Effects of Moderate Aerobic Training on Cognitive Performance and Dyslipidemia in Sedentary Older Adults

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Research

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Abstract

Background: The present study was designed to evaluate the effects of 24 weeks of moderate aerobic exercise on the levels of lipids and lipoprotein; Lipo(a) markers and its association with cognitive performance in healthy older adults.

Methods: A total of 150 healthy subjects (100 males, 50 females; age range; 65-95Yrs) were recruited for this study. Based up on LOTCA test score, subjects were classified randomly into two groups control group (n= 50) and cognitive impairment group (n=100).Cognitive functioning, Leisure-time physical activity (LTPA), lipid profile; total cholesterol, TG, HDL-c, LDL-C, and Lipo(a) were assessed at baseline and post- 24 week aerobic exercise interventions using LOTCA battery, pre validated PA questionnaire, colorimetric and immunoassay techniques respectively.

Results. Significant improvements in the cognitive function and modulation in lipid profile and lipoprotein (a) markers were reported in all older subjects following 24 week of moderate exercise. LOTCA-7-sets scores showed a significant correlation with physical activity status and the regulation of lipids and lipo(a) markers. Physically active persons showed a higher cognitive performance along with reduction in the levels of T-Cholest., TG, LDL-C, Lipo(a) , and increase in the levels of HDL-C and aerobic fitness VO_2max compared with sedentary participants. Cognitive performance correlated positively with the increase in aerobic fitness, HDL-C, and negatively with T-Cholest.,TG, LDL-C, Lipo(a) respectively. However, a significant increase, in the improvement of motor praxis, vasomotor organization, thinking operations, attention and concentration was reported among older adults.

Conclusions: The data concluded that supervised moderate aerobic training for 24 weeks plays a positive significant effect in improving cognitive functions via modulating lipid profile and lipoprotein (a) of older adults.

1. Introduction

Cognitive abilities refer to all essential mental skills that control the behavioral life style of human such as every day routine work [1]. Decline in cognitive abilities were shown to produce more drastic problems for older adults to perform their daily life activities [2]. However, more studies tried to maintain or enhance cognitive abilities in older adults via enhancing or delaying functional disabilities [3]. The results of these trials are not clear; this is may be due to that most of these trials concentrated on treatment schedules rather than prevention in older subjects with cognitive deficits or functional disabilities. Previously it was reported that prevention or improve of cognitive deficits among normal older adults is accessible but the treatment parameters not included the outcome measures which may related to the limited and lack of sample randomization[4–5]. The impairment in brain function in older age, performed via many pathological mechanisms [6–7], the most important are tissue damage and neural cell death, which occurs via the interaction of complex path physiological processes [8].

It was reported in many studies, that human aging is associated with an increase in a serious age-related diseases, which related to chronic pathological processes such as inflammation. Whereas, the incidence of inflammation along with immunosenescence resulting in a decline of multiple physiological systems and functional dependence among elderly [9–11].

In addition, many research studies reported that cognitive impairment and increased risk for CVD among older subjects are associated with abnormal lipid profiles [12–14], higher levels of low density lipoprotein (LDL) cholesterol, total cholesterol levels, and lower of high-density lipoprotein (HDL) cholesterol were significantly linked with lower scores of cognitive impairment older subjects with dementia [15–16]. However, lower levels of LDL, HDL and higher HDL were associated with reduction or improvement in cognitive impairment [17–18].Similarly, lipoprotein (a) Lp(a) was reported as possible risk factor for vascular dementia and cognitive impairments in older subjects[19–20]. Lipoprotein (a) in many studies was reported as one of cholesterol derivatives that exist in human plasma and structurally similar to low density lipoprotein (LDL), but with a glycoprotein called [21–22].

Many studies focused on the importance of body physical activity and its positive effects up on cognitive abilities especially in older ages. Physical exercise was shown to play a protective role against hippocampal cell injury which produces brain memory loss[23].Whereas, physical facilitate recovery from injury and improves cognitive function via increase the expression of many neurotrophic and physiological factors which involved in neural survival, differentiation, and improvement of memory function [24].

