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Aquarobic exercises improve the serum blood irisin and brain-derived neurotrophic factor levels in elderly women

Ji-Hyeon Kim, Do-Yeon Kim*

Department of Physical Education, Pusan National University, Busan, South Korea

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ABSTRACT

Background: The increase in the prevalence of degenerative brain diseases owing to the growing elderly population is becoming a serious social issue, and regular exercises can be effective in preventing and treating such diseases. Irisin, one of the myokines expressed in the muscles during exercise, is highly associated with the expression of brain-derived neurotrophic factor (BDNF). Therefore, the purpose of this study was to analyze the effect of aquarobic exercises on serum irisin and BDNF levels to help prevent and delay degenerative brain diseases in elderly women.

Materials and methods: Twenty-six elderly women voluntarily participated in the study (12 in the control group and 14 in the exercise group). The exercise group underwent a 16-week aquarobic exercise program. The irisin and BDNF levels and liver function were measured in both groups: three times in the exercise group and two times in the control group.

Results: Significantly higher serum irisin ($p < 0.001$) and BDNF ($p < 0.05$) levels in the aquarobic exercise group than in the control group were found after 16 weeks of exercise, and significant interaction effects of irisin ($p < 0.001$) and BDNF ($p < 0.01$) were found in both the control and exercise groups. The serum irisin ($p < 0.01$ and $p < 0.001$, respectively) and BDNF ($p < 0.05$, $p < 0.001$, respectively) levels were significantly higher 30 min after the first exercise session and 30 min after the last exercise session in the 16th week than during the rest period before the 16 weeks of exercise.

Conclusions: Aquarobic exercises were found to improve the serum irisin and BDNF levels; thus, it could be effective in preventing degenerative brain diseases and enhancing brain function of elderly women.

1. Introduction

The quality of life of elderly individuals is an essential concern in an aging society, and health is one of the most important aspects of quality of life. As a major part of efforts to maintain and improve health, exercises have been studied extensively; studies have shown that exercises are an effective intervention for the prevention and treatment of degenerative brain diseases (Kim et al., 2016; Ohman et al., 2016; Tarumi and Zhang, 2014).

Skeletal muscles comprise the largest area of the body and are primarily responsible for performing the mechanical activities required for posture, exercise, and respiration, which rely on muscle fiber contraction. However, the fact that these muscles serve as the largest secretory part of the body (Pedersen, 2013) and secrete various biological polypeptides provides a new conceptual framework for understanding the important role of skeletal muscles in coordinating energy balance in the entire body (Seldin and Wong, 2012).

Irisin, a leading myokine, has been found in the presence of exercise-induced peroxisome proliferator-activated receptor γ coactivator-1α (PGC-1α) (Bostrom et al., 2012). It is the protein separated from fibronectin type III domain-containing protein 5 (FNDC5), which is associated with the expression of PGG-1α and consists of 112 amino acids (Erickson, 2013).

Irisin, which tends to increase with exercise and exposure to cold (Cho, 2016) and has its highest levels in the kidney, liver, and muscle, plays an important role in the regulation and metabolism of metabolic diseases, such as obesity and diabetes in various organs (Bostrom et al., 2012). In the pancreas, irisin increases beta cells by promoting betatrophin secretion, thereby lowering insulin resistance and inhibiting type 2 diabetes (Sanchis-Gomar and Perez-Quilis, 2014). Irisin is also directly involved in bone metabolism, which can accelerate the transformation of mature osteoblasts into bone marrow (Colaianni et al., 2014), and low bone density and osteoporotic fractures in postmenopausal women are highly correlated with irisin levels (Anastasilakis et al., 2014). In addition, FNDC5, a precursor of irisin, is involved in the formation of dendrites (Cheng et al., 2012) and

* Corresponding author.
E-mail address: kdy4955@pusan.ac.kr (D.-Y. Kim).

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suppresses neurodegenerative diseases by increasing the brain-derived neurotrophic factor (BDNF) mRNA level in the hippocampus and thus the volume of the hippocampus; it also promotes the expression of the BDNF gene in the cerebral cortex (Wrann et al., 2013).

BDNF is known to be an important substance in the growth and development of neurons and to enhance neuronal survival by increasing resistance to nerve damage (Cotman and Berchtold, 2002); further, it is a potent regulator of brain cell formation, synapse generation, and synaptic plasticity in adults (Park and Poo, 2013). In particular, BDNF in the adult brain influences brain activities, such as learning, memory, and high-level thinking by affecting the hippocampus, cerebral cortex, and basal forebrain (Alonso et al., 2002; Bekinschtein et al., 2007; Yamada and Nabeshima, 2003). Thus, the BDNF level in the brain is closely related to diseases of the nervous system, such as dementia, depression, and Parkinson's disease, in addition to aging (Arancio and Chao, 2007; Duman et al., 2008).

