
**EFFECTS OF KARATE-DŌ TRAINING IN OLDER ADULTS COGNITION:
RANDOMIZED CONTROLLED TRIAL****EFEITOS DO TREINAMENTO DE KARATE-DŌ NA COGNIÇÃO DE IDOSOS: ENSAIO
CLÍNICO RANDOMIZADO E CONTROLADO**Brandel José Pacheco Lopes Filho¹, Camila Rosa de Oliveira² and Maria Gabriela Valle Gottlieb¹¹Pontifícia Universidade Católica. Porto Alegre-RS, Brasil.²Faculdade Imed. Passo Fundo-RS, Brasil.**RESUMO**

O objetivo deste estudo foi verificar a eficácia do treinamento de Karate-Dō, estilo Wadō-ryū, sobre a cognição em idosos saudáveis. Quanto ao método, realizou-se um estudo randomizado controlado com 33 adultos idosos, divididos em Grupo de Karate (GK) e Grupo de Controle (GC). Na pré e pós-intervenção os participantes responderam a um questionário sociodemográfico, uma bateria de testes neuropsicológicos, escalas de queixas cognitivas subjetivas, sintomas depressivos e de ansiedade. A intervenção foi realizada duas vezes por semana durante 12 semanas (duração de 60 minutos). O GC não realizou nenhuma atividade física orientada ou estimulação cognitiva durante o período de intervenção. A análise dos dados foi realizada por meio de estatísticas descritivas e inferenciais. As comparações de desempenho em testes neuropsicológicos e escalas de queixas cognitivas subjetivas, entre e intra grupos, pré e pós-intervenção, foram realizadas por testes de Mann-Whitney e Wilcoxon. Conforme resultados, GK apresentou melhores resultados do que GC em tarefas de memória visual, funções executivas e queixas de memória subjetiva na análise pós-intervenção. Os resultados sugerem que três meses de prática de Karate-Dō estão relacionados a uma melhora significativa das funções cognitivas em idosos saudáveis.

Palavras-chave: Envelhecimento. Cognição. Artes marciais. Atividade física.**ABSTRACT**

The aim of this study was to verify the effectiveness of a Karate-Dō training, Wadō-ryū style, on cognition in healthy older adults. We conducted a single-blind randomized controlled trial with 33 older adults divided into Karate Group (KG) and Control Group (CG). In the pre and post-intervention, participants answered a sociodemographic questionnaire, a battery of neuropsychological tests, scales of subjective cognitive complaints, depressive and anxiety symptoms. The intervention was conducted twice per week for 12 weeks (lasting 60 minutes). The CG did not perform any physical activity or cognitive stimulation during the intervention period. Data analysis was performed using descriptive and inference statistics. Performance comparisons in neuropsychological tests and scales of subjective cognitive complaints, within and between groups, pre and post-intervention, was performed by Mann-Whitney and Wilcoxon tests. KG shows better results than CG in visual memory tasks, executive functions and memory complaints in post-intervention analysis. The results suggest that 3 months of Karate-Dō practice is related to a significant improvement of the cognitive functions in healthy older adults.

Keywords: Ageing. Cognition. Combat sports. Physical activity.**Introduction**

Cognitive functions are defined as the brain's ability to perform skills needed to carry out different tasks. They concern different mental processes such as attention, perception, memory, language, motor skills and visuoconstrutive abilities in addition to the executive functions¹. During the aging process, some of these functions have a natural decline, e.g. in explicit memory, working memory, attention, executive functions and fluid intelligence². However, the speed of the cognitive impairment can be influenced by the individual's lifestyle. Physical exercise, in general, is an important factor to reduce the cognitive impairment³, by reducing the impact of neurodegenerative diseases associated with aging⁴.

Martial arts are exercises that have a positive impact on physical health, stimulate cognitive and motor skills and can improve the quality of life and the emotional health of practitioners^{5,6}. Among the different styles of martial arts, *Karate-Dō* is a discipline of personal development through struggle practices, which also stimulate memory and motion

tasks. It is based on three core educational pillars: *kihon* (basic techniques), *kata* (form) and *kumite* (fight, combat)⁷.

Kihon is the study of the fundamentals of this martial art. The practitioner makes repeated movements (strikes and defenses, walking or standing) in order to enhance technical gestures. *Kata* are predetermined sequences of techniques that simulate a combat against multiple opponents, individually performed as *Kihon*, where pre-established attack and defense moves are performed. *Kumite* explores physical contact between the practitioners, through real or adapted body contact exercises⁷⁻⁹. It is a global development process where the *karateka* are entirely focused on the technique and body coordination. This indicates the presence of a demanding cognitive task. When this is associated with the muscle memory, concentration and meditation practices, it should result in increased benefits to the psychological balance of the practitioner⁵.