Recent studies reported the potential action of exercise as anti apoptotic parameter against many brain diseases such as brain inflammatory conditions [25], mice Parkinson’s disease [26], in the improvement of depressive symptoms [27], traumatic brain injury [28–29], and alleviation of memory impairment [30].

It was reported that physical exercise performs good effects on cognitive abilities with different ways which argue its importance as non-drug and non-invasive essential targets for long term health programs for all ages [31–32]. The marked improvement was manifested on both function and biomarker integrity as shown in recent studies [33–34]. This indicates the non-drug efficiency of exercise especially of moderate type to change lifestyle and improving the levels of lipoprotein and lipid in adults [35]. A significant positive change in the levels of lipids and lipoproteins was reported among both men, and women following aerobic exercise [36–37]. Most research topics studied the combined effects of exercise and diet on lipids and lipoproteins furthermore, few studies concentrated on the effects of physical exercise alone [38–39]. Thus, the benefits of regular physical exercise as a health-ensuring necessity over age, gender, occupation and affective status cannot be overestimated [40–41].

Therefore, the present study was designed to evaluate the effects of 24 weeks of moderate aerobic exercise on the levels of lipids and lipoprotein (a) markers and its association with cognitive performance in healthy older adults.

2. Material And Methods

2.1 Subjects

The participants involved in this study were subjected to randomized selection. A random selection of 200 subjects on electoral roll was informed for participation. Out of them, only 150 healthy subjects (100 males, 50 females), were recruited into this study. Their age ranged between 65–95 years and mean age of (69.7±5.91) (Table-1). Subjects with physical disability and with endocrine, immune, psychiatric illness, eating disorders, and taking glucocorticoid medication that could interfere with lipid profile and cognitive ability measurements were excluded from this study. Also subjects who participated in other exercise programs were excluded from this study. Based up on LOTCA test score, subjects were classified into two groups, control group (n= 50) and cognitive impairment group (n=100). The participants were reported not to change their diet of lifestyle during the period of exercise program 924 week). Demographic and anthropometric data of participants were included in table (1). The study protocol approved by Ethical committee of Rehabilitation Research Chair of King Saud University, under file number (RRC-2014-011).

2.2 Training Procedure:

Participants were involved in exercise program designed according to Karvonen's formula [42], three times per week for 24 weeks. Whereas, training intensity of each intervention prepared according to maximum and resting heart rate of each participant. During warming, the subject performed stretching exercises and walking for 5 to 10 minutes. During the active phase, the subject was allowed to reach his pre-calculated training heart rate (THR max; 60 to 70% for 45-60 min) in bouts form using treadmill, bicycle and stair master [43-44]. The exact calculated heart rate of each participant was monitored via a wearable automatic portable heart rate meter (Polar Electro, Kempele, Finland).The exercise test was performed to give the participants physical activities corresponding to 30-45% of VO_2max uptake [45].

2.3 Leisure-time physical activity (LTPA):

A validated questionnaire was used to calculate physical activity in the form of a leisure-time physical activity (LTPA). The energy expenditure rates were calculated weekly in metabolic equivalents per hour/week (T-LPTA-MET/H/W) as previously reported [46].

2.4 Assessment of cognitive abilities

2.4.1 Instrument

Trained research assistants assessed the cognitive abilities of older adult's pre and post supervised aerobic exercise using the Loewenstein Occupational Therapy Cognitive Assessment (LOTCA) battery. Assessments required between 45 and 90 minutes. The LOTCA consists of seven major domains divided into 26 subtests, with each subtest scored on a four- or five-point Likert scale. The assessment of LOTCA test performed according to instruction manuals as reported in literature [47].

Results are presented as a profile along all subtests. A composite score for each domain was calculated by summing the scores of the relevant subtests. The LOTCA score was calculated by summing the score of all subtests. The maximum score on the test is 123, and the minimum score is 27. A higher score indicates better cognitive performance.

