DOI 10.26773/jaspe.241001

Journal of Anthropology of Sport and Physical Education

ORIGINAL SCIENTIFIC PAPER

Effect of a 12-Week High Intensity Interval Training on Serum Brain Derived Neurotrophic Factor of Obese Undergraduates

Karl E. Eimuhi[1]

[1]Department of Agricultural and Life Sciences, College of Engineering, Science, Technology and Agriculture, Central State University, Wilberforce, Ohio, USA

Abstract

The study investigated the effect of a 12-week High Intensity Interval Training (HIIT) on Serum Brain Derived Neurotrophic Factor (BDNF) among obese undergraduates of the University of Benin. The pretest-posttest randomized experimental design was employed for the study. The study involved a population of one hundred and twenty obese undergraduates, with a sample of twenty-four selected using simple random sampling. The participants' anthropometric profiles were analyzed descriptively using mean and standard deviation, and the hypothesis was tested using analysis of covariance (ANCOVA) with statistical significance set at a p-value of <0.05. The Bonferroni post-hoc test was conducted to pinpoint the source of the differences between the groups. The results showed a significantly higher increase in Serum BDNF levels (2.07 ± 1.9 vs. 2.38 ± 2.1) in the experimental group. This suggests that the HIIT protocol had a notable impact on the serum BDNF concentration of the obese undergraduates. Therefore, HIIT may serve as an effective intervention for elevating BDNF levels and potentially enhancing brain health. The study recommends that policymakers in Nigeria and other sub-Saharan African nations should prioritize addressing obesity due to its potential cognitive complications.

Keywords: *BDNF, Obese undergraduates and HIIT*

Introduction

Obesity is a multifaceted condition that is influenced by genetics, control of the energy balance, and significant environmental factors. It presents serious negative effects on the health of the general population. The prevalence of obesity and overweight has been steadily rising worldwide, and the pace of increase in African nations like Nigeria is comparable to that seen in affluent nations (Chukwuonye, et al., 2022; Templin et al., 2019). Obesity is associated with psychosocial disorder, and one of which is a decline in academic achievement and cognitive function (Taras & Potts-Datema, 2005; Cournout et al., 2006). Obesity-related research on cognitive function has centered on Brain Derived Neurotrophic Factor (BDNF), a neurotrophin associated with memory and appetite control. Secretion of BDNF through increased expression of BDNF mRNA in the hypothalamus is influenced by physical exercises. Since exercise triggers an upsurge in BDNF mRNA gene expression within the hippocampus, the protein has been regarded as a possible component of the biological processes that form the basis for how aerobic exercise influences the hippocampal memory system. (Rossanti et al., 2015).

Exercise is also known to improve mood and cognitive abilities, although, the physiological mechanism underlying this benefit is yet unknown. Previous studies conducted by Eimuhi et al., (2021) revealed that the use of an acute exercise of HIIT initiated an increase in the serum BDNF concentration of obese undergraduates, however, with no significant level. Furthermore, inconsistency in findings has existed regarding increase, decrease or no change in the levels of serum BDNF following HIIT protocol (Airin et al, 2014; Alberto et al., 2018; Jimenez-Maldonado et al., 2018). Therefore, the aim of this research is to investigate the impact of a 12-week HIIT protocol as a chronic exercise intervention on the serum BDNF levels in obese undergraduates from the University of Benin.

Hypothesis

A hypothesis was formulated to guide the study.

Correspondence:

K. E. Eimuhi
Central State University, College of Engineering, Science, Technology and Agriculture, Department of Agricultural and Life Sciences, 1400 Brush Row Road, Wilberforce, Ohio 45384, USA
E-mail: karl.eimuhi@uniben.edu

- There will be no significant difference in the Serum BDNF concentration of obese undergraduates following a 12-week HIIT programme in the experimental and control groups.

Methodology

The pretest-posttest randomized experimental design was employed. A subset of twenty-four (24) individuals was selected from a larger pool of one hundred and twenty (120) obese undergraduate students at the University of Benin. These participants were members of the University of Benin's Obesity Fitness Group (OFG) and regularly participated in exercise sessions. Twenty % of the population was represented by the sample that was chosen. Participants without any form of visible disability met the study's inclusion criteria. Participants who fell below the rigorous BMI cut-off of 30 kg/m2 were excluded from the study. Using a simple random sample method, the candidates were chosen. Subsequently, the participants were randomly divided into the experimental and control groups. This division involved numbering the 24 selected obese participants and then assigning them to either the control or experimental group, resulting in twelve individuals in each group. Ethical approval for the study was obtained from the Ethics Board of the University of Benin, Benin-City, Nigeria with approval number EC/UNIBEN/28/2024.