Physical activity plays a key role on cognitive performance³ and several studies report cognitive benefits derived from the practice of martial arts, especially in global cognitive function¹⁰, attention tasks, working memory¹¹, delayed recall and subjective cognitive complaints¹² of the practitioner. Such studies focused on *Tàijí Quán*. However, there are few studies on the therapeutic effects of *Karate-Dō* regarding cognitive aspects, especially regarding older adults. A better understanding of the effects of this physical activity may contribute to the development of more appropriate interventions for the treatment of neurological conditions through physical activities and sports. Therefore, this study aimed to assess the effectiveness of the training of *Karate-Dō Wadō-ryū* style on the cognition of older adults.

Methods

This study is characterized as a single-blind randomized controlled trial, approved by the Research Ethics Committee of the Pontifical Catholic University of Rio Grande do Sul (PUCRS) (CAAE number 26742314.8.0000.5336) and registered at the Brazilian Registry of Clinical Trials (REBEC – number 2494). All the requirements of the Ministry of Health's Resolution 466/2012 on research with human beings were met for this study.

Participants, Randomization and Blinding

The study included older adults (between 60 and 85 years old) residents of the city of Porto Alegre, recruited by convenience sampling and in newspaper advertisements. In total, 123 individuals were selected, and 73 agreed to participate. Of these, 11 were deemed ineligible, leaving 62 subjects (59 females and 3 males) who completed the first tests and were randomized, in a one by one draw. All researchers involved in the study were blindfolded. However, the *Karate-Dō* teacher and the trained participants were not blindfolded.

The groups were named Karate Group (KG) and Control Group (CG). After the training, some participants have withdrawn from the study, and the final sample consisted of 33 older adults (16 participants in KG and 17 in the CG). This withdrawal had different reasons, as follows: 1) some participants did not complete the second evaluation session (after training) on a timely basis; 2) health problems (subjects or family members); 3) some respondents did not attend the minimum number of intervention sessions; 4) some subjects simply quit the study.

Inclusion criteria were: being literate; have 60 years of age or older; submitted of a medical certificate authorizing them to practice exercises; signed the consent form. Exclusion criteria were: alcoholism; practice of physical exercises on a regular basis; use of drug(s) antidepressant(s); submission of a score below the cut-off point of the Mini-Mental State

Examination (MMSE)¹³; use of crutches, canes, walkers, wheelchairs or similar devices; self-reported walking difficulties to perform the practice of intervention, or participants who needed accessories to assist in displacement. All participants had no previous experience with *Karate-Dō* and were classified as a “white belt”.

Cognitive Battery

The older adults participated individually in 90-minute sessions, approximately, for the completion of a sociodemographic and clinical questionnaire and a cognitive battery. This battery was reapplied after the training period (12 weeks), in both groups, to verify the results. The cognitive battery was applied by a psychologist and scored by another expert to avoid conflicts. Both were trained in the application and correction of tests. The assessments was applied in a private room (without interferences) in the Post Graduate Program in Psychology of PUCRS.

The cognitive battery included: (1) MMSE: which evaluates time and spatial orientation, registration, attention and calculation, delayed recall and language. The Portuguese version¹³ was used in this study; (2) Trail Making Test (TMT): for measuring divided attention and visual processing speed¹⁴; (3) Digit Span subtest of the Wechsler Intelligence Scale for Adults, third edition: for assessment of concentrated attention and working memory¹⁵; (4) Rey-Osterrieth Complex Figure (ROCF): for assessment of visual perception, visuoconstrutive functions, planning and visual memory (delayed recall)¹⁶; (5) Rey Auditory-Verbal Learning Test (RAVLT): for measuring episodic verbal memory (immediate and delayed recall) and recognition¹⁷; (6) Visual Memory Span subtest (VMS) of the Wechsler Memory Scale: for assessment of object-centered attention (visual modality) and visuospatial memory¹⁸; (7) Motor Task Sequence: for assessment of motor sequencing capacity through hand movements¹⁹; (8) Wisconsin Card Sorting Test (WCST-64): for assessment of executive functioning and that requires the ability to develop and maintain an appropriate strategy for solving problems²⁰; (9) Verbal Fluency (VF - FAS and animals): for investigating cognitive flexibility, lexical production and semantic memory²¹; (10) Geriatric Depression Scale (GDS-15): a brief questionnaire for the identification and quantification of depressive symptoms²²; (11) Beck Anxiety Inventory (BAI): for measuring the intensity of anxiety; consists of 21 items that reflect the increasing levels of severity for each investigated symptom²³; (12) APT-II Attention Questionnaire (APT-II): for measuring the subjective complaints of memory in the responses of the participants and their informants²⁴; (13) Prospective and Retrospective Memory Questionnaire (PRMQ): for investigating complaints of difficulties in prospective and retrospective memory, in the short and long-term²⁵; (14) Memory Complaint Questionnaire (MAC-Q): for investigating complaints of memory problems, in the short and long term, observed by the older adult's informant²⁶; and (15) Dysexecutive Questionnaire (DEX): for the subjective assessment of executive functions, composed of 20 questions and answered by the participants and their informants²⁷. The instruments administered had the objective of evaluating a wide range of cognitive functions, since some skills could show improvement with the training and others did not. All the instruments are extremely recognized in neuropsychology, demonstrating robust evidence of validity and reliability in the cognitive evaluation of older adults, besides being validated for the Brazilian context.

