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ARAŞTIRMA / RESEARCH

The Effect of Physical Activity Level on Executive Functions in Obese Cases

Obez Olgularda Fiziksel Aktivite Seviyesinin Yürütücü Fonksiyonlar Üzerindeki Etkisi

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Abstract

Objective: The aim of this study was to compare the executive functions (inhibitory control, cognitive flexibility and working memory) of obese subjects with different levels of physical activity.

Material and Method: The study included 31 obese subjects. The patients were divided into two groups: high physical activity (HAOG, n=14) and minimal physical activity (MAOG, n=17), according to International Physical Activity Questionnaire-Short Form (IPAQ-SF). After the demographic data of the subjects were recorded, the body fat ratio was assessed by bioelectrical impedance analysis. Inhibitory control, cognitive flexibility, and working memory were evaluated with Stroop Test Çapa Form, Trail Making Test A-B, and 2-back test, respectively.

Results: Body mass index, age, waist circumference, hip circumference, and waist/hip ratio were similar between the groups, whereas the percentage of fat mass was lower in HAOG (p=0.016) and the percentage of muscle mass was higher in HAOG (p=0.009). Inhibitory control, cognitive flexibility and working memory scores were similar in the groups in our study (p>0.05).

Conclusion: According to the results of our study, although executive functions were similar in obese subjects with different physical activity levels, further studies are needed due to the limitations of publications in this field.

Keywords: Obesity, executive function, physical activity.

Öz

Amaç: Bu çalışmanın amacı, farklı fiziksel aktivite düzeylerine sahip obez olguların yürütücü fonksiyonlarını (inhibitör kontrol, kognitif fleksibilite ve çalışma belleği) karşılaştırmaktı.

Gereç ve Yöntem: Çalışmaya 31 obez olgu dahil edildi. Olgular Uluslararası Fiziksel Aktivite Anketi-Kısa Formu'na (IPAQ-SF) göre yüksek aktif obez grup (YAOG, n=14) ve minimal aktif obez grup (MAOG, n=17) olmak üzere 2 gruba ayrıldı. Olguların demografik özellikleri alındıktan sonra biyoelektrik empedans analizi ile vücut yağ oranları değerlendirildi. İnhibitör kontrol, kognitif fleksibilite ve çalışma belleği alt başlıklarında sırasıyla Stroop Testi Çapa Formu, İz Sürme Testi A-B ve 2-Geri Testi ile değerlendirildi.

Bulgular: Olguların vücut kitle indeksi, yaş, bel çevresi, kalça çevresi ve bel/kalça oranı değerleri gruplar arasında benzerlik gösterirken, vücut yağ oranı YAOG'da daha düşüktü (p=0.016), kas oranı ise YAOG'da daha yüksekti (p=0.009). Grupların demografik değerleri arasında fark yoktu. Çalışmamızdaki grupların inhibitor kontrol, kognitif fleksibilite ve çalışma belleği değerleri benzerdi (p>0.05).

Sonuç: Çalışmamızın sonuçlarına göre, farklı fiziksel aktivite düzeylerine sahip obez bireylerde yürütücü fonksiyonlar benzer olmakla birlikte, bu alandaki yayınların kısıtlılığı nedeniyle daha ileri çalışmalara ihtiyaç duyulmaktadır.

Anahtar Kelimeler: Obezite, yürütücü fonksiyon, fiziksel aktivite.

1. Introduction

Obesity continues to be a public health problem, with a high increase of 138% between 1975 and 2016 across the world. According to the World Health Organization 2016 data, 13% of the world population is made up of obese individuals (1), and this rate is expected to reach 45% by 2035 (2). It has been stated that this fast increase in obesity rate is associated with the consumption of high-calorie foods and reduced physical activity resulting from developing technology and changes in lifestyle (3). Therefore, treating obesity, before applying surgical and medical methods, a change in lifestyle which consists of diet, physical activity, and behavioral changes has been recommended in recent years (4). In realizing lifestyle changes and adopting sustainable approaches, cognitive functions occupy a significant place (5). It is known that there is deterioration in cognitive functions in obese individuals (6), and it may be these deteriorations would create a risk in the energy input-output balance by affecting decision-making performance (7) and negatively affect adaptation to lifestyle changes recommended for losing weight (8).

In order to ensure weight management through lifestyle changes, it is necessary to identify a goal and display behaviors aimed at this target. Neurocognitive processes of target-oriented behaviors are defined as "executive functions" (9). Executive functions are examined under 3 main area: inhibitory control, cognitive flexibility, and working memory (10). Inhibitory control is defined as the ability to control responses given to a stimulant. In poor inhibitory control, the controlling mechanism overeating weakens, and as a result of excessive eating, increases are seen in body mass index (BMI) (11). Cognitive flexibility is the ability to change behaviors (12) and to switch between decisions. With negative changes in cognitive flexibility, difficulties are experienced in having access to healthy food and deciding to start physical activity or maintaining it (13). Working memory is the part that controls reflexive factors (14). When the performance of working memory is affected, decreases occur in individuals' planning and problem-solving skills, and adaptation to weight loss program is disrupted (15).