Anthropometric Measurements

The study's goals were explained to the participants, and they became acquainted with the anthropometric tests and tools. Prior to commencing the High-Intensity Interval Training (HIIT) program, initial data collection involved conducting pre-test assessments of anthropometric parameters. The same protocols were used to conduct post-test measurements immediately after the intervention period had ended. In particular, a calibrated stadiometer was used to measure each participant's height as they stood barefoot The study utilized an Omron Body Composition Monitor (Omron Healthcare, 2019) to measure participants' body mass and percentage of body fat, with participants wearing snug attire during the measurements. In this research, we assessed internal consistency reliability. To ensure the appropriateness of both the HIIT protocol and the measuring instrument, a preliminary study was conducted involving eight (8) independent subjects, with four (4) individuals in each group. The data collected using the multilevel modeling method were then subjected to Interclass Correlation Coefficient (ICC) analysis, yielding a high reliability with a Correlation Coefficient of 0.75. This result validated the suitability of employing the instrument and protocol for the present study.

Biochemical Analysis

The blood sample collection process followed the guidelines presented by WHO (2010). Two blood samples were taken: once prior to training and once just after the HIIT intervention. A medical laboratory expert took blood samples from the antecubital veins of the volunteers who had not eaten or drunk all night as they sat in a chair for 15 minutes. To allow blood to coagulate, blood samples were kept at room temperature for an hour. The expressed serums from the blood sample were centrifuged and stored at -80°C for further analyses. BDNF levels were assessed using an ELISA kit (enzyme-linked immunosorbent assay) (Eastbiopharm, Hangzhou Co. Ltd, China).

Training Protocol

The HIIT protocol consisted of: 1) a 10-minute warm-up session that incorporated activities like jogging, stretching, and running at an initial intensity of 50% of the maximum heart rate, gradually increasing to 85% during the session; and 2) a 20-minute strength training routine targeting major upper and lower body muscles.

The 12-week HIIT protocol was applied to the Experimental group. The HIIT intervention required a 10-minute warm-up that includes stretching, jogging, and running for 5 minutes at 50% to 85% of one's maximum heart rate (training began with 50% intensity). Next, the participants took part in a 20-minute session focused on strengthening their major upper and lower body muscles. This session involved a variety of exercises such as windmills, burpees, sit-ups, heel raises, side jumps, alternate lateral tilting, and alternate leg-arm kicking, which they executed at intensity levels varying from 50% to 80% of their one-repetition maximum. They completed three sets of 10 repetitions for each exercise, with a 1-minute rest interval between sets and a 2-minute break between exercises. This training regimen was carried out over a duration of 12 weeks. The end of each training session was followed by a mild 10-minute walk to cool down. The research carried out by Machado et al. (2017) and Nazari et al. (2016) confirmed the effectiveness of the HIIT protocol. In contrast to subjecting the participants in the control 10 min warm up with a consistent pace + 20 min strength training with 50% of 1RM.

Statistical Analysis

The data analysis was conducted with the IBM version 20 of the Statistical Package for Social Sciences (SPSS). Descriptive statistics, including mean and standard deviation, were employed to characterize the sample's anthropometric and BDNF profiles. Inferential statistics involving analysis of covariance (ANCOVA) was employed to test the hypothesis. The Bonferroni post-hoc test was conducted to pinpoint the source of the differences between the groups. The significance level, denoted by the alpha level, was set at 0.05.

Table 1: Descriptive Statistics Showing Physical, Anthropometric Characteristics and Serum BDNF concentration of the Subjects (n=24)

Variable	Group		
	Measuring	Control (n=12)	Experimental (n=12)
Age (yrs)	Pre-training	26.3 ± 9.4	27.5 ± 4.1
Height (cm)	Pre-training	1.69 ± 0.1	1.74 ± 0.1
Weight (kg)	Pre-training	90.2 ± 8.4	92.9 ± 8.2
	Post-training (Chronic)	90.1 ± 8.3	90.7 ± 8.6
BMI (kg/m^2)	Pre-training	31.9 ± 4.0	30.5 ± 4.2
	Post-training (Chronic)	30.4 ± 3.9	30.2 ± 4.1
Body Fat (%)	Pre-training	39.0 ± 8.2	38.1 ± 10.1
	Post-training (Chronic)	38.1 ± 9.4	39.2 ±10.9
BDNF (ng/ml)	Pre-training	2.61 ± 2.8	2.07 ± 1.9
	Post-training (Chronic)	2.63 ± 2.9	2.38 ± 2.1

