Original Article

An Acute Bout of Dynamic Sitting Exercises Improves Stroop Performance and Quality of Sleep in Older Adults with Cognitive Impairment

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Abstract

Aims: The study was aimed at identifying the acute effects of dynamic sitting exercises (DSE) on Stroop performance and quality of sleep in elderly persons with cognitive impairment. **Materials and Methods:** Sixty-eight elderly males with cognitive impairment were attended in research voluntarily, following screening tests, 62 participants were assigned randomly assigned to either DSE or control groups. At the end, 5 participants discontinued from the study. The experimental group participated in eight sessions of DSE in 2 weeks (four sessions a week). The exercise protocol consisted of stepping patterns on a chair; stretching and finger movements. The Stroop test was used to evaluate the cognitive performance of participants before and after exercise intervention. Actiwatch 7 was used to measure sleep quality. Paired *t*-test and independent *t*-test were used to analyze the data. **Results:** It was suggested that Stroop performance was positively affected by DSE ($P \leq 0.05$); meanwhile, no statistically significant change was found in the control group ($P \geq 0.05$). All parameters of sleep patterns, including sleep efficiency, wake after sleep onset, and movement and fragmentation index, were improved significantly ($P \leq 0.05$). **Conclusion:** Although the aging process besides the environmental factors, especially lifestyle could result in cognitive impairment, DSE would improve the cognitive performance in Stroop performance test.

Keywords: Cognitive, dynamic sitting exercises, exercise, stroop

Introduction

Medical achievements have increased the life expectancy among the elderly in the world.[1,2] Additional, precedent growth of the aged population is another factor needed to be considered. Aging is accompanied by a decline in cognitive abilities, which may lead to dementia. The prevalence of dementia is expected to rise in the upcoming decade due to increasing longevity in several regions of the world. Major consequences of cognitive decline in elderly people include impaired quality of life, loss of social functions, and ultimately total dependence of home care services or hospitalization, demanding enormous financial resources from the public health system.[3] The issue has also been of utmost importance for Iranian policy makers as one of the leading challenges for health. Based on reports of Iran Ministry of Health, Treatment and Medical Education, the accelerating rate of the aging population will be kept on by 2032. Apparently, having appropriate plans for this population has good potential for decreasing the possible costs of health-care systems. In addition to the physical and physiological problems that the elderly have in aging, there are many psychological and cognitive impairments that disturb the functional independency.[4,5] The rate of sleep disorders increases with age. Based on epidemiological, 20%–40% of the aged population do have night-time insomnia complaints and 10%–20% experience day-time symptoms of fatigue or impaired concentration.[6,7]

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Given the myriad of psychological and physiological challenges facing with older adults, it is necessary to attenuate the negative consequences of degenerative consequences of aging. Hence, optimal physical and psychological performance in vulnerable population either exceptional persons[8,9] or aged ones is of utmost importance in the view of health authorities.[5] In this regard, exercise therapy has always been considered as an optimal strategy which not only provides the people with the prevention of illness but also can have positive effects in treatment.[10-12]

There are many studies suggesting that different kinds of exercise have positive effects on the cognitive performance of individuals in all age groups.[13,14] For example, the effect of aerobic exercise,[15] balance training,[16] strength training,[17] and aquatic training[18,19] on cognitive functions is well-defined. The necessity of such exercise protocol for elderly's is to prevent from putting pressure on joints that is caused by intensified exercises. To the best of our knowledge, the effect of DNS training on the cognitive functioning of the elderly has not been studied. This notion is significant in two aspects. The first one deals with the lowering rate of injury caused by DNS compared to high intensity exercises. Second, the elderly who are reluctant to exercise due to their physical limitations, can do these exercises at home, and are gradually ready to enter sports activities outdoors and in group settings. Notably, DNS can be used with both healthy and frail older adults because they are relatively safe to perform.[20] Therefore, we targeted a combination of sitting exercises (stepping as aerobic exercise, stretching, and finger movements) to determine the effects of acute exercises on cognitive performance measured by Stroop performance in the Vienna Test System.

Materials and Methods

Participants

Among those elderly males in Qazvin who referred to health clinic, 68 elderly males with cognitive impairment were attended in research voluntarily. Meanwhile, eleven aged males did not meet the inclusion criteria. Then, they were randomly allocated in the two groups of DSE and control groups. All procedures were conducted in Imam Khomeini International University.