2.4.2 LOTCA Test Validity

The test has excellent intra-rater reliability (100%), and good inter-rater reliability (86%) as well as criterion validity (78%) [48]. This LOTCA test was chosen because of its psychometric properties and primarily non-verbal nature, making it potentially more suitable for evaluating the cognitive abilities of individuals from non-Western and non-English-speaking cultures. Several studies have been conducted using this instrument in both Western and Arab populations [1, 48].

2.5 Assessment of Dyslipidemia

All serum samples were taken from all participants in the morning following an overnight fast at pre and post exercise training program for estimation of the following parameters;

2.5.1 Analysis of Lipoprotein A and lipid profile

Immunoassay ELISA technique was performed to measure lipoprotein A levels in the serum of participants pre- and post- exercise interventions using DRG ELISA kit of Total Human Lipoprotein (A) (DRG International Inc.,USA). The serum analyzed for total cholesterol by enzymatic (CHOD-PAP) colorimetric method, and triglycerides by enzymatic (GPO-PAP) method [49-50]. HDL-Cholesterol estimated by precipitant method and LDL-Cholesterol by Friede wald formula (1972) [LDL-C = TC - HDL-C – (TG/5)] [51-52].

2.6 Statistical analysis

Statistical analysis was performed using SPSS version 17. The data were expressed as mean± SD. The comparison and correlation of the studied parameters were investigated using both student’s t-test and Pearson’s correlation coefficient respectively. Paired t-test was used for within group comparison. The data deemed to be significant at P-values < 0.05.

3. Results

A total of 150 healthy subjects were involved in this study. Sixty-seven percent of the sample was male (n = 100), and 70% of subjects were highly educated (n = 105). They are classified according to LOTCA test scores into control group (n = 50) and cognitive impairment group (n = 100). There was significant difference in WHR (P = 0.05), LPTA (P = 0.001), and average LOTCA scores (P = 0.01) of exercise participants compared to control group (Table-1).

In this study, a significant (P = 0.01) improvement in all LOTCA 7 -subsets variables among subjects following 24 weeks of moderate aerobic training compared to pre test and control group which showed slight improve in LOTCA scores as shown in Table (2). However, significant increase (P = 0.001), in the improvement of motor praxis, vasomotor organization, thinking operations, attention and concentration was reported among older adults following 24 weeks aerobic exercise. The data revealed positive significant correlations between the LOTCA scores of older subjects and their performance of cognitive abilities. Moreover, significant correlations were obtained between the older subjects in the motor praxis, vasomotor organization, thinking operations, attention and concentration domains of the LOTCA –scores and their performance of functional physical activity as shown in table (4).

Lipid profile and lipoprotein (a) makers; choelestrol, TG, HDL-C, LDL-C, and Lipo (a) were estimated in this study. Paired t-test and student t-test analysis showed that participants with cognitive impairments had abnormal basal levels of lipids and lipoprotein (a) makers compared with (p = 0.001) control groups (Table 3). Paired t-test analysis within groups showed significant reduction in the levels of TG, LDL-C, and Lipo (a), along with increase in the level of HDL-C in participants with cognitive impairment (p = 0.001) and control (p = 0.01) compared with baseline values following 24 week of moderate aerobic training as shown in Table (3). The data were significantly correlated with physical fitness of the participants. Physical fitness scores were correlated negatively with the reduction in the levels of TG, LDL-C, and Lipo (a), and positively with the increase in the level of HDL-C (Table 4).