The expression of irisin, which plays an important role in various organs and is associated with BDNF expression, is closely related to liver function, and the serum irisin levels of patients with nonalcoholic fatty liver disease are different from those of healthy adults (Polyzos et al., 2014).

Therefore, this study was conducted to determine the effects of a 16-week aquarobic exercise program on the irisin and BDNF levels of elderly women and to suggest an exercise method for the prevention and improvement of degenerative brain diseases.

2. Materials and methods

2.1. Participants

Thirty-two elderly women aged between 65 and 80 years and living in Busan metropolitan, Korea, were initially recruited using simple random sampling (16 in the control group and 16 in the aquarobic exercise group). Of the 32 participants, data from 26 participants (12 in the control group and 14 in the aquarobic exercise group) were included in the analysis, excluding data from those who dropped out during the experiment owing to personal reasons and unreliable test results. Before the experiment, the study was approved by the institutional human research committee, and the study participants were fully informed regarding the purpose of this study; only those who were willing to participate in the experiment submitted their consent for participation. All elderly women were sedentary, not regularly participating in physical activity (defined as < 20 min of exercise twice a week), not having a history of drug or alcohol abuse, weight was stable (± 2 kg weight change in 3 months), and not taking hormones or other medications known to influence serum irisin and BDNF levels. The women were categorized as non-smokers. The health of the participants was determined by a health questionnaire, physical examination, and laboratory tests.

2.2. Study design

Participants were tested in the morning at the same time of day to avoid potential diurnal variations. Body composition, irisin and BDNF levels were measured using the same methods and conditions. The measurements were performed thrice in the exercise group (at the rest period before the 16-week experimental period, 30 min after the first session in the 16th week, and 30 min after the last session in the 16th week) and twice in the control group (at the rest period before the 16-week period and the rest period after the 16-week period). Participants were advised to make no changes to their diet and exercise habits during the study.

2.3. Body composition and blood analysis

The participants were instructed to wear light clothing, and their height, weight, percentage of body fat, and skeletal muscle mass were measured using X-SCAN PLUS II (Jawon Medical, Korea).

Table 1
Aquarobic exercise program.

Week	Exercise		Intensity (%)	Frequency
	Warm-up (10 min)	Slow walking, stretching, bounce		
1–4	Main exercise (40 min)	1. bounce(front, back, side, slide)	40–50%HRR (RPE 11–12)	2 times/week
5–8		2. knee jogging (narrow, wide)	50–60%HRR (RPE 13–14)	
9–12		3. jumping jack	60–65%HRR	
		4. scissers	(RPE 14–15)	
13–16		5. grounded	65–70%HRR	
		6. leg curl	(RPE 14–15)	
		7. elevated		
		8. leg movement – scissers & jump – jazz kick & soccer kick – rocking horse – heel cross, ankle reach – kick & hold, mambo, step – leg swing, kick swing – frog jump, tuck jump – twist hell & toe – kick(front, back, side) – side step, step & cross – ankle inversion, eversion		
	Cool-down (10 min)	Slow walking, stretching, bounce		

Rest-period blood samples were collected between 8 a.m. and 9 a.m., after 12–13 h of fasting. Post-exercise blood samples were collected from the aquarobic exercise group after a 30-minute rest after an exercise session. Blood samples (10 mL) were collected by a clinicopathologist from the antebrachial vein using a disposable syringe and a serum separator Vacutainer. The samples were centrifuged at 3000 rpm for 10 min on Combi-514R (Hanil, Korea). After separating the serum, the supernatant was transferred to a 1.5-mL micro tube and stored at −80 °C for analysis.

2.3.1. Irisin level

The irisin level was analyzed using an Irisin Recombinant Enzyme-Linked Immunosorbent Assay (ELISA) Kit (Phoenix Pharmaceuticals, USA) and Thermo Scientific Multiskan GO (Thermo Scientific, Waltham, MA, USA) at OD 450-nm wavelength.

2.3.2. BDNF level

The BDNF level was analyzed using the Total BDNF Quantikine ELISA Kit (R&D Systems, USA) and Thermo Scientific Multiskan GO (Thermo Scientific, USA) at OD 450-nm wavelength.

2.4. Aquarobic exercise program

The program was developed by modifying the aquarobic program of Park and Cheon (2016). The program consisted of two aquarobic sessions a week for 16 weeks implemented in a pool at air temperatures of 30–33 °C, a humidity level of 70–75%, a water temperature of 29 ± 1 °C, and a depth of 1.2 m. Each session lasted for 60 min, which included 10 min of warm-up, 40 min of exercise, and 10 min of cool-