WATER-BASED EXERCISE AND RESISTANCE TRAINING IMPROVE COGNITION IN OLDER ADULTS

HIDROGINÁSTICA E TREINAMENTO RESISTIDO MELHORAM A COGNIÇÃO DE IDOSOS

HIDROGIMNASIA Y ENTRENAMIENTO RESISTIDO MEJORAN LA COGNICIÓN DE PERSONAS DE LA TERCERA EDAD

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ABSTRACT

Introduction: Physical exercise has been associated with maintenance of physical abilities and the reduction of age-related cognitive decline, and is considered both a low-cost primary prevention strategy and a non-pharmacological treatment of cognitive dysfunction in older people. However, the contribution of each type of physical exercise to the cognitive health of the elderly population has not yet been fully investigated. Objective: This study investigated the possible influences of water-based and resistance training exercises on the cognitive performance of healthy older adults in automated tests, and investigated which test(s) would be the most effective indicator of differences in aging cognitive performance. Methods: Three groups of community-dwelling healthy older adults: water-based exercise group, resistance training group and sedentary group, were assessed using an automated set of neuropsychological tests (CANTAB) and tests to assess functional exercise capacity. Results were compared by one-way analysis of variance (ANOVA) and Pearson linear correlation. Results: The water-based exercise group had the best functional exercise capacity scores and the best performance in the reaction time evaluation (response and movement latencies). The resistance training group had less movement latency than the sedentary group. Functional mobility was positively correlated with response and movement latency. Conclusions: Taken together our findings show that physical exercise contributes to the preservation of cognitive function in healthy older adults and that water-based exercise has better results than resistance training in terms of reaction time. Moreover, the changes related to reaction time function were detected before the changes in working memory functions, sustained attention and learning in the sedentary participants, suggesting that this variable could be an early sensitive indicator of subtle cognitive changes associated with aging. ***Level of Evidence II; Retrospective study.***

Keywords: Physical fitness; Neuropsychological tests; Reaction time; Primary prevention; Cognitive dysfunction; Physical activity.

RESUMO

Introdução: A prática de exercícios físicos tem sido associada à manutenção das habilidades físicas e redução do declínio cognitivo durante o envelhecimento, sendo considerada uma estratégia de prevenção primária de baixo custo, assim como tratamento não-farmacológico da disfunção cognitiva em idosos. Entretanto, a contribuição das diferentes modalidades de exercícios físicos sobre a saúde cognitiva da população idosa carece de investigação. Objetivo: O presente estudo investigou as possíveis influências da hidroginástica e musculação no desempenho cognitivo dos adultos idosos saudáveis em testes automatizados e qual(is) teste(s) seria o indicador mais sensível das diferenças de desempenho cognitivo. Métodos: Três grupos de idosos saudáveis, residentes na comunidade, praticantes de hidroginástica, musculação ou sedentários foram avaliados através de uma bateria automatizada de testes neuropsicológicos (CANTAB) e testes para avaliação da capacidade funcional ao exercício. Os resultados foram comparados através da análise de variância de 1 critério (ANOVA) e da correlação linear de Pearson. Resultados: O grupo de hidroginástica apresentou melhor capacidade funcional ao exercício e melhor desempenho na avaliação do tempo de reação (latências de resposta e de movimento). Os praticantes de musculação apresentaram menor latência de movimento do que os sedentários. A mobilidade funcional foi positivamente correlacionada às latências de resposta e de movimento. Conclusão: Considerados em conjunto, nossos resultados indicam que o exercício físico contribui para a preservação da função cognitiva em idosos saudáveis e que a hidroginástica apresenta melhores resultados do que a musculação em relação ao tempo de reação. Além disso, as mudanças relacionadas à função tempo de reação foram detectadas antes das mudanças nas funções de memória de trabalho, atenção sustentada e aprendizado nos participantes sedentários, sugerindo que essa variável pode ser um indicador sensível e precoce de sutis mudanças cognitivas associadas ao envelhecimento. ***Nível de Evidência II; Estudo retrospectivo.***

Descritores: Aptidão física; Testes neuropsicológicos; Tempo de reação; Prevenção primária; Disfunção cognitiva; Atividade física.