Table 1
General Characteristics of Subjects

Parameters	Control group (n = 50)	Cognitive group (n = 100)
Male/Female	30/20	70/30
Age (years)	67.3 ± 2.8	66.8 ± 3.7
BMI (kg/m2)	22.3 ± 2.7	23.4 ± 1.7 *
Waist (cm)	75.3 ± 10.2	86.3 ± 11.7
Hips (cm)	88.5 ± 5.2	87.5 ± 18.3
WHR	0.82 ± 0.07	0.98 ± 0.10 *
Systolic BP (mmHg)	122.2 ± 6.5	118.5 ± 10.8
Diastolic BP (mmHg)	78.5 ± 11.9	82.5 ± 10.3
Fasting Blood sugar (mg/dl)	98.5 ± 6.3	105 ± 3.5
HbA1c (%)	6.2 ± 1.5	6.4 ± 1.9
VO2 max (ml/kg*min)	34.6 ± 3.7	31.4 ± 2.9
Mean LOTCA score (SD)	97.8 ± 7.91	76.2 ± 8.24**
LTPA (MET-H /week)	156.9 ± 15.6	96 ± 9.7**
Values are expressed as mean ± SD; * P < 0.05, ** P < 0.01, *** P < 0.001. Significance at p < 0.05.		

Table 2
LOTCA scores in studied subjects following 24 weeks supervised aerobic training program (means ± SD)

Parameters	Control Group (n = 50)		Cognitive Group (n = 100)	
	Pre	Post	Pre	Post
Orientation	12.8 ± 1.8	16.7 ± 2.5 *	9.0 ± 2.3	21.8 ± 0.5 **
Visual Perception	18.2 ± 2.9	21 ± 0.98*	11.3 ± 2.5	18.1 ± 1.9 **
Spatial Perception	10.5 ± 0.4	13.5 ± 0.4 *	9.5 ± 2.1	21.13 ± 0.91 **
Motor Praxis	8.8 ± 0.68	11.9 ± 0.52 *	9.4 ± 3.8	25.7 ± 2.3 **
Vasomotor organization	21.3 ± 2.6	25.1 ± 2.86 *	11.9 ± 3.7	38.1 ± 2.9 **
Thinking Operations	23.7 ± 3.7	26.8 ± 2.95 *	9.6 ± 2.65	315 ± 2.6 **
Attention and Concentration	3.7 ± 0.51	3.9 ± 0.18 *	2.1 ± 0.31	5.3 ± 0.45 **
Total LOTCA score	97.8 ± 7.91	98.9 ± 7.5 *	76.2 ± 8.24	110.8 ±5.6 **

Values are expressed as mean ± SD; * P < 0.05, ** P < 0.01, *** P < 0.001. Significance at p < 0.05

Table 3
Changes in the levels of lipid and lipoprotein (a) markers, and leisure-time physical activity (LTPA) score of participants Pre- and Post- 24 weeks supervised aerobic training program (Paired t-test analysis).

Parameters	Control group (n = 50)		Cognitive group (n = 100)	
	Pre	Post	Pre	Post
T-Cholesterol (mg/dl)	185 ± 3.7	181.5 ± 4.2 *	231 ± 38.7	198 ± 21.3 * *
TG (mg/dl)	125.2 ± 5.7	124.9 ± 6.2 *	157.6 ± 52.4	134 ± 25.1 * *
HDL-C (mg/dl)	48.5 ± 2.7	49.9 ± 2.5 *	43.7 ± 11.3	76.3 ± 9.7 * *
LDL-C (mg/dl)	102.5 ± 3.4	98.7 ± 2.5 *	128 ± 31.5	98.7 ± 12.3 * *
Lipo(a) (mg/dl)	23.8 ± 2.5	22.9 ± 3.4 *	35.4 ± 6.7	27.2 ± 3.8 * *
LTPA (MET-H /week)	157 ± 15.6	165 ± 12.8 *	96 ± 9.7	350 ± 21.6 * *
VO2 max (ml/kg*min)	34.6 ± 3.7	38.3 ±1.9 *	31.4 ± 2.9	48.7 ± 5.3 * *

Values are expressed as mean ± SD; * P < 0.05, ** P < 0.01, *** P < 0.001. Significance at p < 0.05.