* BMI – Body Mass Index, * BDNF – Brain Derived Neurotrophic Factor, Values expressed as Mean ± SD

Results

Table one displays the average values and standard deviations for the physical and anthropometric traits (age, height, body mass index, body fat percentage) of individuals in both the experimental and control groups. The table also illustrate a rise in Serum BDNF levels when comparing the pretest and posttest assessments in both the experimental and control groups. In the experimental group, there was an increase in Serum BDNF, with a mean and standard deviation of 2.07 ± 1.9 and 2.38 ± 2.1 at the posttest assessment. Similarly, the control group also showed a slight increase in Serum BDNF, with a mean and standard deviation of 2.61 ± 2.8 and 2.63 ± 2.9 at the posttest assessment when compared to the pretest assessment. To determine whether these differences are statistically significant or not, it became necessary to test the hypothesis.

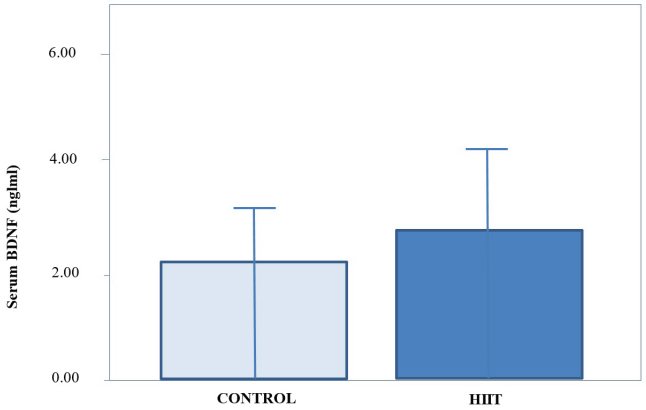

FIGURE 1: Serum BDNF level in the control (n=12) and experimental group (n=12). Data are expressed as the mean±SD; p<0.05.

Table two shows F (1,21) = 5.162, (p < 0.0005) < α = 0.05. Hence, there was a significant difference in post-BDNF between the experimental and control group while adjusting for pre-BDNF. This means that the null hypothesis was rejected. The partial Eta Squared (0.92) when compared with Cohen's guidelines shows that the effect of this difference is large on the Obese Undergraduates. Furthermore, 92% variance in BDNF was accounted for by 12-Week High Intensity Interval Training.

The adjusted mean difference (1.371 ± 1.25) between the experimental and control group is presented in Table three. There was a significant difference ((p < 0.0005) < α = 0.05) between the adjusted means of the experimental and control group while adjusting for the covariate 'pre-BDNF'. Thus, the HIIT protocol (experiment) presented a more significant effect than the control group (without HIIT protocol).

Table 2: ANCOVA test on the difference in the effect of the control and experimental Treatment Measure

Dependent Variable: post						
Variable	Sum of squares	df	Mean Square	F	Sig.	Partial eta squared
Corrected Model	2018.232a	2	2018.232	2.131	<0.001	0.916
Intercept	835.478	1	835.478	1.813	<0.001	0.692
Pre-BDNF	7.288	1	7.288	.824	<0.462	0.017
Treatment SSbetween	2024.855	1	2024.855	5.162	<0.001	0.915
Error SSwithin	1492.372	21	11.267			
Total	19492.000	24				
Corrected Total	2211.232	23				

a. R Squared = .916 (Adjusted R Squared = .912)

Table 3: Pairwise comparisons of the adjusted means of the effect of the control and experimental treatment measure

Dependent Variable: post						
(I) treatment	(J) treatment	Mean Difference (I-J)	Std. Error	Sig.b	95% Confidence Interval for Differenceb	
					Lower Bound	Upper Bound
1.00	2.00	1.371	1.250	<0.001	1.125	3.749
2.00	1.00	-1.371	1.250	<0.001	-3.749	-1.125

Based on estimated marginal means *. The mean difference is significant at the 0.05 level. b. Adjustment for multiple comparisons: Bonferroni.