RESUMEN

Introducción: La práctica de ejercicios físicos ha sido asociada al mantenimiento de las habilidades físicas y reducción de la disminución cognitiva durante el envejecimiento, siendo considerada una estrategia de prevención primaria de bajo costo, así como tratamiento no farmacológico de la disfunción cognitiva en personas de la tercera *edad. Entretanto, la contribución de las diferentes modalidades de ejercicios físicos sobre la salud cognitiva de la población de la tercera edad carece de investigación. Objetivo: El presente estudio investigó las posibles influencias de la hidrogimnasia y musculación en el desempeño cognitivo de los adultos de la tercera edad saludables en tests automatizados y qué test(s) sería el indicador más sensible de las diferencias de desempeño cognitivo. Métodos: Tres grupos de personas de la tercera edad saludables, residentes en la comunidad, practicantes de hidrogimnasia, musculación o sedentarios fueron evaluados a través de una batería automatizada de tests neuropsicológicos (CANTAB) y tests para evaluación de la capacidad funcional para el ejercicio. Los resultados fueron comparados a través del análisis de variancia de 1 criterio (ANOVA) y de la correlación lineal de Pearson. Resultados: El grupo de hidrogimnasia presentó mejor capacidad funcional para el ejercicio y mejor desempeño en la evaluación del tiempo de reacción (latencias de respuesta y de movimiento). Los practicantes de musculación presentaron menor latencia de movimiento que los sedentarios. La movilidad funcional fue positivamente correlacionada a las latencias de respuesta y de movimiento. Conclusión: Considerados en conjunto, nuestros resultados indican que el ejercicio físico contribuye para la preservación de la función cognitiva en personas de la tercera edad saludables y que la hidrogimnasia presenta mejores resultados que la musculación con relación al tiempo de reacción. Además, los cambios relacionados a la función tiempo de reacción fueron detectados antes que los cambios em las funciones de memoria de trabajo, atención sustentada y aprendizaje en los participantes sedentarios, sugiriendo que esa variable puede ser un indicador sensible y precoz de sutiles cambios cognitivos asociados al envejecimiento.* **Nivel de Evidencia II; Estudio retrospectivo.**

Descriptores: *Aptitud física; Pruebas neuropsicológicas; Tiempo de reacción; Prevención primaria; Disfunción cognitiva; Actividad física.*

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INTRODUCTION

The active lifestyle and physical fitness are necessary conditions for the maintenance of independence and functional autonomy of the older adults. Indeed, physical exercise has been associated with maintenance of physical abilities and reduction on age-related cognitive decline, as a low-cost primary prevention strategy.[1,2] In discussions about the aging process, another key factor is the use of sensitive and accuracy tests for early detection of the subtle cognitive changes in healthy aging and to investigated possible relations between physical fitness and cognition.[3,4]

Although the evidences support the benefits of both resistance and aerobics exercises for prevention and non-pharmacological treatment of cognitive dysfunction in aging,[4] the most effective type of exercise for prevention of age-related cognitive decline is not completely known.[2] On the other hand, the published evidence on benefits from aerobic activities and the associated social interaction from water-based aerobic exercise turns this modality of exercise the choice by many old adults in Brazil, especially on the tropical climate regions.

Cognitive functions progressively decline during normal aging. The assessment of functional adaptations through the evaluation of the cognitive function in healthy older adults with different lifestyles need to be performed to establish objective, reliable and specific tests as markers of subtles aging-associated changes in cognition performance. In this regard, the use of automated tests and nonverbal stimuli are good choice to reduce potentially bias of interference from the experimenter in data collection.[5]

In this context, reaction time has been recognized as a measure of changes in cognitive function in healthy normal and pathological aging subjects and patients.[6-8] The mechanisms underlying these findings have been associated with the speed of nerve conduction, integrity of white matter and the gradient of neurodegenerative process on aging and physical exercise can positively modulated these results.[6,9-11]

In this study, we investigated the possible influences of two physical exercise modalities (resistance and water-based training) on cognitive function in healthy older adults using selected tests from an automated neuropsychological test battery (CANTAB) and investigated which one(s) of the test(s) would be the more effective indicator(s) of differences in old adults' cognitive performance.