Table 4
Post training correlation analysis of lipid and lipoprotein (a) markers, and cognitive abilities (LOTCA scores) variables according to the level of Leisure-time physical activity (LPTA-MET-H /week) after 24-week of exercise

Parameters	Cognitive group (n = 100); (R)	
	(low LTPA) (baseline)	(High LTPA) (Pos-training)
Total LOTCA score	0.21*	0.26 **
Orientation	0.16 *	0.35**
Visual Perception	0.25*	0.28**
Spatial Perception	0.21*	0.33**
Motor Praxis	0.21*	0.16**
Vasomotor organization	0. 27*	0.32**
Thinking Operations	0.41*	0.27**
Attention and Concentration	0.51*	0.25**
T-Cholesterol (mg/dl)	0.42*	0.35**
TG (mg/dl)	− 0.35*	− 0.61**
HDL-C (mg/dl)	0.30*	0. 41**
LDL-C (mg/dl)	- 0.38*	− 0.52**
Lipo(a) (mg/dl)	- 0.38*	− 0.53**
Data presented as coefficient (R); * denotes significance at < 0.01; ** denotes significance at < 0.001		

Regarding to LOTCA scores, the improvements in cognitive abilities among physically active participants were significantly correlated with the change in the levels of lipids and lipo(a) markers. Cognitive parameters were correlated negatively with TG, LDL-C, and lipo (a) and positively with the increase in HDL-C and aerobic fitness as measured by VO2 max (Table 5).

Table 5
Post training correlation coefficients among factors involved in Dyslipidemia and cognitive parameters (n = 100).

Parameters	VO2 max	T-Cholesterol (mg/dl)	TG (mg/dl)	HDL-C (mg/dl)	LDL-C (mg/dl)	Lipo(a) (mg/dl)
Orientation	0.33**	− 0.33**	−0.45 **	0.22 **	−0.65**	−0.58**
Visual Perception	0.24**	-0.24**	−0.33 **	0.29 **	−0.32**	−0.51**
Spatial Perception	0.24**	-0.24**	−0.29**	0.37**	−0.58 **	−0.52**
Motor Praxis	0.34 **	-0.34 **	−0.35 **	0.46 **	−0.67 **	−0.69 **
Vasomotor organization	0.25 **	-0.25 **	−0.41**	0.55 **	−0.75 **	−0.78**
Thinking Operations	0.48 **	-0.48 **	−0.39 **	0.57 **	−0.78 **	−0.56**
Attention and Concentration	0.36 **	-0.36 **	−0.47 **	0.62 **	−0.59 **	−0.43**

Data presented as coefficient (R); * denotes significance at < 0.01; ** denotes significance at < 0.001

4. Discussions

Physical activity as non-drug modulates consider one of the most promising strategies to prevent or improve cognitive disabilities among elderly populations [53]. It was reported that physically active people across their entire life minimize the incidence rates of dementia and cognitive difficulties [54–56]. Whereas many studies reported a lower rates of cognitive disorders among subjects who participated in higher levels of physical activity interventions than persons with lower scores of physical activity [57–58].

Recently, many research works revealed that physical exercise with moderate intensity produce remarkable higher levels of improvement in skills, mobility, and mood in both younger [59], and older adults [60]. However little is known about whether the positive effect of moderate exercise on cognitive abilities, which occurs via modulating lipid profile and lipoprotein (a).

Therefore, the current research work aimed to investigate the probable correlation between anti-dyslipidemic mechanisms of exercise on cognitive abilities among 150 older adults participated in supervised aerobic training program for 24 weeks.

In the present study, the cognitive abilities of 150 older adults of both control and exercise group were measured using LOTCA scores, a cognitive evaluation test formed of 7-subsets variables. In older subjects participated in moderate aerobic exercise for 24 weeks, there was significant improve in cognitive performance via increase in all LOTCA 7-subsets variables compared to non exercised group.