Intervention

After the initial assessment, the KG participated in 24 intervention sessions over 12 weeks, conducted in groups, twice a week and lasting 60 minutes. The training was conducted by a trained teacher, with black belt (1st Dan) in *Karate-Dō*, *Wadō-ryū* style. The training session consisted of: (1) brief warmup – 5-10 minutes; (2) *kihon* exercises, *kata* (sequences of

Karate-Dō movements), *kumite* and breathing techniques – 40-45 minutes and (3) relaxation through brief meditation exercises tailored to the needs of the participants – 10 minutes.

The technical exercises of *Karate-Dō* covered in the training sessions were the same exercises of the first belt (white or *Mu Kyū*) in *Wadō-ryū* style. In *kihon*: *Jun Zuki* (straight punch), *Gyaku Zuki* (reverse punch), *Gedan Barai Uke* (low defense), *Jodan Age Uke* (high defense), *Mae Geri* (front kick) and *Zenkutsu Dachi* (advanced posture); in *kata*: *Kihon Kata* (basic form); in *kumite*: applications of the exercises in pairs. Breathing exercises were inserted into the *kihon*. The meditation practice was performed in the supine position on the mats (lying flat on their backs) in order to accommodate all the participants, helping prevent the discomfort of the standing or sitting position.

The practices occurred in an appropriate room. During the intervention period the CG were instructed to continue performing their daily activities. After the end of all sessions, both groups were re-evaluated with the previously used instruments. Figure 1 shows the study design and its steps.

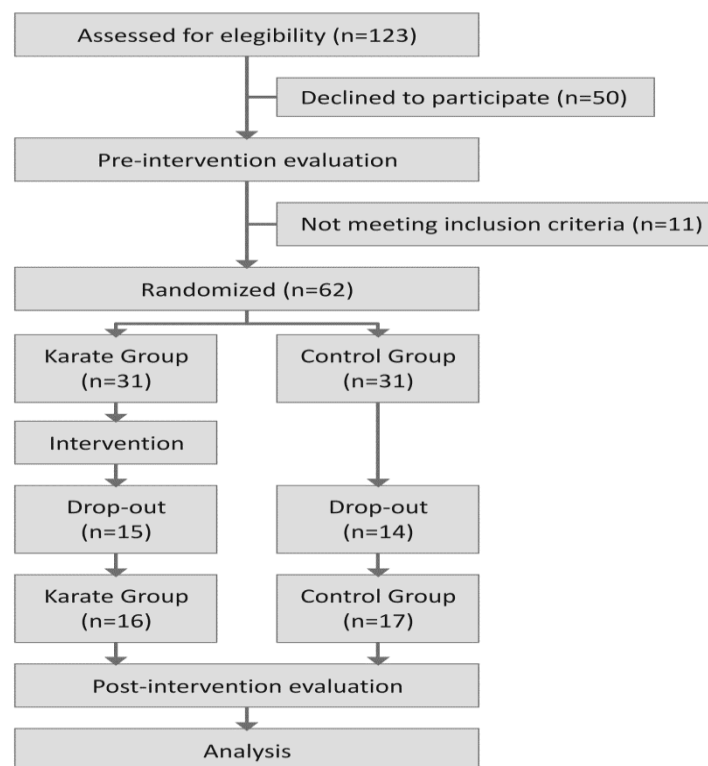


Figure 1. Flow chart of the randomized controlled trial

Source: Authors

Outcome

The outcome measures were performance in cognitive assessment battery, subjective cognitive complaint scales and functional capacity scales, between and within groups, in pre and post-intervention.

Sample Size

The sample size was calculated using the Winpepi software version 11.26²⁸, based on studies of Lam et al¹² and Nguyen and Kruse¹⁰, considering the cognitive functions investigated by these two studies. A sample size of 16 participants per group would be required for the study to have 95% power to show intervention improvements. All *p* values

were two-sided, and a p value of 0.05 or less was considered to indicate statistical significance.

Statistical Analysis

The following variables were investigated: (1) cognition and (2) sociodemographic data. Data was analyzed using the statistic package SPSS version 22.0 for Windows. Chi Square test was used to verify differences in categorical sociodemographic characteristics and Mann-Whitney U test was used for the continuous characteristics. This analysis was performed between groups (KG *versus* CG) in the pre-intervention. Descriptive analysis included frequencies, means, standard deviations and percentage.

