The Effect of Aerobic Training and Vitamin D Supplements on the Neurocognitive Functions of Elderly Women with Sleep Disorders

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Abstract

The age-related physical and mental disorders in the elderly are issues that endure social and economic costs. The aim of the present study was to examine the effect of aerobic training and vitamin D supplements on the neurocognitive functions of elderly women with sleep disorders.

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AbstractPurpose : The age-related physical and mental disorders in the elderly are issues that endure social and economic costs. The aim of the present study was to examine the effect of aerobic training and vitamin D supplements on the neurocognitive functions of elderly women with sleep disorders.

Methods : A quasi-experimental with a pre/post-test study designwas used , where 36 aged women 60-70 years old were randomly divided into four groups: aerobic training (ATG), vitamin D (VDG), aerobic training + vitamin D (ATDG) and control (CG). The aerobic exercise protocol was performed for eight weeks with three sessions a week for 50 min. Pittsburgh Sleep Quality Scale was used to evaluate the sleep status profile of participants. The reaction speed, selective attention and information processing were measures of the neurocognitive functions before and after the training period.

Results : The information processing increased significantly from pre- to post-training by 18.0 % in the ATDG, 15.7 % in the VDG, and 13.2 % in the ATG ($p < 0.001$). Also, selective attention increased significantly from pre- to post-training by 16.2 % in the ATDG , 12.2 % in the VDG , and 11.9 % in the ATG ($p < 0.001$). The quality of sleep score was reduced from pre- to post-training by 42.3 % in the ATDG , 19.1 % in the VDG , and 35.6 % in the ATG ($p < 0.001$). However, no difference was observed in the CG ($p > 0.05$). The reaction time was reduced significantly from pre- to post-training by 8.6 % in the ATDG ($p < 0.01$). However, no-significant difference was observed in the CG, the VDG and the ATG ($p < 0.05$).

Conclusion : The present study showed that aerobic exercise plus vitamin D supplements improved the neurocognitive functions of elderly women.

Keywords : Exercise; aging; Vitamin D supplementation.

Introduction

An increase in the population of the elderly and its associated costs in various societies are issues that has always been considered in recent decades (1, 2). Accordingly, it is necessary to allocate a significant portion of the health and medical resources of any community to the elderly. The consequences of aging due to poor life style have been proven in the form of destructive changes in the physiological, cognitive and psychmotor functions in the elderly population. These changes include changes in the central nervous system, and in particular the brain, which affects most parts of the body and can make the elderly vulnerable to diseases such as Alzheimer's, Parkinson's, Multiple sclrosis and other diseases (1). As the human brain responds to the environmental factors easily and creates structural and functional changes that are called neurodegenerative shapes, intervening proper strategies are highly recommended (3). Based on research evidences, executive functions such as information processing, reaction time, attention capacity are impaired in the elderly following aging process. In this regard, sleeping as part of a daily life to recycle, rejuvenate and restore the functioning of the nervous and physiological system of the body is of utmost importance which contributes to the regulation of biological rhythm and helps to improve mental and physiological regeneration. Insomnia is the most common sleep disorder in aged populations that has been extensively investiated . The patients with sleeping disorders are characterized by inability to sleep and lack of effective sleep. A previous study found that 30.7% of the elderly were suffered from sleep disorders (4).

Recently, it has been hypothesized that vitamin D plays an important role in controlling sleep in the brain stem, and it has been argued that vitamin D deficiency is the epidemic reason of sleep disorder (5, 6). On the other hand, the beneficial role of exercise in improving the quality of sleep has always been of interest for scientists (1, 4). The effectiveness of organized exercise protocols such as weight loss exercises (7), strength training (8), aerobic exercises (1, 9) and aquatic excercises on the quality of sleep have been proven. Spiegel et al. (2005) concluded that sleep disorders for several consecutive days increased the resistance of pripheral tissues to insulin, impaired glucose tolerance, increased hunger, and food intake which were somewhat different stimulants to disturb the hormonal balance in the body (12). It has been shown that the lower the quality of sleep, the more stressful hormones are produced in the body (13). The prevention of sleep disorders, due to the importance in various functions of the body, is one of the issues that has a high value of research and can affect the fuctions of various organs in the body (13, 14). With respect to the importance of lifestyle in the elderly, proper life style and physical activity and having a suitable sleep pattern are among the factors that can lead to successful aging. Considering the current prevalence of sleep disturbances, the reduction in sleep time and the decrease of physical activity in the elderly, the aim of the present study was to investigate the effect of an aerobic training protocol along with vitamin D supplementation on neurocognitive functions of elderly women with sleep disorders.

In view of the above consideration, it was hypothesized that combined aerobic training with vitamin D supplementation could improve the neurocognitive functions of elderly women with sleep disorders.