Executive functions and subdomains are affected by factor such as physical activity. Although there are publications in the literature which show that physical activity levels are similar in obese groups and normal-weight groups (16), physical activity level is a great risk factor for obesity. Moreover, the extent to which the cut-off value of physical activity affects obesity is unknown (17). While it has been reported in studies conducted so far that increasing physical activity developed cognitive functions in obese cases, no study has been encountered in which the effect of current physical activity level on cognitive function was examined. Therefore, considering the protective mechanism of physical activity, this study aimed to compare the executive functions of obese subjects with different levels of physical activity.

2. Material and Method

The study was a cross-sectional study planned in order to evaluate the effect of physical activity levels on executive functions in obese cases. The study sample consisted of obese cases who were referred to the Diabetes and Obesity Treatment Center affiliated with Fatih Sultan Mehmet Training and Research Hospital for exercise purposes. This study was conducted in line with the principles of the Declaration of Helsinki between 31.09.2022-31.05.2023. The sample size was determined as at least 30 based on Kurtoğlu's study (18) and 33 cases were included in our study with a data loss rate of 10%. Ethical approval of our study was obtained from the Istanbul Medipol University Non-Interventional Clinical Research Ethics Committee (Ethics Committee Approval Number and Date: E-10840098-772.02-6791, 30.12.2021). Participation in the study was on a voluntary basis, and cases who signed the Informed Consent Form and met the inclusion criteria were included in this study. The inclusion criteria were being in the age range of 18-65 years, with a BMI of 30 and over, and having eight years of schooling and more. Exclusion criteria are color blindness, moderate or severe depression score (19 points or more), having a Montreal Cognitive Assessment (MoCA) Test score of less than 21, and being diagnosed with a psychiatric or neurological disorder. Demographic data of the cases were recorded. The participants' inhibitory control, working memory, and cognitive flexibility levels were evaluated by the Stoop Color and Word, 2-back, and Trail Making Test A-B, respectively.

2.1. Measurements

2.1.1. International Physical Activity Questionnaire – Short Form (IPAQ-SF)

This questionnaire evaluates physical activity in the last seven days under the headings of heavy, medium physical activity, walking, and sitting. The cases were inquired about how many hours/minutes per day and how many days they do physical activity for each heading. These values were multiplied by the MET value, and the total score was obtained (day x minute x MET value). If weekly heavy exercise MET-min./week score was 1,500, or all activity values were above 3,000 MET-min./week, the case was evaluated as highly active, and at least 20 minutes a day for at least three days a week was evaluated as vigorous-intensity exercise, at least five days a week and at least 30 min. a day was evaluated as moderate-intensity exercise or walking, and a combination of moderate and vigorous intensity exercises five days a week and above was evaluated as moderate-intensity activity. Individuals who were not evaluated in these groups were included in the inactive group. Turkish validity and reliability study was conducted for the questionnaire (19).

2.1.2. Body Fat Measurement

Body fat measurement was made through (Tanita, BC-418 MA model) Bioelectric Impedance Analysis. Evaluations were made in line with the ESPEN guidelines (20). Fat mass, lean mass, and total body fluid values were recorded both in percentages and kilograms.

2.1.3. Stroop Color and Word Test

This test assesses inhibition control, one of the subdomains of executive functions (21). It consists of Parts A, B, and C. Part A includes reading-colored boxes, part B involves reading the names of colors printed in different colors, and Part C includes reading the colors of words printed in different colors. The colors used are red, blue, and green. Test pages were given to the cases, and they were asked to track test readings with their pens. The test duration obtained using a stopwatch was recorded in seconds.

In this study, the open-access Çapa form, whose Turkish validity and reliability study was used (22).

2.1.4. 2-Back Test

In order to assess the working memory of the obese cases, 2-back test on the PsyToolkit platform was used due to its high similarity to laboratory tests (E-Prime) in terms of correct answer and reaction time (23), practical usage, and being available online and free of charge. According to this test, 25 letters were randomly displayed for 500 milliseconds with 2,500 millisecond intervals. Thus, 25 letters were shown respectively. The case was requested to push the button if the same letter appeared after a letter came in-between. The analysis of the test was performed by the platform. The results of the test repeated three times were recorded as number of match, percent of correct answer, and reaction time.