Performance on cognitive tests and subjective cognitive complaints of questionnaires between groups in the pre and post-interventions were investigated using Mann Whitney U test, since the data did not present normal distribution according to the Kolmogorov-Smirnov test. Performance on cognitive tests and subjective cognitive complaints questionnaires, pre and post-interventions within the groups, were analyzed by Wilcoxon test. The effect size was calculated with Cohen's d test. The results were considered significant when $p \leq 0.05$.

Results

Table 1 shows the sociodemographic characteristics and clinical data of KG and CG. There were no statistically significant differences between groups regarding age, education, socioeconomic status and gender distribution between the groups. The KG was composed by 93.75% women and 6.25% men, and CG by 94.12% women and 5.88% men. Also, the groups did not differ in subjective perception of health, general cognitive ability, number of depressive and anxiety symptoms in the pre-intervention period.

Table 1. Sociodemographic characteristics and clinical data of KG and CG.

	KG ($n = 16$)	CG ($n = 17$)	p
Age (years)	69,06±7,40	68,35±6,89	0,790
Education (years)	13,88±4,86	13,00±4,53	0,510
SES	26,81±6,39	25,94±7,34	0,581
Subjective perception of health	3,00±0,52	2,71±0,47	0,217
MMSE (score)	26,94±2,27	27,47±2,10	0,488
GDS-15 (score)	2,06±2,21	2,59±3,47	0,845
BAI (score)	5,44±6,37	3,47±3,34	0,606
Female	15	16	0,965
Male	1	1	

Note: SES = Social Economic Status; MMSE = Mini-Mental State Examination; GDS-15 = Geriatric Depression Scale - 15 points; BAI = Beck Anxiety Inventory; degrees of freedom (df) = 31; The "sex" variable was analyzed using Chi Square test. The other variables were analyzed using the Mann-Whitney U test

Source: Authors

Table 2 shows the performance of both groups in the cognitive assessment battery, in the pre and post-intervention, and between and within groups analysis. In the pre-intervention, KG obtained significantly higher scores compared to CG in ROCF copy (score) and WCST-64 (failure to maintain context); whereas CG had higher scores in ROCF delayed recall (time in seconds) and VMS (forward).

Table 2. Comparison of cognitive performance, pre and post-intervention, between groups (KG versus CG) and within groups

	Between groups performance Pre-intervention comparison			Between groups performance Post-intervention comparison			Within group performance comparison (pre x post-intervention)		Cohen's <i>d</i>
	KG	CG	<i>p</i>	KG	CG	<i>p</i>	<i>p</i>		
							KG	CG	
Digit Span (forward)	6,94±1,84	7,29±1,93	0,557	6,94±1,00	7,41±2,15	0,763	0,842	0,593	0,000
Digit Span (backward)	4,38±1,82	5,12±1,69	0,260	5,00±1,10	5,35±1,77	0,790	0,138	0,248	-0,412
RAVLT A1-A5	43,88±7,74	43,00±11,43	0,631	49,06±8,06	43,47±11,33	0,102	≤0,001*	0,465	-0,656*
RAVLT A7	9,19±2,64	9,12±3,74	0,901	9,50±2,92	8,82±3,52	0,510	0,553	0,190	-0,111
RAVLT Recognition	9,38±5,75	11,82±3,45	0,245	10,38±4,10	11,76±3,49	0,309	0,178	0,655	-0,200
VF fonemic (FAS)	41,81±7,16	40,06±11,65	0,444	43,00±10,78	39,18±9,98	0,157	0,509	0,515	-0,130
VF semantic (animals)	17,75±4,24	18,41±5,79	0,736	18,69±4,77	19,41±6,12	0,631	0,468	0,166	-0,208
ROCF – Copy (time)	252,85±95,47	215,36±145,22	0,204	237,58±93,52	219,17±143,16	0,345	0,877	0,068	-0,162
ROCF – Copy (score)	27,97±4,86	24,50±4,65	0,025*	26,63±3,42	24,26±4,36	0,045*	0,210	0,398	0,319
ROCF – Delayed recall (time)	118,72±35,59	98,47±75,14	0,008*	112,61±32,31	97,03±77,09	0,005*	0,756	0,523	-0,180
ROCF – Delayed recall (score)	11,78±6,12	10,00±3,37	0,488	14,38±5,35	10,03±3,43	0,019*	0,041*	0,917	-0,452*
Sequential Motor Task	1,19±1,60	1,00±0,79	0,790	0,94±0,77	0,88±0,86	0,763	0,744	0,414	-0,199
VMS Forward	6,50±2,31	7,94±1,30	0,014*	7,31±1,74	8,18±1,38	0,168	0,128	0,285	-0,360
VMS Backward	5,88±2,25	6,18±1,51	0,581	6,63±1,09	6,35±1,32	0,581	0,132	0,405	-0,424
WCST-64 Conceptual responses	21,88±15,07	30,47±15,14	0,094	31,88±14,91	29,65±14,68	0,958	0,024*	0,064	-0,667*
WCST-64 Categories	1,63±1,50	1,76±1,15	0,557	2,38±1,41	1,65±1,06	0,231	0,072	0,317	-0,515
WCST-64 Perseverate errors	18,50±12,44	15,12±12,16	0,382	13,19±5,68	15,65±11,93	0,790	0,063	0,285	-0,549
WCST-64 Non perseverate errors	13,25±9,06	11,71±11,48	0,326	12,44±6,54	12,00±11,30	0,276	0,836	0,218	-0,079
WCST-64 Failure to maintain the context	0,13±0,34	1,18±1,42	0,014*	0,38±0,72	1,41±1,42	0,028*	0,234	0,102	0,444
TMT-A Time(s)	45,23±20,72	51,35±25,16	0,363	42,23±19,47	50,22±24,31	0,326	0,079	0,193	-0,149
TMT-A Errors	0,00±0,00	0,24±0,75	0,581	0,13±0,50	0,06±0,24	0,986	0,317	0,180	0,368
TMT-B Time(s)	146,98±92,74	147,61±89,50	0,631	121,39±70,71	148,33±89,33	0,292	0,017*	0,112	-0,310*
TMT-B Errors	1,31±1,54	1,35±1,41	0,817	1,00±1,03	1,41±1,54	0,533	0,609	0,739	-0,237

