



Impact of Obesity on Physical Activity

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Abstract

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BACKGROUND: Obesity occurs due to an imbalance between the calories and the energy released. On the animal model, obesity is considered as the ground for low physical activity. This is caused by low dopamine D2 receptor in the striatum. However, this suggestion is still unproven in the human condition.

AIM: The aim of this study was to find out difference in dopamine expression in obese subjects compared to non-obese subjects when triggered by the stimuli of physical activity.

METHODS: This is a quasi-experimental study. The sample was obese and non-obese (control) female who met inclusion and exclusion criteria. Before treatment was given, subjects were asked to fill out a depression, anxiety, and exercise motivation questionnaire. All subjects were tested for vital signs, anthropometrics, and neurological examinations to determine the initial condition. Then, the subjects saw video about physical activity and were taken for blood to measure blood dopamine levels using enzyme-linked immunosorbent assay. Differences in dopamine levels between the obese and control groups were analyzed using independent t-test. The relationship between dopamine levels and exercise motivation was analyzed using Pearson.

RESULTS: The obese group's dopamine level was 71.19 ± 3.02 ng/ml and the control group was 81.15 ± 3.17 ng/ml (independent t-test, $p = 0.032$). The obese group's motivation score was 58.46 ± 1.59 and the control group score was 62.38 ± 1.54 (independent t-test, $p = 0.09$). Furthermore, there was no correlation between dopamine levels and motivation scores (Pearson test, $p = 0.09$).

CONCLUSION: There are significant differences in dopamine levels between the obese group and the control group but no correlation between dopamine levels and exercise motivation scores.

Introduction

Obesity has become a problem. Global epidemiological data indicate high incidence of obesity and its related diseases is even exceeding the incidence of infectious disease. In general, obesity occurs due to an imbalance between intake calories and released energy. However, there are predisposing factors that influence, including genetic, gender, and behavioral. One common behavior that encourages the incidence of obesity is eating pattern on consuming too much carbohydrate. The findings around obesity including its causes and influencing factors lead to the idea that low physical activity appears to contribute to obesity. This allegation has gained numerous evidence from several studies.

However, a recent study conducted on mice showed the opposite, in which obesity is considered as the cause of low physical activity. This finding is certainly a controversial finding because until now, low physical activity is believed to be the culprit behind obesity. The basis of this controversial finding is the discovery of basal ganglia dysfunction in studies conducted on

obese mice. It has been established that one of the functions and activities of the basal ganglia is related to encouragement of excitement and pleasure through serotonin secretion in the presence of physical activity. Meanwhile, defects in this structure on the mice lead to the lack of enthusiasm for a physical activity which is characterized by little serotonin secretion [1].

Another study that supports this finding is the discovery of depressed action on type 2 dopamine receptors in conditions of low physical activity. This particular receptor type is numerous found around the striatum to control pleasure, especially after physical activity. It is also responsible for the emergence of addiction in some populations who like to do exercise [2].

Research conducted by Friend *et al.* and Nikolaus *et al.* led to a change in mindset from causes to consequences or vice versa. However, the translation of its finding in the animal to the human condition is still unproven. Therefore, concrete evidence about the dopamine theory in human samples is encouraged. This study aims to determine whether there is a difference in dopamine expression in obese subjects compared

to non-obese subjects when triggered by stimuli of physical activity [1], [2].

Materials and Methods

Participants

Design of this study was quasi-experimental using a non-randomized post-test control group design. The study has been approved by the Ethics Committee of the Faculty of Medicine, Islamic University of Indonesia. Subjects of the study were female with an age range of 18–40 years. The exclusion criteria were subjects with Parkinson's condition, depression, anxiety, and strokes that are proven through psychiatric and neurological examination results, breastfeeding or pregnancy, smoking, and taking L-Dopa or methyldopa drugs. Sample size is calculated by the experimental sample formula. The sample size of each group is six people [3]. Subjects were non-randomization into two groups: Obese and non-obese (control). Obese was defined by body mass index (BMI) of more than 25. Subject was matched based on age between two groups. Recruitment was carried out through open announcements on social media starting in June 2018.

Ethical clearance

The present study was approved by the Ethics Committee, Faculty of Medicine, UII, as stated in letter of ethical clearance No. 48//Ka.Kom.Et/70/KE/V/2018.

Procedures and measurement

Interventions and data collection were carried out in JIH Hospital, Yogyakarta. Subject was asked to come to JIH hospital and conduct the registration procedure as a general patient. Furthermore, subject will be measured blood pressure, height, and weight by the nurse. While waiting for the checking queue, subjects filled out three types of questionnaires for anxiety, depression, and exercise motivation questionnaire.