Discussion

In this study, we examined variations in BDNF levels among obese undergraduate students after a 12-week HIIT program. The results of our investigation demonstrated a noteworthy rise in serum BDNF levels among the obese students after undergoing the HIIT intervention when compared with the control group without HIIT intervention. This discovery aligns with the findings of Nazari et al. (2016) and Saucedo Marquez et al. (2015), both of which also observed increased serum BDNF concentrations in their participants. The 12-week HIIT exercise may have promoted the release

of BDNF from a number of tissues, which could have contributed to the increase in BDNF levels. Increased gene expression and the activation of transcriptional pathways may also be responsible for this. According to Wrann et al. (2013), the biochemical pathways that lead to an increase in BDNF concentration in the brain may be started by the musculoskeletal contractions that occur during HIIT programs. The level of physical activity during an intervention period may have a significant impact on how much BDNF is present. Exercise types and intensities can alter BDNF responses as well.

In contrast to this report, the study by Kim (2016) found that serum BDNF concentration had significantly decreased. This divergence in results is not surprising given that Mehrjardi (2017) analyzed a different sample of athletes and found that athletes frequently engage in high-intensity workouts that might cause tissue damage and necessitate on-going healing. Similarly, among the same population, earlier research shown that routine exercise decreased basal BDNF among sports people (Nofuji et al., 2014). BDNF plays a role in the healing process after injuries (Kim, 2016). Another possible explanation for this discrepancy in results is that 90% of blood BDNF proteins are stored in platelets, with platelet activation facilitating their release during the clotting process (Kim, 2016). Exercise causes mechanical and functional stress, which damages the muscles and causes nerve damage (Clarkson & Hubal, 2002). The inconsistencies may have been caused by timing and other blood sample techniques.

The results of ANCOVA of the hypothesis tested showed that the adjusted mean of the experimental group was significantly higher from that of the control group. A variance of 92% in BDNF concentration was accounted for the HIIT protocol. Thus, while both the control and experimental groups in our study exhibited increased serum BDNF levels, it's noteworthy that the magnitude of this increase was more pronounced in individuals who underwent the HIIT intervention. This suggests that the HIIT program could potentially serve as an effective means to promote brain health. The outcome of the independent sample t-test led to the rejection of the null hypothesis, which posited that there would be no significant alteration in the serum BDNF levels of the obese undergraduates after completing the 12-week HIIT program. This implies that the administered HIIT program indeed had a substantial impact on the participants' serum BDNF levels.

Conclusion

In light of the results obtained in this research, it was concluded that HIIT protocol initiated a significantly higher increase in the serum BDNF concentration of the obese undergraduates when compared with the control group not exposed to HIIT protocol.

Recommendation

Based on the findings, policymakers in Nigeria and other sub-Saharan African nations should pay more attention to obesity because as it may pose severe cognitive complications. Obese students should be made aware of the many advantages of the HIIT program on overall health and wellbeing. Also, coaches and personal trainers should attend seminars or courses where they may learn more about how to implement HIIT training into their workouts to enhance serum BDNF levels.

Received: 11 June 2024 | **Accepted:** 22 August 2024 | **Published:** 15 October 2024

References

Airin, S., Linoby, A., Zaki, M. S. M., Baki, H., Sariman, H., Esham, B., Azam, M. Z. M. & Mohamed, M. N. (2014). The Effects of High-Intensity Interval Training and Continuous Training on Weight Loss and Body Composition in Overweight Females. *Proceedings of the International Colloquium on Sports Science, Exercise, Engineering and Technology*, 7, 401– 409. https://10.12965/jer.1734962.481

Alberto, J., Ivan, R., Patricia, C.G, Jose M., & Luiz, F.F. (2018). The Impact of High-Intensity Interval Training on Brain Derived Neurotrophic Factor in Brain: A Mini-Review. *Frontiers in Neuroscience. 12,* 839. https://doi.org/10.3389/fnins.2018.00839

Chukwuonye, I. I., Ohagwu, K. A., Ogah, O. S., John, C., Oviasu, E., & Anyabolu, E. N. (2022). Prevalence of overweight and obesity in Nigeria: Systematic review and meta-analysis of population-based studies. *PLOS Global Public Health, 2*(6), 515. https://doi.org/10.1371/journal.pgph.0000515

Cournout, M., Marqui, J. C., Ansiau, D., Marinaud, C., Fonds, H., & Ferrieres, J. (2006). Relation between body mass index and cognitive function in healthy middle-aged men and women. *Neurology, 67*:1208–14. https://10.1212/01.wnl.0000238082.13860.50