Note. TMT-A = Trail Making Test part A; TMT-B = Trail Making Test part B; RAVLT = Rey Auditory Verbal Learning Test; WCST-64 = Wisconsin Card Sorting Test, 64 cards version; VF = Verbal fluence; ROCF = Rey-Osterrieth Complex Figure; VMS = Visual Memory Span; degrees of freedom (df) = 31; Cohen's *d* = Effect size calculated for Karate Group in within group evaluation (pre x post-intervention). It was used the Mann-Whitney *U* Test to between groups comparisons and the Wilcoxon Test for within group comparisons.

Source: Authors

In the post-intervention was identified that KG obtained significantly higher scores compared to GC in ROCF delayed recall (score). This group also improved their performance in the VMS (forward), eliminating the previous difference. The other data retained its behavior in relation to the pre-intervention.

In within groups analysis, CG did not show significant differences. However KG presented a superior performance in the post-intervention in the following tasks: RAVLT A1-A5, ROCF delayed recall (score), WCST-64 (conceptual level responses) and TMT-B (time in seconds). The effect size of these improvements ranged from moderate (d between 0.7 and 0.5) to small ($d \geq 0.4$).

Table 3 shows the scores of the subjective cognitive complaint scales and of functional capacity from both groups (pre and post intervention). No significant differences were found in the analysis between groups (pre-intervention); however, KG performed much better than CG in the MAC-Q questionnaire (informant) in the post-intervention. There was also a significant difference with strong effect between the initial performance and the final results of the KG group in the same task.

Table 3. Comparison of subjective cognitive complaints and functional capacity, pre and post-intervention, between groups (KG versus CG) and within group

	Between group performance Pre-intervention			Between group performance Post-intervention			Whitin group performance (pre x post- intervention)		Cohen's <i>d</i>
	KG	CG	<i>p</i>	KG	CG	<i>p</i>	<i>p</i>		
							KG	CG	
PTA-II participant	11,00±6,45	12,29±9,48	0,958	10,13±7,16	11,76±8,77	0,683	0,449	0,350	-0,128
PRMQ participant	17,94±7,43	20,65±11,02	0,709	17,63±8,30	20,35±10,43	0,657	0,706	0,586	-0,039
DEX participant	17,63±6,78	18,24±12,04	0,929	17,50±8,27	17,29±12,61	0,557	0,850	0,178	-0,017
PTA-II informant	7,69±6,55	7,53±8,53	0,606	6,88±5,30	7,94±7,99	0,958	0,491	0,266	-0,136
MAC-Q informant	24,63±3,12	24,47±4,93	0,557	19,69±5,61	24,41±5,12	0,008*	0,003*	0,959	-1,088*
DEX informant	14,13±10,59	15,18±12,53	0,929	10,69±8,46	14,94±12,71	0,423	0,093	0,723	-0,359

Note. PTA-II = Attention questionnaire; PRMQ = Prospective and Retrospective Memory Questionnaire; DEX = Dysexecutive Questionnaire; MAC-Q = Memory Complaint Questionnaire; deegres of freedom (df) = 31; Cohen's *d* = Effect size calculated for Karate Group in within group evaluation (pre x post-intervention). It was used the Mann-Whitney *U* Test to between groups comparisons and the Wilcoxon Test for within group comparisons.