MATERIALS AND METHODS

Participants

We performed a cross-sectional cognitive evaluation of 47 healthy community-dwelling older adults grouped as water-based exercises practitioners, resistance training or sedentary. Inclusion criteria included minimum visual acuity of 20/20 (Snellen test); no history of traumatic brain injury, stroke, language disease, chronic alcoholism or neurological diseases; no depressive symptoms, screened by the Geriatric Depression Scale and Diagnostic and Statistical Manual for Mental Disorders - Fifth Edition. All participants had normal Mini-Mental State Examination scores, after adjustments for years of schooling according to the criteria for the Brazilian population, with the following cutoffs: illiterate, 13 points; 1–7 years of schooling, 18 points; ≥8 years of schooling, 26 points.

The exercised groups included subjects who performed at least three supervised weekly sessions of water-based or resistance training exercises, during twelve or more months prior to the study. The sedentary group was composed by individuals that did not perform any physical exercise in the twelve months prior to assessments.

All volunteers met these criteria and performed assessments of sustained visual attention, reaction time, learning ability, visual memory functions, body mass index (BMI), waist-hip ratio and functional exercise capacity.

Functional exercise capacity assessment

All participants performed lower limbs muscle strength (30-seconds Chair Stand Test - 30 CST) and functional mobility (8-foot up-and-go Test - 8UG) assessments as described by Rikli and Jones.[12] The tests were performed twice, with 5 minutes inter-trial interval, and the best performance was recorded for statistical analysis. The assessment of cardiorespiratory fitness was conducted by Six-Minute Walk Test (6MWT), following the recommendations of American Thoracic Society.

Cognitive Assessment

Cognitive assessment was performed using selected tests from Cambridge Neuropsychological Test Automated Battery (CANTAB). The tests were administered by trained researchers, performed all on the same day, in appropriate conditions of mesopic lighting and noise control, according to the administration protocol as described in program's instruction manual. The tests performed in the present study were Rapid Visual Information Processing (RVP), Reaction Time (RTI), Paired Associative Learning (PAL) and Spatial Working Memory (SWM). Table 1 shows the descriptions of cognitive tests and related areas of activation. All tests were realized on a single day and completed within 2 hours and a brief rest between different tests was offered to the volunteers.

Table 1. Description of cognitive tests and related functions.

Tests	Description
Rapid Visual Information Processing (RVP)	Evaluation of sustained visual attention and working memory. Evaluates frontoparietal functions.
Reaction Time (RTI)	Measure the response speed and movement following presentation of a visual stimulus. The test is characterized by requiring complex chain of responses and cognitive processes involving frontoparietal functions connected with subcortical areas that regulate the beginning, the planning, and execution of the motor action.
Paired Associates Learning (PAL)	Assesses the learning ability and visual memory. Evaluates functions of the frontal, temporal and cingulate lobes.
Spatial Working Memory (SWM)	Assesses working memory and therefore frontal lobe function.

Statistical analysis

One-way analysis of variance (ANOVA) was conducted to compare the functional exercise capacity and performance on cognitive assessments of groups attending to different physical exercise modalities or sedentary. Kruskal-Wallis was applied in case of unequal variances. Outliers' values (based on deviations) were excluded prior to statistical analysis. Bonferroni was used as post hoc test. Results are present as means (± standard deviation). Linear Pearson Correlation analysis was performed between variables of functional exercise capacity and cognitive. The statistical significance level was set at p values < 0.05

Ethical Considerations

Ethical recommendations in research involving human volunteers were observed and the study was approved by the institutional the Ethical Committee for Human Experiments (Nº 3955/09). Free and Informed Consent Form was signed by all participants

RESULTS

Groups were age- and educational-matched and all subjects performed within the normal range in the Mini-Mental State Examination, according to the individual years of schooling (Years of age - sedentary (n=19): 70.9 ± 5.2 years, resistance training (n=14): 71.7 ± 4.6, water-based (n=14): 71.2 ± 4.4; Years of schooling - sedentary: 9.3 ± 4.2 years, resistance training: 9.5 ± 3.4, water-based: 10.9 ± 3.4; Mini-Mental State Examination - sedentary: 28.47 ± 1.35 points, resistance training: 28.50 ± 1.70, water-based: 27.79 ± 1.63). Groups were also matched for BMI (water-based: 27.9 ± 4.8; resistance training 26.7 ± 3.3; sedentary: 26.8 ± 4.6; p = 0.75) and waist-hip ratio (water-based: 0.90 ± 0.1; resistance training 0.93 ± 0.1; sedentary: 0.93 ± 0.1; p = 0.53).