The inclusion criteria included as follows: age >65 years old; no medical history which disturbed their ability to exercise; no experience of strop test; mild sign of depressive symptoms, measured by the Beck Depression Index ranging from 14 to 19; lack of dementia applying a cutoff of <23/24 evaluated using the Mini-Mental State Examination. In this regards, five participants were dropped out during the experiment, 3 persons had an experience of taking Stroop test and 3 ones had sign of depression. Totally, the data of 57 patients as DSE (n = 29) and control groups (n = 28) were considered for further analyses. The experimental group participated in eight sessions of dynamic sitting exercises (DSE) in 2 weeks (four sessions a week). The exercise protocol consisted of stepping patterns on a chair (stepping at their usual pace while sitting on a 41-cm chair for 10 min); stretching movements (dynamic stretching such as flexion and extension of the neck and lateral bending of the trunk for 10 min); and finger movements (symmetrical or asymmetrical movements of bending and extending each finger for 5 min).[21]

Procedure

Before starting the first session of exercise protocol, the participants were asked to perform the Stroop color-word test task (approximately 6 min long), after which they engaged in exercise protocol for 25 min. After completing the exercise protocol, the participants performed the Stroop task again. Meanwhile, the control group engaged in a 25-min rest instead of DSE. To avoid any residual effects, they were given food instruction for having isocaloric diet. In addition, they were prevented from doing any other exercise programs during the experiment.

Stroop test

The Stroop test included a series of computerized tasks evaluated by the Vienna Test System. It measures perceptual motor speed when reading color-words (e.g., the words "Red" and "Green") and naming colors that a word is written in. The test measures two experimental conditions including reading speed of color-word and color naming speed. Two interference conditions are also measured by the test. First one deals with reading interference tendency (RIT) and the second one refers to naming interference tendency (NIT). In the first phase, they are asked to select the correct color option as fast as possible and to ignore the meaning of the word, and in the second phase, they must focus on the meaning of words instead of color. There is no enforced time limit to complete the test. The main scoring variables are reading interference (the different in reaction times between the reading interference condition and reading baseline) and naming interference (the difference in reaction times between the color naming interference condition and the color naming baseline). The validly of reliability of Stroop test has been extensively reported in studies.[22,23]

Sleep measurement

The subjects wore an Actiwatch-7 on their nondominant wrist for 7-consecutive days in order to be analyzed in terms of sleep quality.[24] The Actiwatch has been validated against polysomnography in sleep studies.[25,26] The total score of analysis was obtained in the past 3 days of the experiment as index of sleep quality. In posttest condition, they attended exercise physiology laboratory of Imam Khomeini International University at 8:00 am and the tests were repeated.

Ethical considerations

This study was approved by the Ethical Committee of Qazvin University of Medical university (Ref No., IR.QUMS.REC.1397.324). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. All participants were provided

with an explanation of the study and obtained their written informed consent before their enrollment in the study.

Statistical method

The normality of data was determined using the Kolmogorov–Smirnov test. Paired *t*-test and independent *t*-test were used to analyze the data using the SPSS version 22 (Chicago, Ill., USA) at statistical significant level of $P \leq 0.05$.

Results

General characteristics of subjects are shown in Table 1. No significant difference was found in the traits of subjects in baseline ($P \geq 0.05$)

The results are shown in Figures 1 and 2. It was indicated that both dimensions of Stroop performance, including RIT and NIT were significantly improved in DSE compared to control group in posttest ($P = 0.003$ and $P = 0.002$, respectively).

As shown in Table 2, different reaction time measures (both concurrent and incongruent) for measures of RIT and NIT were positively changed after exercise intervention ($P \leq 0.05$). However, no significant change was found in control group ($P \geq 0.05$). The results of sleep patterns are also shown in Table 3.

Discussion

A growing number of research have suggested that exercise training could be beneficial for maintaining or even improving cognitive function in older adults with or without cognitive impairment. However, the optimal workload related to the type, frequency, intensity, and duration of the exercise sessions has not been clearly well understood. Physiologically, the ability of the brain to function better in aged persons with high cognitive reserve may be due to neurogenesis as a function of a cognitively stimulating or enriched environment. Hence, the present study aimed at assessing the acute effects of DSE on quality of sleep and executive functions in elderly persons with cognitive impairment. It was hypothesized that DNS would attenuate the cognitive impairment in aged males. The results suggested that all components of reaction time measures (both concurrent and incongruent) along with RIT and NIT as indices of Stroop performance were positively improved after exercise intervention. On the other hand, it was shown that all factors regarding sleep quality (sleep efficiency, wake after sleep onset and movement and fragmentation index) were improved significantly. The results indicated the positive effects of DNS on all variables of sleep index. One of the possible mechanisms for the improvement of psychomotor performance in training group may be due to augmentation of oxygen uptake, inhibition of vascular inflammatory processes, and rheological alterations in blood.[15,18] Consistent with our result, Irandoust and

Table 1: General characteristics of participants (mean±standard deviation)

Group	Exercise	Control
Age (year)	2.1±67.3	2.4±68.1
Height (cm)	5.4±167.2	6.1±166.1
Weight (kg)	4.1±65.2	4.8±66.8
BMI (kg/m^2)	2.3±24.3	3.4±24.5