Source: The authors

Discussion

In a single-blind randomized controlled trial with healthy and sedentary older adults, the impact of the *Karate-Dō Wadō-ryū* style practice on cognitive abilities was investigated. The KG performed better than CG in visual memory ability (delayed recall). This was also observed in the comparison within groups. Such behavior can be explained by the characteristics of *Karate-Dō* practice: in a typical training session, the student watches the teacher perform the movements, then memorizes and performs these sequential tasks themselves. This repetition begins in non-automated form, evolving until the student is able to use only their memory to perform the techniques^{7,8}.

In within group comparisons, the KG did not achieve significant results in VMS test (forward), but the significant difference in the analysis between groups (pre-intervention) is not observed in post-intervention, suggesting a possible improvement in the KG. The VMS test evaluates, among other functions, concentrated attention and visuospatial memory¹⁸. Furthermore, significant improvements were reported in the alternating attention function (TMT-B - Time in seconds), in KG within group comparison. Such improvements can be associated to the *kata* (form) and *kumite* (fight) practices. Concurrent to visual stimulation provided by the teacher, *kata* practitioners should perform sequence movements in the environment in multiple directions⁸. They should be very careful to perform the task correctly to avoid clashing with their colleagues during the process. In *kumite* the student is supposed to calculate strength, speed and distance, in defense and attack exercises with arms and legs, in order to move in harmony with the partner⁹. Overall, it is a task of great attentional demand and visuospatial ability.

Also, significant improvements were observed in KG regarding the episodic verbal memory (immediate recall) in the RAVLT A1-A5 task, in comparisons within group. This improvement may be related to the social interaction provided by the activity²⁹: conversation and interaction among participants was always encouraged during the intervals. The specific verbal content of the martial art discussed in the sessions may have also influenced the results of episodic verbal memory; the techniques and movements of *Karate-Dō* are named in Japanese, and these terms should be learned by the participants. This is a brief experience of speaking a foreign language.

Regarding to the executive functions, the WCST-64 tests (conceptual responses) and TMT-B (Time in seconds) has identified improvements in logical-abstract reasoning ability and visual processing speed in the KG in comparisons within groups. The visual stimulation associated to the coordination skills required in *Karate-Dō* may provide a strong stimulus for visual processing speed. The practice of *kumite* (combat) may be responsible for the improvement of this executive function: in addition to performing the movements correctly, the participant must perform defenses and counter attacks effectively⁹; such tasks stimulate the reaction time, which also depends of the visual stimulus³⁰. The logical-abstract reasoning ability is strongly associated with the *kata* (form) practice: it is a sequence of predetermined movements, which simulates a fight against imaginary opponents. The student should perform the movements in the correct order, trying to hit his "enemies" at specific points of the body⁸. There are similar demands in *kihon* exercises (basic movements) and *kumite* (combat)⁹, for it is necessary to choose and perform the techniques (attacks, defenses and dodges) that are most appropriate for each situation. The use of a cognitive process that involves logical-abstract reasoning is clear in these tasks and may be responsible for the improvement.

A substantial improvement of subjective memory complaints was identified in KG in comparison within groups, as reported by family members in the MAC-Q questionnaire (informant). There was also a noteworthy improvement in this questionnaire compared to CG in post-intervention. It is a functional measure of the intervention, suggesting that the

improvements in the assessment instruments may have impacted the daily routine of the participants. This data is very relevant because the outstanding performances in a retest maybe associated to the learning of these tasks, rather than to a real improvement in the older adult's condition³¹. Taking into account the aforementioned data, these results reinforce the improvements detected in the visual and verbal memory.

Several studies show significant improvements in cognition after several protocols of physical training. A recent study³² investigated the effects of systematized physical exercise for 282 older adults, within a three-year period, which showed benefits related to executive functions and processing speed. The study of Antunes et al.³³ conducted a six-month fitness program, with emphasis on aerobic metabolism, in which the experimental group improved significantly in attention process, memory and motor skills (agility). Another study was conducted with two groups (46 volunteers) subjected to resistance training for eight weeks. This survey identified moderate improvements on psychological well-being and cognitive functions of older adults, especially in memory. The intervention group maintained its improvement one year after the training period compared to the control group³⁴.

In the field of martial arts, Kasai and contributors³⁵ found significant improvements in memory abilities in a 6-month training pilot study of *Tàijí quán* with 26 older adults. In another study on the same martial art, during a 10-week intervention, the researchers found significant benefits in concentrated attention, episodic verbal memory, visual memory and visuospatial memory in the older adults¹¹. Several studies on *Tàijí quán* showed significant improvements in global cognitive function, delayed recall and subjective cognitive complaints¹², as well as in executive functions¹⁰ and speed processing³⁶.

Regarding *Karate-Dō*, there are few studies conducted that have investigated cognitive functions. A survey found improvements in children's confidence in their own abilities and memory function by parental report³⁷. However, the martial art investigated was the *Kenpō Karate*, a practice with a similar name but different formative contents. Another study that investigated the *Karate-Dō Shōtōkan-ryū* style practice found no positive effects⁵.