The water-based exercises practitioners performed better on lower limbs muscle strength (sedentary: 12.4 ± 4.2 repetitions; resistance training 12.8 ± 1.4 repetitions; water-based: 18.4 ± 3.7 repetitions) and functional mobility (sedentary: 7.7 ± 2.3 sec; resistance training 7.0 ± 1.1 sec; water-based: 5.1 ± 0.8 sec) as compared to resistance training (p < 0.05) and sedentary groups (p < 0.01). Water-based group showed better cardiorespiratory fitness than Sedentary group (p < 0.01) but did not differ from Resistance training group (sedentary: 400.5 ± 79.3 meters; resistance training 457.5 ± 64.8 meters; water-based: 568.8 ± 111.1 meters). There was no difference in functional fitness assessment between resistance training practitioners and sedentary groups (Figure 1).

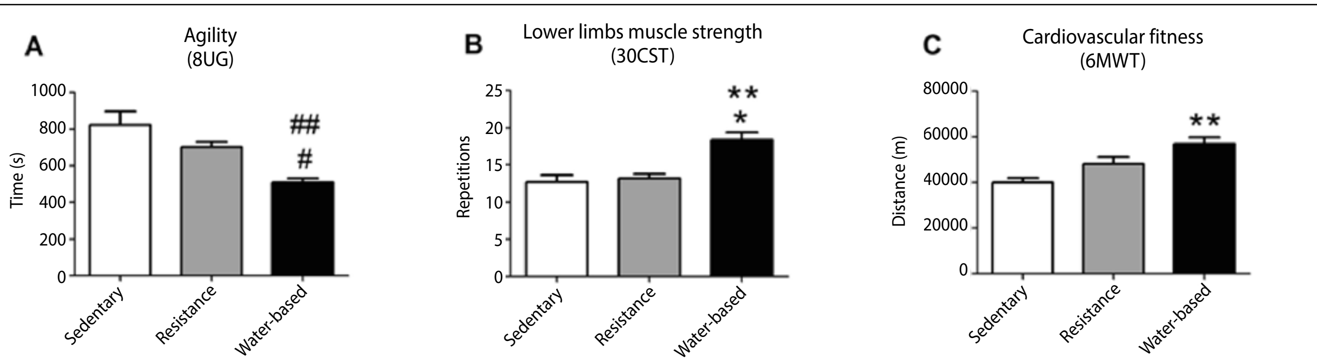
The reaction time assessment pointed significant different performances between groups, in both response and movement latencies components (Figure 2). The latency in response to the presence of the visual stimulus was lower in the water-based exercises practitioners group than in the sedentary group (362.6 ± 69.4 ms *vs* 438.4 ± 77.3 ms; p < 0.05). There was no difference between water-based and resistance training groups (406.1 ± 58.5 ms) or between resistance training and sedentary groups in response latencies. The movement latency of water-based exercise (651.8 ± 186.6 ms) and resistance training groups (689.2 ± 145.8 ms) were significantly lower than the sedentary group (922.0 ± 210.6 ms, p < 0.01) and did not differ one from another.

Analysis of Variance of sustained visual attention (RVP test), learning ability and visual memory and working memory (SWM test) functions showed no differences on groups performances (Sedentary group - RVP Latency: 668.72 ± 150.31 ms; PAL First Trial Memory Score: 10.32 ± 4.08 score; PAL Total Errors Adjusted: 40.05 ± 24.99 score; SWM Total Errors: 69.95 ± 10.57 score. Resistance training group - RVP Latency: 649.04 ± 146.53 ms; PAL First Trial Memory Score: 9.50 ± 2.65 score; PAL Total Errors Adjusted: 41.79 ± 18.99 score; SWM Total errors: 68.64 ± 7.85 score. Water-based group - RVP Latency: 688.8 ± 202.54 ms; PAL First Trial Memory Score: 8.57 ± 3.06 score; PAL Total Errors Adjusted: 54.79 ± 33.97 score; SWM Total errors: 69.57 ± 6.71 score)

Functional mobility performance was positively and significantly correlated with response and movement time (Figure 3).