Methods

Participants

A quasi-experimental study with pre/post-test designs was conducted. From 51 aged womens who referred to the sports councelling center in Qzvin, Iran, only 42 were eligible to the inclusion criteria. After this selection, 6 women dropped out from the study. The inclusion criteria were: The age range of 60-70 years, the incidence of sleep disorders (scores above 11 in the Pittsburgh Sleep Quality Scale), without sleep apnea, not smoking, and no taking hypnotic drugs. The exclusion criteria were: taking drugs during the study, absence from exercise protocols in the study.

The present study was conducted according to the Ethical Committee of Imam Khomeini International

University (Ref no.17628) and a consent form was signed by all participants prior to the beginning of the experimentation.

Experimental design

During the study, the participants had an isocaloric diet according to their physical condition.

Then, participants were randomly divided into four groups including aerobic exercise (ATG), aerobic exercise and vitamin D supplement (ATDG), vitamin D supplement (VDG) and a control group (CG). A daily intake of 1000 IU vitamin D per day was selected for the ATDG and VDG. The participants of the ATG and ATDG performed three 50 minutes training sessions per week for 8 consecutive weeks based on Rockport one-mile walking/running test at the intensity of 60-70% of maximal heart rate (MaxHR). The CG continued their habitual daily activities during the period of the study. The exercise intensity was controlled with heart rate monitoring. The training session consisted of warm-up (10 min with 20-30% MaxHR), 35 min of moderate aerobic exercises and cool-down for 5 min, respectively (5). All sessions had been sepervised by two excerise physoplogists. The Pittsburgh Sleep Quality Index (PSQI) was employed in order to measure the quality of sleep of the participants. All participants were subjected to the Neuropsychological Test battery Vienna (NTBV) for assessment of their neurocognitive functions. All measurement tests including PSQI and NTBV were performed before and after study intervention in the Labritary of Imma Khomeini International University.

The Pittsburgh Sleep Quality Index (PSQI)

The Pittsburgh Sleep Quality Index (PSQI) is an instrument with seven components (sleep quality, delay in falling asleep, the sleep duration, the sleep efficiency, sleep disorders, consumption of sleep-inducing medications, and the daily performance) and 18 questions. The score of every item in this questionnaire is between 0 and 3. The sum of the scores means of seven components was used as index of sleep quality (5).

The Neuropsychological Test battery Vienna (NTBV)

The NTBV-short assesses several cognitive domains including reaction speed, selective attention, and information processing (6). In this regards, COG test was used. In this test, four images appear in a row and an image below it. The participant must decide, within a maximum of 1.8 seconds, which of the four images corresponds to the one below. The number of triggers provided was 60 stimulants. The test components consisted of sum hits (number of successful trials as Information processing index); sum correct rejection (number of successful trials in rejecting the improper response as selective attention index) and mean time hits (Reaction time index) (17) .

Statistical analysis

The statistical analysis was performed using the SPSS v21.0 software (SPSS Inc., Chicago, IL). Data are presented as mean ± SD in the table and the text. The normality of the distribution was realized using the Shapiro-Wilk test.

A two-way analyses of variance (ANOVA) [4 (Group) × 2 (Training)] was used. When significant, pairwise comparisons were assessed using the Bonferroni post-hoc test. Partial eta squared ($_p^2$) was calculated to assess the practical significance of the findings.$_p^2$ between 0 and 0.059 represent small effect, between 0.06 and 0.13 represent moderate effect and over 0.13 represent large effect.

Δ (%) = ((Post-training – Pre-training) / Post-training) × 100

Significant difference was set at p[?]0.05.

Table 1. Evolution of information processing, selective attention, reaction time and score of sleep quality between before and after the training intervention for the control group (CG), the aerobic training plus vitamin D supplementation group (ATDG), the vitamin D supplementation group (VDG) and the aerobic training group (ATG).

	CG	CG	CG	CG	ATDG	ATD
	Pre-training Mean ± SD	Pre-training CI	Post-training Mean ± SD	Post-training CI	Pre-training Mean ± SD	Pre- CI
Information processing (n)	21.44 ± 1.01	20.66 - 22.22	21.88 ± 1.26	20.91 - 22.86	21.22 ± 1.2	20.29
Selective attention (n)	29.88 ± 0.92	29.17 - 30.60	30.00 ± 1.41	28.91 - 31.08	31.44 ± 1.58	30.2
Reaction time (s)	1.70 ± 0.15	1.58 - 1.81	1.74 ± 0.08	1.67 - 1.80	1.76 ± 0.10	1.68
Quality of sleep	12.55 ± 1.01	11.77 - 13.33	12.44 ± 0.88*	11.76 - 13.12	12.55 ± 1.13	11.6

*: significant difference compared to pre-training.

Results

Information processing

The statistical analysis showed significant Group (F = 17.64; $p < 0.001$; $n^2 = 0.68$) and Training (F = 179.20; $p < 0.001$; $n^2 = 0.95$) main effects. Also, the interaction Group × Training (F = 30.27; $p < 0.001$; $n^2 = 0.79$) was significant.