Eimuhi K.E., Adodo S.M., & Agbonlahor, E.I. (2021). Changes in Serum Brain Derived Neurotrophic Factor Level (BDNF) following High Intensity Interval Training among Obese Undergraduates. *Proceedings of the Nigerian Academy of Science (PNgAS). 14* (2), 21-28. https://nasjournal.org.ng/index.php/pnas/article/view/350

Jimenez-Maldonado, A., Rentera, I., Garcia-Suarez, C. P., Moncada-Jiménez, J & Freire-Royes, L.F. (2018). The Impact of High-Intensity Interval Training on Brain Derived Neurotrophic Factor in Brain: A Mini-Review. *Frontiers in Neuroscience. 12*: 839, 1-9. https://doi.org/10.3389/fnins.2018.00839

Kim, I.Y.J. (2016). The impact of exercise training on basal BDNF in athletic adolescents. *Journal of Physical Therapy Science. 28*, 3066–3069. http://0.1589/jpts.28.3066

Machado, A. F., Baker, J. S., Junior, A. J. F, & Bocalini, D. S. (2019). High-intensity interval training using whole-body exercises:training recommendations and methodological overview. *Clinical Physiology and Functional Imaging, 11*;39(6):378-383. https://10.1111/cpf.12433

Marquez S M C, Vanaudenaerde B, Troosters T, & Wenderoth N. (2015). High-intensity interval training evokes larger serum BDNF levels compared with intense continuous exercise. *Journal of Applied Physiology, 119*: 1363–1373. http://doi:10.1152/japplphysiol.00126.2015

Mehrjardi R Z (2017). Effect of 8 weeks moderate intensity aerobic exercise on brain derived neurotrophic factor (BDNF) in female athletes. *Journal of Physical Activity and Hormones, 1*(2): 029-038. https://journals.iau.ir/article_532182.html

Nazari Y, Nikbakht M, Habibi A, & Shakeryan S (2016). Acute and Chronic Effects of Combined Training on Brain-Derived Neurotrophic Factor Levels and Its Association with Anthropometric Variables in Overweight Men. *Annals of Military and Health Sciences Research, 12*(14): 4. doi: 10.5812/amh.13037.

Nofuji Y, Suwa M, Moriyama Y, Nakano H, Ichimiya A, Nishichi R, Sasaki H, Radak Z, & Kumagai S. (2008). Decreased serum brain-derived neurotrophic factor in trained men. *Neuroscience Letters. 437*, 29–32. http://10.1016/j.neulet.2008.03.057

Omron Healthcare (2019). Omron Body Composition Monitor and Scale with Bluetooth https://omronhealthcare.com/wp-content/uploads/Body-composition-monitor-and-scale-with-bluetooth-bcm500.pdf.

Rossanti, R., Gurnida, D. A., & Fadlyana E. (2015). Short term memory, physical fitness, and serum brain-derived neurotrophic factor in obese adolescents**.** *Indonesian Journal of Paediatrics and Perinatal Medicine. 55* (5), 1-5. https://doi.org/10.14238/pi55.5.2015.277-81

Saucedo Marquez, C. M., Vanaudenaerde, B., Troosters, T., & Wenderoth, N. (2015). High-intensity interval training evokes larger serum BDNF levels compared with intense continuous exercise. *Journal of Applied Physiology.* 119, 1363-1373.

Taras, H., & Potts-Datema, W. (2005). Obesity and student performance at school. *Journal of School Health, 75*:291 https:// 10.1111/j.1746-1561.2005.00040.x

Templin, T., Cravo, O. H. T, Thomson, B., Dieleman, J., & Bendavid, E. (2019). The overweight and obesity transition from the wealthy to the poor in low- and middle-income countries: A survey of household data from 103 countries. *PLOS Medicine 16(*11): e1002968. https://doi.org/10.1371/journal. pmed.1002968

World Health Organization (2010).WHO guidelines on drawing blood: best practices in phlebotomy. https://www.who.int/publications-detail-redirect/9789241599221

Wrann C D, White J P, Salogiannnis J, Laznik-Bogoslavski D, Wu J, Ma D, Lin J D, Greenberg M E, & Spiegelman B M (2013). *Exercise induces hippocampal BDNF through a PGC-1alpha/FNDC5 pathway. Cell Metab. 18, 649–659.* Kim, I.Y.J. (2016). The impact of exercise training on basal BDNF in athletic adolescents. *The Journal of Physical Therapy Science.* 28: 3066–3069.