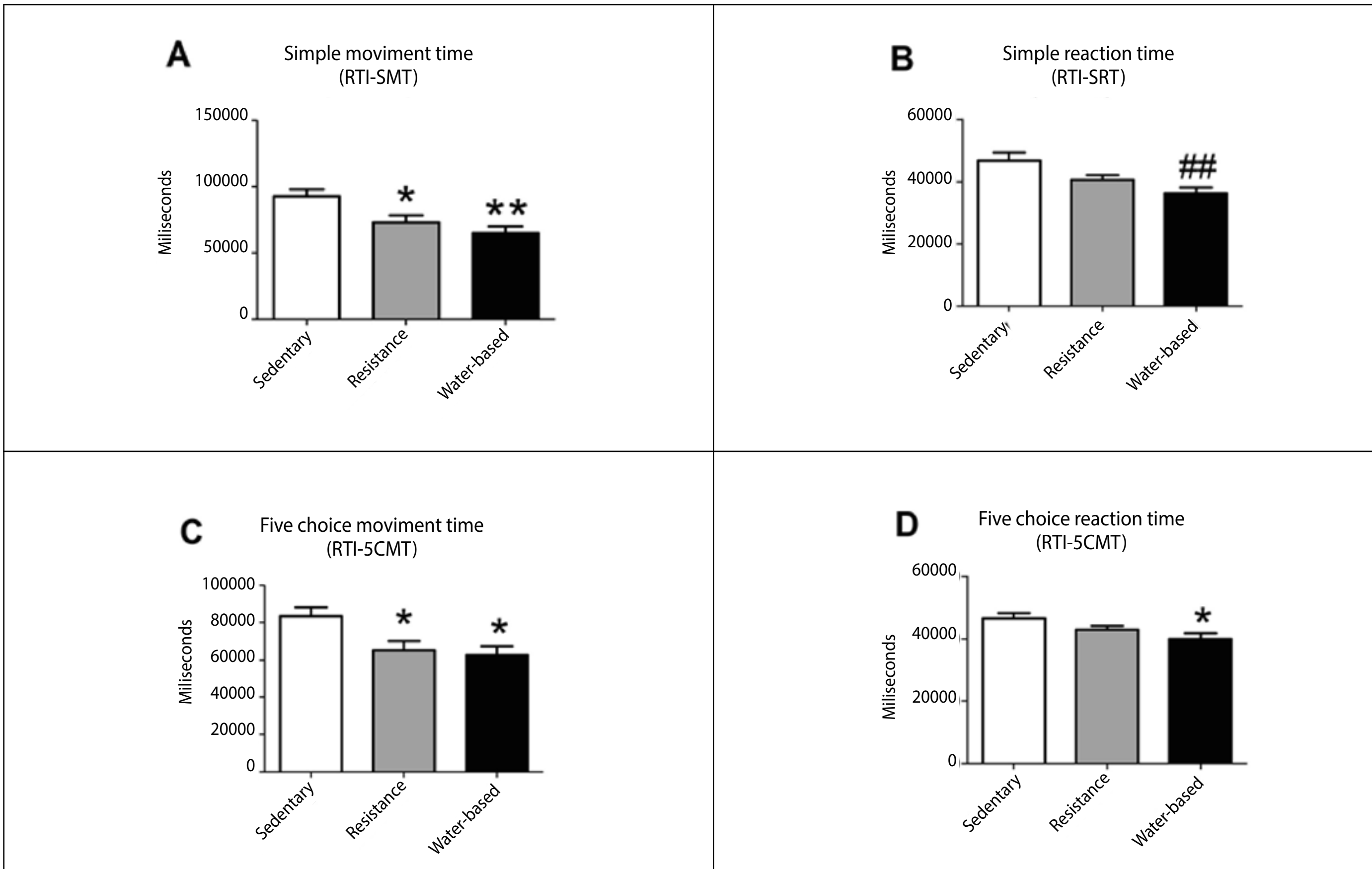
DISCUSSION

Regular physical exercise can modulate age-related cognitive decline by mechanisms related to increased cerebral blood flow, cerebral volume and preservation of white matter microstructure.[13-15] In line with these observations, our findings showed improved performance on reaction time of physically active health-aged volunteers. The groups under consideration



