also in this sense, other limitations were reported, such as: insufficient assessment of subjective memory concerns (based on self-reported deficits and with only three items on cognitive function) and lack of information on symptom onset and progression seem to compromise the results.[11]

These findings are in contrast to those of a systematic review, in which the authors found an improvement in cognitive function after AT and ST interventions due to an improvement in cardiovascular and circulatory capacity, resulting in increased blood flow to the brain tissue and, consequently, better nourishment of the region.[16]

In contrast to these results, a meta-analysis showed a slight difference between aerobic and resistance exercises when compared to the control groups. However, the differences found were not statistically significant ($p = 0.10$).[17]

The duration of the intervention performed for ST has also been the subject of research, as knowledge of the ideal duration of intervention to promote significant improvements in cognitive function is still lacking. Some authors suggest that it is possible to perform shorter ST interventions (e.g., 12 weeks) and achieve positive cognitive outcomes. In addition, the limitations of the study were highlighted and cautioned against generalizing the results to other groups, as the population consisted of healthy elderly people. Besides, according to the authors, the lack of blinding of the evaluators may have introduced a bias into the results.[12]

Finally, in a systematic review, it was found that another relevant factor to explain is the importance of ST on the concentration of the growth factor IGF-1, since this intervention promotes an increase in its concentration, which becomes essential for the process of brain regeneration in the hippocampus area. This relationship between IGF-1 concentration and the brain has also been observed by other authors who have found positive results of this growth factor on cognitive function in ST practitioners.13,18

CONCLUSÃO

It is concluded that strength training is effective in improving cognitive function in healthy elderly, demonstrating the clear relationship between cognitive and physical function as cognitive decline affects motor ability. In addition to resistance training, methods such as cardiorespiratory and unstable surface resistance training have also shown benefits on cognitive function, possibly due to the additional challenges they provide. It should also be noted that research into the optimal duration of interventions that promote these positive effects is still needed, with future studies investigating different intervention durations in different populations to gain a more complete understanding of this aspect.

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