Improvement in cognition obtained with the practice of *Karate-Dō* demonstrated by this study was corroborated in the studies of *Tàijí quán* and others types of physical exercises. This can be explained by the presence of a memory training in which the subject learns the complex tasks sequences performed in an intervention session. It is a coordinated pathway between memory, attention, postural control, voluntary motor actions, verbal and visual imagery, which constitute the learning process¹². In addition, *Tàijí quán* is assumed as an effective activity to prevent cognitive impairment (in normal or pathological aging) because their practice stimulates neurogenesis and angiogenesis processes in the brain³⁶. As shown, the results of this survey are consistent with the literature, indicating that *Karate-Dō* can be classified as a cognitive training activity with an efficacy similar to that of *Tàijí quán*.

Study Limitations

This study does has some limitations. One of the greatest difficulties consisted in obtaining a sample that would meet all the inclusion criteria and maintaining the number of participants until the end. Also, additional results could have been obtained if there is the presence of a third group of participants, practicing another type of physical exercise.

Such points may have affected the results in some way. However, despite the limitations, this is the first study that investigated the effects of the practice of *Karate-Dō Wadō-ryū* style in cognition in the older adults. In addition to finding benefits for cognition, it was possible to find the functions that the practice of *Karate-Dō* affects specifically.

Conclusions

According to the findings, the results suggest that 3 months of *Karate-Dō*, *Wadō-ryū* style practice is related to a significant improvement of the cognitive functions in healthy older adults. Substantial improvements were observed in abilities of visual memory (delayed recall), alternative attention, episodic verbal memory (immediate recall), executive functions (logic-abstract reasoning and visual processing speed), and a decrease of subjective cognitive complaints by informants.

Thus, the present study shows evidence that *Karate-Dō* may serve as a cognitive stimulation activity. Additional studies with longer training periods or longer weekly frequency are still needed to fully understand the impacts of its effects on cognitive functions. Another strategy is to work with a third sample group, practicing another type of physical exercise. It is also necessary to investigate the maintenance of these benefits in long term. For future studies, we would like to further examine the cognitive functions investigated, as well as other factors that may impact health, which include strength, flexibility and biological markers.

References

1. Sternberg RJ, Sternberg K. *Cognitive Psychology*. Wadsworth: Cengage Learning; 2008.
2. Salthouse TA. Correlates of cognitive change. *J Exp Psychol Gen* 2014;143(3):1026-1048. Doi: 10.1037/a0034847
3. La Rue A. Healthy brain aging: Role of cognitive reserve, cognitive stimulation, and cognitive exercises. *Clin Geriatr Med* 2010;26(1):99-111. Doi: 10.1016/j.cger.2009.11.003.
4. Stern Y. Cognitive reserve in ageing and Alzheimer's disease. *Lancet Neurol* 2012;11(11):1006-1012. Doi: 10.1016/S1474-4422(12)70191-6.
5. Jansen P, Dahmen-Zimmer K. Effects of cognitive, motor, and karate training on cognitive functioning and emotional well-being of elderly people. *Front Psychol* 2012;3:1-7. Doi: 10.3389/fpsyg.2012.00040
6. Burke DT, Al-Adawi S, Lee YT, Audette J. Martial arts as sport and therapy. *J Sports Med Phys Fitness* 2007;47(1):96-102.
7. Nakayama M. *Dynamic Karate*. London: Ward Lock limited; 1976.
8. Nakayama M. *Best Karate: Comprehensive*. New York: Kodansha; 2000.
9. Nakayama M. *Best Karate: Fundamentals*. New York: Kodansha; 2000.
10. Nguyen MH, Kruse A. A randomized controlled trial of Tai chi for balance, sleep quality and cognitive performance in elderly Vietnamese. *Clin Interv Aging* 2012;7:185-190. Doi: 10.2147/CIA.S32600
11. Man DWK, Tsang WWN, Hui-Chan CWY. Do Older T'ai Chi practitioners have better attention and memory function? *J Altern Complement Med* 2010;16(12):1259-1264. Doi: 10.1089/acm.2009.0462.
12. Lam LCW, Chau RCM, Wong BML, Fung AW, Lui VW, Tam CC, et al. Interim follow-up of a randomized controlled trial comparing Chinese style mind body (Tai Chi) and stretching exercises on cognitive function in subjects at risk of progressive cognitive decline. *Int J Geriatr Psychiatry* 2011;26:733-740. Doi: 10.1002/gps.2602.
13. Chaves ML, Izquierdo I. Differential diagnosis between dementia and depression: a study of efficiency increment. *Acta Neurol Scand* 1992;85(6):378-382. Doi: 10.1111/j.1600-0404.1992.tb06032.x
14. Army Individual Test Battery. Manual of directions and scoring. Washington: Adjutant General's Office; 1944.
15. Nascimento E. *WAIS III - Escala de inteligência Wechsler para adultos*. São Paulo: Casa do Psicólogo; 2004.
16. Oliveira MS, Rigoni MS. *Figuras Complexas de Rey*. São Paulo: Casa do Psicólogo; 2010.
17. Malloy-Diniz LF, Lasmar VAP, Gazinelli LSR, Fuentes D, Salgado JV. The rey auditory-verbal learning test: Applicability for the Brazilian elderly population. *Rev Bras Psiquiatr* 2007;29(4):324-329. Doi: <http://dx.doi.org/10.1590/S1516-44462006005000053>
18. Wechsler D. *Wechsler memory scale-revised manual*. New York: Psychological Corporation; 1987.
19. Nittrini R, Caramelli P, Herrera Jr E, Charchat-Fichman H, Porto CS. Performance in Luria's Test according to educational level. *Cogn Behav Neurol* 2005;18(4):211-214. Doi: <http://dx.doi.org/10.1590/S1980-57642008DN10100004>.
20. Cunha JA, Trentini CM, Argimon IL, Oliveira MS, Werlang BG, Prieb RG. *Teste Wisconsin de classificação de cartas: manual*. São Paulo: Casa do Psicólogo; 2005.