ANOVA one-way: ** water-based vs sedentary p<0.01, * water-based vs resistance p<0.05; Kruskal-Wallis - ## water-based vs sedentary p<0.01, # water-based vs resistance p<0.05

Figure 1. Functional exercise capacity assessment revealed that water-based exercise group has better performance at all tests as compare to sedentary group and better performance on 8UG and 30 CST when compared to resistance training group.



Differences from sedentary group: ANOVA one-way ** p<0.01, * p<0.05; ## Kruskal-Wallis p<0.01.

Figure 2. Cognitive assessment pointed out that water-based and resistance training groups had lower movement time latencies than sedentary group (A and C). Water--based exercise group had smaller response latency on reaction time (B and D).

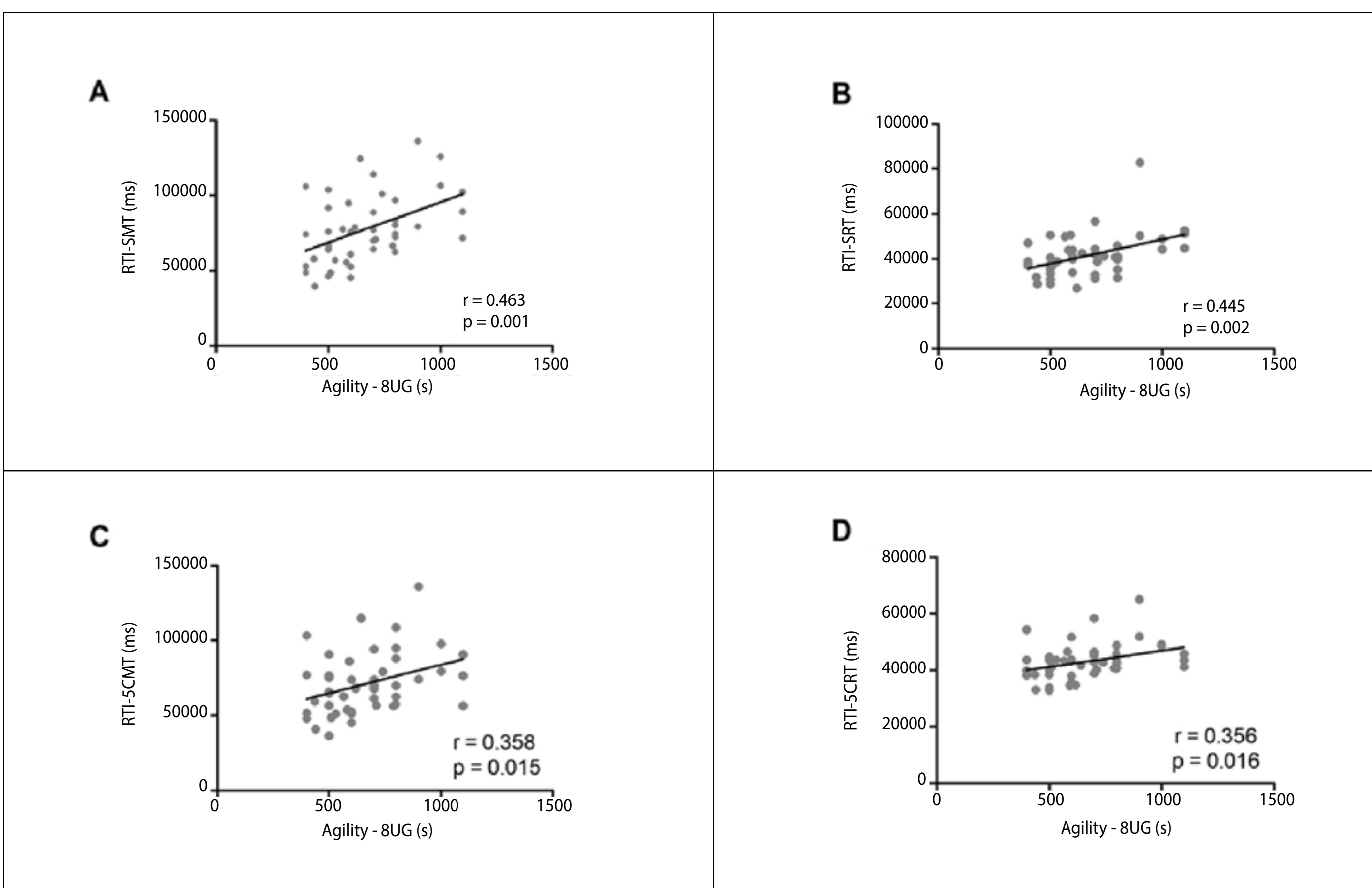


Figure 3. The neuropsychological assessment of movement (A and C) and response (B and D) latency are positively correlated with functional mobility performance.

were composed by volunteers without cognitive dysfunction and matched by age and education level, minimizing potential biases.

The highest performance of the water-based exercise group in the evaluation of muscle strength, functional mobility, and cardiovascular fitness is indicative that this modality is contributing in higher proportion to the preservation of physical fitness in healthy older adults included on this study. Previous studies pointed out that old adults engaged in physical exercises intended to strength muscle have better executive function than sedentary (16) and that the quadriceps strength were associated with cognition.[17]

Reaction time performances were influenced by physical exercise modalities and this is confirmed by significant differences between the exercised and sedentary groups and between groups of different exercise modalities. The Reaction Time test requires a sequence of complex cognitive processing and sensorimotor responses that depend on the integrity of connected frontoparietal and subcortical areas that regulate the planning, beginning, and execution of the motor action.[18] Indeed, there is scientific evidence indicating loss of motor and cognitive functional capacity associated with aging and sedentary lifestyle.[19] The latency response is the Reaction Time test component to assess attention and speed of central cognitive processing necessary to identify the visual stimulus, while movement latency is Reaction Time test component that involves the execution of the voluntary motor act associated to the screen finger touch.