The post-hoc analysis showed that the information processing increased significantly from pre- to post-training by 18.0 % in the ATDG ($p < 0.001$), 15.7 % in the VDG ($p < 0.001$), and 13.2 % in the ATG ($p < 0.001$). However, no-significant difference was observed in the CG ($p < 0.05$).

Selective attention

The statistical analysis showed significant Group (F = 23.22; $p < 0.001$; $n^2 = 0.74$) and Training (F = 49.43; $p < 0.001$; $n^2 = 0.86$) main effects. Also, the interaction Group × Training (F = 19.30; $p < 0.001$; $n^2 = 0.70$) was significant.

The post-hoc analysis showed that the selective attention increased significantly from pre- to post-training by 16.2 % in the ATDG ($p < 0.001$), 12.2 % in the VDG ($p < 0.001$), and 11.9 % in the ATG ($p < 0.001$). However, no-significant difference was observed in the CG ($p < 0.05$).

Reaction time

The main effect of Group was not-significant (F = 0.60; $p > 0.05$; $n^2 = 0.06$). However, the statistical analysis showed a significant Training (F = 10.95; $p < 0.01$; $n^2 = 0.58$) main effect. Also, the interaction Group × Training (F = 6.09; $p < 0.01$; $n^2 = 0.43$) was significant.

The post-hoc analysis showed that the reaction time was reduced significantly from pre- to post-training by 8.6 % in the ATDG ($p < 0.01$). However, no-significant difference was observed in the CG, the VDG and the ATG ($p < 0.05$).

Quality of sleep

The statistical analysis showed significant Group (F = 16.7; $p < 0.001$; $n^2 = 0.67$) and Training (F = 226.00; $p < 0.001$; $n^2 = 0.96$) main effects. Also, the interaction Group × Training (F = 31.37; $p < 0.001$; $n^2 = 0.79$) was significant.

The post-hoc analysis showed that the quality of sleep score was reduced significantly from pre- to post-training by 42.3 % in the ATDG ($p < 0.001$), 19.1 % in the VDG ($p < 0.001$), and 35.6 % in the ATG ($p < 0.001$). However, no-significant difference was observed in the CG ($p < 0.05$).

Discussion

The purpose of the present study was to determine the effect of an aerobic exercise and vitamin D supplements on the quality of sleep and neurocognitive functions of elderly women. The main finding was that the three neurocognitive factors in the experimental groups were better than the control group and the ATDG showed

the better improvements compared to ATG and VDG. That is, both factors of nutrition and physical activity have had a double effect on the neurocognitive status of elderly women. The obtained results are consistent with a previous study that pointed out that therapeutic supplementation can fascilitate the response time and information processing (18). Contrary to the results of the present study, Antypa et al. (2009) showed that the use of supplements in the main foods had no significant effect on the change in performance and the tasks that require decision making (19)(7). Differences in age groups (elderly versus youth), supplementation modes, and different research designs are of reasons in obtaining the divergent results. As indicated, the neurocognitive performance of elderly people improved significantly after aerobic exercises. For information processing, it was shown that the experimental groups were in a better condition than the control group. On the other hand, the selective attention of experimental groups were also better compared to control group. It should be noted that selective attention plays an important role in motor control of the elderly (20). In this regard, the results of the present study concerned the effectiveness of exercises on psychomotor function is consisitent with the results of the research of Monleon et al. (2018) who reported that appropriate exercise protocols lead to optimal psychomotor functions. Along with the current study, some studies have suggested that any type of exercise program that has decision-making challenges can lead to improved neurocognitive behavior in the elderly (18, 20). An explanation of these findings might be that changes and adaptations of the musculoskeletal system caused by functional exercises improve neurocognitive function. Possible reasons for this result include the use of more effective neural units, reorganization in the sensory cortex, increased efficacy of synaptic connections and activation of the nervous system, and reducing neural inhibitory reflexes (21). It has to be acknowledged that vitamin D deficiency is cross-sectionally associated with neurocognitive disfunctions, particularly mental shifting, information processing, and processing speed (8, 9). Furthermore, when results have been combined across trials, meta-analytic studies have consistently reported cognitive benefits from aerobic exercise interventions (10, 11).

There are some limitations in the present study. This research may have been underpowered due to a relatively smaller sample size. It is also possible to study both sexes together. To study each sex separately would remove sex as a confounding factor. Further studies that include subjects in both acute and chronic effects of vitamin D and exercise protocols are needed.

In conclusion, aerobic exercises plus vitamin D supplements improve the neurocognitive functioning of elderly women. As this condition improves as a result of increasing the quality of life of the elderly, it is recommended that vitamin D supplementation and aerobic exercise be used in conjunction with older women.

Acknowledgment

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