2.1.5. Trail Making Test A-B

The most frequently used test in order to assess cognitive flexibility is Trail Making Test A and B Forms. In Form A, the participants were asked to connect the numbers from 1 to 25 by drawing a line in an order. In Form B, they were asked to connect the numbers from 1 to 13 and letters to "L" which were randomly distributed by drawing a line as 1-a, 2-b, 3-c. The results were recorded as part A completion time, part B completion time, and TMT B-A difference score. Trail Making Test is an open-access test with Turkish validity and reliability (24).

2.2. Statistical Analysis

The sample size was determined using the mean and standard deviation values in the IPAQ parameter of the study of Kurtoğlu et al. with 80% power ratio and 5% Type I error (18). SPSS 16.0 (SPSS Inc., USA) software was used for statistical analyses. Shapiro-Wilk test was employed in order to determine the normal distribution of the data. Student's t-test was used to compare groups. The results were evaluated with 95% confidence interval. The statistical significance value was accepted as $p<0.05$.

3. Results

Considering a 10% data loss, 33 cases were included in our study. 2 cases were excluded from the study because they did not meet the inclusion criteria according to the Beck Depression Scale. A total of 31 cases completed our study, 14 in the HAOG group and 17 in the MAOG group. Of the cases who participated in the study, 28 were female, and three were male. Table 1 shows the demographic data of the cases. Accordingly, the mean age of MAOG was 44.82 years, while the mean age of HAOG was 47.92 years. Both groups were similar in terms of mean age. In our study, the body fat ratio of the MAOG group was significantly higher than the HAOG group (p=0.016, Table 1).

Table 1. Demographic Data

	Minimal Active Obese Group (n=17) Mean±SD	Highly Active Obese Group (n=14) Mean±SD	p
Age	44.82±9.15	47.92±9.58	0.365
Height (cm)	161±6.70	158±5.81	0.127
Weight (kg)	96.81±17.98	88.52±12.51	0.156
BMI	36.76±5.59	35.32±4.71	0.451
Waist Circumference (cm)	103.90±12.72	99.37±9.12	0.274
Hip Circumference (cm)	119.07±13.79	119.95±6.31	0.828
WC/HC Ratio	0.88±0.18	0.82±0.05	0.269
Muscle (%)	51.65±10.23	59.56±4.57	0.012*
Fat (%)	45.54±7.13	40.34±3.88	0.021*
Water (%)	42.73±5.47	42.85±4.15	0.946
IPAQ	1585±720	4588±2560	0.000*

Student's t Test, SD: Standart deviation, *: p<0.05, WC/HC: Waist Circumference/Hip Circumference

The HAOG group was significantly different from the MAOG group regarding body-muscle ratio (p=0.009, Table 1). All executive function values of both groups were similar (p>0.05, Table 2).

Table 2. Executive Functions

	Minimal Active Obese Group (n=17) Mean±SD	Highly Active Obese Group (n=14) Mean±SD	p
Stroop First Part Completion Time	31.05±7.45	33.47±7.89	0.416
Stroop Second Part Completion Time	24.03±4.78	27.53±8.52	0.179
Stroop Third Part Completion Time	62.93±22.91	62.61±15.61	0.967
"2-Back Test" Number of Match	19.26±5.34	19.75±3.32	0.770
Correct Percent of "2-Back Test"	55.48±26.75	57.76±12.36	0.772
Reaction Time of "2-Back Test"	698.78±155.18	719.66±114.94	0.680
TMT Part A Completion Time	37.56±12.63	43.58±17.14	0.270
TMT Part B Completion Time	81.84±31.30	112.06±65.40	0.102
TMT B-A	44.27±6.43	68.47±14.33	0.113

Student's t Test, SD: Standart deviation, *: p<0.05, TMT: Trail Making Test

4. Discussion

The main result of our study was the executive function of obese subjects with high (HAOG) and minimal physical activity (MAOG) levels were similar. In our study, all inhibitory control values were similar in obese subjects with different physical activity levels. From another point of view, Fagundo et al. (25) compared the executive functions of obese and morbidly obese (MO) subjects with similar physical activity levels. Although there was no significant difference between the two groups in their inhibitory control comparisons using the Stroop test, which is the same as our study, it was observed that the obese group had worse performance. When this unexpected situation is examined, it is noteworthy that the MO group included in the study of Fagundo et al. was younger, although all parameters that may affect inhibitory control were more unfavorable. We think that the lack of difference between the inhibitory control values of both groups in our study may be due to the similar age of the groups. Dupuy et al. (26) reported that inhibitory control reaction times were faster in people (women) with higher levels of physical fitness. We think that this study can be compared with our study because physical fitness is correlated with IPAQ (27, 28), and the use of functional near-infrared spectroscopy (fNIRS) and bicycle ergometry in Dupuy et al.'s study (26) increases the accuracy of their results. Unfortunately, we could not find any information about the BMI and body fat percentage of the participants of Dupuy et al. Although there are studies in the literature examining the relationship between BMI and inhibitory control (29, 30), we have not yet found a study examining the relationship between body fat ratio and inhibitory control. The groups in our study had different body fat ratios, but all inhibitory control values of both groups were similar. There is a need for publications supported by fMRI and fNIRS in obese subjects.