21. Strauss E, Sherman EMS, Spreen O. A compendium of Neuropsychological Tests: Administration, norms and commentary. New York: Oxford University Press; 2006.
22. Almeida OP, Almeida SA. Reliability of the Brazilian version of the geriatric depression scale (GDS) short form. *Arq Neuro-Psiquiatr* 1999;57(2B):421-426. Doi: <http://dx.doi.org/10.1590/S0004-282X1999000300013>
23. Cunha JA. Escalas Beck. São Paulo: Casa do Psicólogo; 2001.
24. Sohlberg KM, Mateer CA. Reabilitação Cognitiva. São Paulo: Santos; 2009.
25. Smith G, Sala DS, Logie R, Maylor EA. Prospective and retrospective memory in normal aging and dementia: A questionnaire study. *Memory* 2000;8(5):311-321. Doi: 10.1080/09658210050117735.
26. Crook TH, Feher EP, Larrabee GJ. Assessment of memory complaint in age-associated memory impairment: the MAC-Q. *Int Psychogeriatr* 1992;4(2):165-176.
27. Wilson BA, Alderman N, Burgess PW, Emslie H, Evans JJ. Behavioral assessment of the Dysexecutive Syndrome. Edmunds: Thames Valley Test Company; 1996. Doi: <http://dx.doi.org/10.1590/1413-82712016210201>.
28. Abranson JH. WINPEPI (PEPI for Windows) computer program for epidemiologists. *Epidemiol Perspect Innov* 2005;1(1):1-6. Doi: 10.1186/1742-5573-1-6
29. Vance D, Wadley V, Ball K, Roenker D, Rizzo M. The effects of physical activity and sedentary behavior on cognitive health in older people. *J Aging Phys Act* 2005;13(3):294-313.
30. Schmidt RA, Lee TD. Motor Learning and Performance: from principles to application. Champaign: Human Kinetics Publisher; 2013.
31. Salthouse TA. Frequent assessments may obscure cognitive decline. *Psychol Assess* 2014;26(4):1063-1069. Doi: 10.1037/pas0000007
32. Frederiksen KS, Verdelho A, Madureira S, Bänzner H, O'Brien JT, Fazekas F, et al. Physical activity in the elderly is associated with improved executive function and processing speed: the LADIS Study. *Int J Geriatr Psychiatry* 2015;30(7):744-750. Doi: 10.1002/gps.4220
33. Antunes HKM, Santos RF, Heredia RAG, Bueno OFA, Mello MT. Alterações Cognitivas em Idosas Decorrentes do Exercício Físico Sistematizado. *Rev Sobama* 2001;6(1):27-33.
34. Perrig-Chiello P, Perrig WJ, Ehram R, Staehelin HB, Krings F. The effects of resistance training on well-being and memory in elderly volunteers. *Age Ageing* 1998;27:469-475.
35. Kasai JYT, Busse AL, Magaldi RM, Soci MA, Rosa PM, Curiati JA, et al. Effects of Tai Chi Chuan on cognition of elderly women with mild cognitive impairment. *Einstein* 2010;8(1):40-45. Doi: 10.1590/S1679-45082010AO1470.
36. Chang JY, Tsai P, Beck C, Hagen J, Huff DC, Anand KJ, et al. The effect of Tai Chi on cognition in elders with cognitive impairment. *Medsurg Nurs* 2011;20(2): 63-70.
37. Conant KD, Morgan AK, Muzykewicz D, Clark DC, Thiele EA. A Karate program for improving self-concept and quality of life in childhood epilepsy: Results of a pilot study. *Epilepsy Behav* 2008;12:61-65. Doi: 10.1016/j.yebeh.2007.08.011.

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