The water-based group performed better than the sedentary in response and movement latencies, while the resistance training group only differed from the sedentary in movement latency. These results may be related to the resistance training characteristics that lead in greater proportion to peripheral neuromuscular adaptations.[20,21] If on one hand, peripheral motor control improvements are important for the better performance on Movement Time, on the other hand, it is known that improved cardiovascular fitness are associated with cognitively improved performance in cognitive tests, including attentional function.[14,22,23] Future longitudinal studies of larger sample size concerning training parameters in different modalities may improve evidence-based exercise prescription.

Cognitive assessment of the groups differed only in reaction time function components, but no significant differences were detected in sustained visual attention, learning ability, visual memory functions. These results can be interpreted in view of the evidence suggesting that the neurodegenerative process of aging has an initial impact in the white matter, affecting cortical pathways in a fronto occipital gradient, leading to impairments in executive function and processing speed.[13,24,25] Our findings are in agreement with previous studies that point out reaction time assessments as sensitive early marker of subtles changes in cognition of community-dwelling health older adults and pathological aging,[6-8] indicator of quality of life,[26] as well a predictor of functional decline[27] and shorter time to death[28] and is associated with functional mobility.[29] The neuroprotection of alpha motor neurons and motor endplate found in senile exercised rats[30] may also support the shorter movement latency founded in exercised groups.

CONCLUSIONS

Taken together our findings show that physical exercise contributes to the preservation of cognitive function in healthy older adults and that water-based exercise training shows better results compared to the resistance training on improving the reaction time. It is of interest that the cognitive changes related to the reaction time may be detected before the impairment of working memory, sustained attention and associative learning in healthy older adults sedentary volunteers, suggesting it as a sensitive and earlier indicator of subtle cognitive changes of aging.

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