In our study, there was no difference between the cognitive flexibility levels of both groups. Although there are studies in the literature showing the relationship between BMI and TMT (31), we could not find a publication examining cognitive flexibility in obese subjects according to physical activity levels. Therefore, we searched for studies that increased the level of physical activity with regular exercise practice and compared this with a control group that was not physically active. It has been reported that 52-week progressive exercise applications in obese older adults provided improvement in the TMT-A group, and there was a significant difference in the TMT-B test only in the diet + exercise group compared to the control group. TMT values of the group whose physical activity level was increased improved (32). In our study, the TMT performances of HAOG and MAOG groups were expected to differ, but they were similar. This may be because they were following an exercise program, whereas the physical activity level assessments of the groups in our study covered the last week. Sanchez-Cubillo et al. (33) investigated the cognitive mechanism of the TMT test and reported that TMT-A is more related to visioperceptional abilities; TMT-B gives information about working memory and task-switching ability. Task-switching test performance, reflecting the TMT-B section, worsens with increasing body fat percentage (34). However, in our study, although both group's body muscle and fat ratios differed, the TMT test results were similar.

In our study, there was no difference between the working memory levels of obese subjects in the HAOG and MAOG groups. Boidin et al. (35) compared the working memory values of obese subjects with different physical fitness levels and found no difference between the groups, similar to our study. BMI and body fat ratios of both obese groups were also similar. The fact that the neurocognitive assessments of the obese group with high physical fitness levels and the non-obese group were similar supports the idea that physical fitness may play an important role in preventing the devastating effects of obesity. While the majority of the participants in the Boidin et al.'s study were male, the majority of our participants were female. It should be taken into consideration that gender may have an effect on the difference in our results. Although BMI provides indirect information about body fat, its relationship with body fat mass is not considered sufficient (36). In our study, although BMI was similar, body fat was lower in the MAOG group. Despite this, working memory values were similar between the groups. It is known that those with higher levels of physical activity have better endothelial function (37), and that endothelial function is associated with working memory (38). The reason why there was no difference between subjects with different physical activity levels in our study may be because the decline in working memory starts in the seventh decade (39). However, publications showing that working memory performance is similar at different ages (40) suggest that other factors should be considered.

Although there are publications in the literature comparing obesity, BMI, age, gender and physical activity parameters with executive functions, there is a need for publications comparing all these parameters in a single study. The evaluation of different topics of executive functions together in our study is the strength of this study. The non-obese group was not included in our study, which is a limitation of our study. Detailed studies comparing obese individuals with different physical activity levels, which is the focus of our study, with non-obese individuals in similar age groups are needed.

5. Conclusion and Recommendations

The findings of the current study indicated that, there was no difference between the executive functions of obese subjects at different levels of physical activity. There is a need for comprehensive studies including different parameters related to executive functions, which have an important role in weight loss and maintenance.

6. Contribution to the Field

This study is important because it is the first study to compare the executive functions of obese subjects with different levels of physical activity under several headings.

Ethical Aspects of the Research

Ethics committee approval was obtained for the study (Istanbul Medipol University Non-Interventional Clinical Research Ethics Committee, Approval No and Date: E-10840098-772.02-6791, 30.12.2021), and then the necessary permission was obtained from the Provincial Health Directorate to conduct the study in the hospital. The subjects who participated in our study were also informed about our study and read and signed the "Informed Consent Form".

Conflict of Interest

This article did not receive any financial fund. There is no conflict of interest regarding any person and/or institution.

Authorship Contribution

Concept: ZBK, İD, HOK, ÖEO, ET, ÖEÜ, YS, MGP; **Design:** ZBK, İD, HOK, ÖEO, ET; **Supervision:** HOK, YS, MGP; **Funding:** ZBK, İD; **Materials:** ET, ÖEÜ, YS; **Data Collection/ Processing:** ZBK, İD, ET; **Analysis/Interpretation:** ZBK, İD, HOK, ÖEO, ET, ÖEÜ, YS, MGP; **Literature Review:** ZBK, İD; **Manuscript Writing:** ZBK, İD, HOK, ÖEO; **Critical Review:** ZBK, İD, HOK, ÖEO, ET, ÖEÜ, YS, MGP.

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