BMI: Body mass index

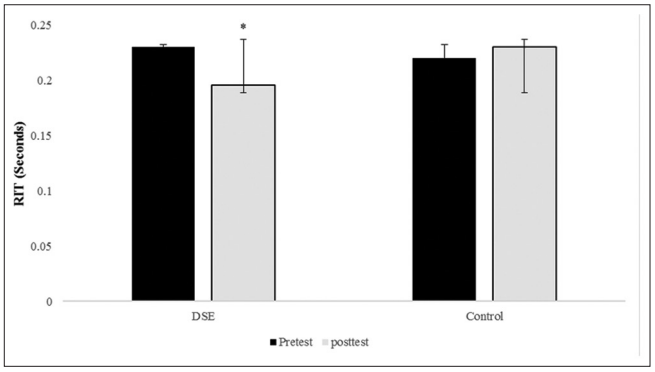

Figure 1: Reading interference tendency in dynamic sitting exercises and control groups. *RIT: Difference in reaction time between reading congruent and reading incongruent

Table 2: The results of paired *t*-test and independent *t*-test in the two experimental and control conditions

Test variable	Raw score				*P* (independent *t*-test) Mean differences (post−pre)
	DSE		Control		
	Pretest	Posttest	Pretest	Posttest	
RIT					
Median for reaction time -reading congruent (s)	0.92±0.01	0.75±0.03*	0.93±0.01	0.95±0.02	0.001
Median for reaction time -reading incongruent (s)	1.10±0.03	1.01±0.02*	1.02±0.02	1.03±0.04	0.03
NIT					
Median for reaction time -naming congruent (s)	0.78±0.02	0.69±0.05*	0.76±0.03	0.75±0.02	0.002
Median for reaction time -naming incongruent (s)	0.93±0.02	0.85±0.03*	0.95±0.02	0.96±0.03	0.01

*Significant at $P \leq 0.05$. RIT: Reading interference tendency, NIT: Naming interference tendency

Table 3: Sleep patterns before and after intervention

Test variable	Raw score				*P* (independent *t*-test) Mean differences (post−pre)
	DSE		Control		
	Pretest	Posttest	Pretest	Posttest	
Sleep efficiency[a] (%)	58.1 (4.8)	63.1 (3.8)*	58.9 (3.9)	57.6 (3.4)	0.001
Wake after sleep onset (min)	38.4 (4.2)	35.4 (3.7)*	38.2 (4.2)	38.1 (3.7)	0.002
Movement and fragmentation index[b]	14.1 (4.3)	11.8 (3.96)*	14.4 (4.0)	14.8 (3.96)*	0.001

[a,b]Significant at $P \leq 0.05$, *Significant difference ebtwwen pretest and posttest. DSE: Dynamic sitting exercises

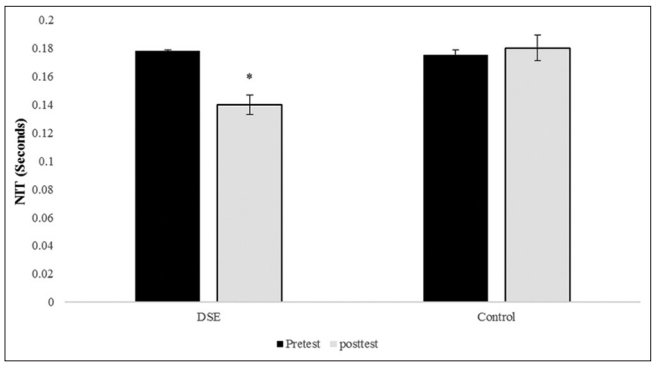

Figure 2: Naming interference tendency in in dynamic sitting exercises and control groups. *NIT: Difference in reaction time between naming congruent and naming incongruent

Taheri and indicate that regular training can improve sleep in aged people.[17]

Till date, there are not many studies comparing the effects of different modes of exercise on cognition. Liu *et al*.[27] compared resistance training to balance training and found that resistance training induced a greater increase in perfusion during some cognitive tasks. Along these lines, when regional brain perfusion was measured in older adults, women who performed strength training at least once per week demonstrated greater cerebral perfusion than those who did not.[28]

In agreement with this study, some studies supported the positive effects of exercise on executive functions.[20,29,30] Furthermore, there is some other research showing that acute exercise improves executive function in older adults.[31-34] In agreement with these studies, we confirmed that an acute bout of DSE improves Stroop performance in older adults with cognitive impairment. A potential limitation of the research protocol is that participants and exercise coaches cannot be blinded because it is difficult to conduct blinding in nonpharmacological trials.

The strengths of this study deal with the combination use of three types of sitting exercise simultaneously. Monitoring the exercise intensity in sitting exercises in future studies is highly recommended, since it is possible to have different results, when moderate-to-high-intensity exercise in the sitting position be conducted. In addition, considering the effects of such an exercise can be studied in those elderly that have dementia, depression, or physical frailty. It should be noted that we indicated the acute effects of DNS on Stroop performance, while the long-term effects are unclear. Hence, studying the effects of long-term interventions are highly recommended to reveal the continuous effects.

Conclusion

In summary, it was shown that acute exercises in a sitting position are beneficial for sleep quality Stroop performance in older adults. These results raise the possibility that performing DSE may be a key point for increasing the potentials of cognitive performance improvement in aged population with cognitive impairment. Given the equivocal understanding of DNS and cognitive functioning, more research involving a more controlled environment with larger sample size is needed to make more conclusive decisions regarding the notion.

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Conflicts of interest

There are no conflicts of interest.

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