The data revealed positive significant correlations between the total LOTCA scores of older subjects and their performance of cognitive abilities. Thus, the accuracy and evaluation of LOTCA test supports its use as diagnostic tool for cognitive function as previously reported [1].

Moreover, significant positive correlation was obtained between the older subjects in the motor praxis, vasomotor organization, thinking operations, attention and concentration domains of the LOTCA –scores and their performance of functional physical activity. The data matched with others who suggested the strongest indication of physical exercise benefits on cognition function via enhancing academic performance, psychological and well-being [61–62].

Similarly, our study was in accordance with recent studies that reported improving in cognitive performance on a working memory task among younger and older adults following moderate intensity cycling [63]. In addition, our study supported that positive effects of physical exercise intervention relay in enhancing psychological well-being, cognitive functioning and quality-of-life especially in older subjects with mild cognitive impairment as reported recently in literature [64–65].

In present study, there was slight in significant change in cognitive abilities scores and lipid profile related markers among non exercised control group. This change may be due to low-intensity physical activity such as routine day time life which accounts for most activity energy expenditure (AEE) in people who do not regularly exercise [66], these activities may useful in health outcomes such as cognitive impairment. This indicated with other research work who reported that older women identified a positive association between cognitive performance and total daytime movement, which suggests that total activity may be important for cognitive outcomes [67]. Cognitive impairment and other metabolic disorders like CVD and stroke are significantly interrelated in older subjects with dyslipidemia [16, 68–69]. However, lipid-lowering therapies have demonstrated benefits in stroke prevention and prognosis [18, 57, 69, 70].

Lipid profile and lipoprotein (a) makers; choelestrol, TG, HDL-C, LDL-C, and Lipo (a) were estimated in this study. Paired t-test and student t-test analysis showed that participants with cognitive impairments had abnormal basal levels of lipids and lipoprotein (a) makers. The data matched with many studies that reported significant relationship between abnormal lipid profiles and a negative impact on cognition in old age [71–74].

Also, in this study, there was significant association between physical activity and cognitive impairment as measured by LOTCA scores. In physically active participants, there was significant reduction in the levels of TG, LDL-C, and Lipo (a), along with increase in the level of HDL-C and LOTCA scores with overall cognitive improvements status following 24 week of moderate aerobic training. The data were in line with many studies that performed the positive effects of physical exercise as anti-dyslipidemdic modulates via significant reduction in the levels of in circulating lipids and apolipoproteins (apos) induced by regular physical exercise [75–77]. Thus, the incorporation of exercise as non-drug modulates in subjects with abnormal lipid profiles has the priority among many clinical trials [78–79]. The association between biological and cognitive aging among older ages greatly supported by the presence of dynamic link between physical activity and cognitive functioning via changes in biological fluids related to cognitive domains [80–82].

In the present study, cognitive parameters correlated negatively with the reduction in the levels of TG, LDL-C, and lipo (a) and positively with the increase in the levels HDL-C and aerobic fitness as measured by VO2 max. The data were in consistence with other studies that reported the potential positive link of many physiological mediators including lipid profiles and aerobic fitness as potential mediators in physical activity-cognition relationships [83], and that the improved cognition significantly correlated with the increase in aerobic fitness and reduction in the levels of lipid profile [83–85].

Finally, the data obtained showed that physical activity status, aerobic fitness, and lipid profile played a pivotal role on cognitive performance of healthy older adults.

In conclusion, the data concluded that supervised moderate aerobic training for 24 weeks plays a positive significant effect in improving cognitive functions via modulating lipid profile and lipoprotein (a) of older adults.

Declarations

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Competing interests:

The authors declare that they have no competing interests.

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Availability of data and materials

All data generated or analyzed during this study are presented in the manuscript. Please contact the corresponding author for access to data presented in this study.

Authors' contributions

Research idea, design, and practical work, were proposed by GSA. Data collection and analysis was executed by GSA. Reformatting, drafting, and preparing of the revised manuscript were done by AHA and GSA. Finally, manuscript preparation and submission were done by GSA

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