Questionnaire for anxiety was the beck anxiety inventory [4]. Beck depression inventory was used to measure level of depression [5], [6]. Subjects who indicated having severe anxiety and having moderate or severe depression were excluded from the study. The third questionnaire was exercise motivation questionnaire consisting of 19 statement items with 5 Likert scales. This questionnaire was independently developed by researchers with a reliability of 0.71.

Subjects were examined for general conditions, physiological reflexes, pathological reflexes, and sensibility by independent neurologist to screen

exclusion criteria. Then, subjects were given stimulus of physical activity in the form of 3 min exercise videos. Exercise videos were taken from YouTube for five videos and then survey was conducted on about 10 female respondents aged 18–40 years to determine the most video that triggers their exercise motivation. Blood was taken while subject saw the exercise video. Blood was taken about 3 cc to examine dopamine levels using enzyme-linked immunosorbent assay (ELISA). Blood samples were examined at research laboratory, Faculty of Medicine, Universitas Islam Indonesia.

Statistical analysis

Differences in dopamine levels between obese groups compared with the control group were analyzed using independent t-test. The relationship between variable dopamine levels and motivation scores was analyzed using the Pearson test.

Results

A total 26 subjects (13 obese and 13 control) were recruited from Sleman and Bantul regencies, Yogyakarta. The mean of age was 27.54 ± 1.8 for obese group and 26.92 ± 1.7 . There were no significant differences in the mean age of subjects between the obese group and the control group ($p = 0.81$). The mean of BMI in the obese and control groups was 33.70 ± 1.5 and 20.25 ± 0.5 , respectively (Table 1). The mean score of exercise motivation in the obese group was 58.46 ± 1.6 and 62.38 ± 1.5 in the control group.

Table 1: Characteristics of the research subject

Characteristics	Number/percentage n = 26	Mean (± SEM)
Education		
High school	11 (42.3)	
Diploma	3 (11.5)	
Graduate	9 (34.6)	
Postgraduate	3 (11.5)	
Occupation		
Employee	10 (38.5)	
College student	5 (19.2)	
Artist	2 (7.7)	
Unemployed	6 (23.0)	
Entrepreneur	3 (11.5)	
Age		
Obese group		27.54 ± 1.8
Control group		26.92 ± 1.7
Dopamine level		
Obese group		71.19 ± 3.0
Control group		81.15 ± 3.2
BMI		
Obese group		33.70 ± 1.5
Control group		20.25 ± 0.5
Motivation score to exercise		
Obese group		58.46 ± 1.6
Control group		62.38 ± 1.5

BMI: Body mass index

There was no difference between the average motivation scores of the two groups ($p = 0.09$) using independent t-test (Table 2). Dopamine levels in obese group were 71.19 ± 3.0 ng/ml while the control group were 81.15 ± 3.2 ng/ml. Analysis using independent

t-test showed that there were significant differences ($p = 0.032$). Meanwhile, the results analysis using Pearson showed no significant relationship between dopamine levels and exercise motivation scores ($p = 0.09$) (Table 2).

Table 2: Dopamine levels and motivation scores

Group	Obese	Non-obese	p	Correlation
Dopamine level (ng/L)	71.19 ± 3.0	81.15 ± 3.2	0.032 ^a	0.09 ^b
Motivation score	58.46 ± 1.6	62.38 ± 1.5	0.090 ^a	

^aIndependent t-test, ^bPearson test

Discussion

Obesity is a condition in which a person's BMI exceeds the size of the majority of the population of a particular region. Obesity is influenced by race and environmental factors. Cutoff point obesity in Indonesia is BMI values >26 [7]. Obesity is mainly caused by two risk factors; genetics or heredity and lifestyle. Some studies suggest several genes that affect obesity including FTO, AKT1, and AKTIP genes, which are associated with an increased appetite and hunger [8]. Meanwhile, lifestyle factors can be seen from variety of perspectives, including diet and food menu. High frequency of eating accompanied by diet that contains a lot of fat and high calories can also increase body mass as shown by previous mouse model studies [9], [10]. Another lifestyle factor is a lack of physical activity. Study by Telford states that lack of physical activity causes decrease of lipid metabolism in a person's body that leads to lipid accumulation in peripheral tissue instead of degradation for energy [11].

Lack of physical activities is the well-known risk factor for obesity, in which a significant relationship between them has also been supported by several studies. Nevertheless, the direction of the causal relationship is not yet to be determined [12], [13], [14]. Therefore, the statement that lacking physical activity causes obesity is considered a premature assumption. In fact, this statement has been rejected, at least on the animal level, based on research conducted by Friend *et al.* (2017). They compared two different groups of the mice with both high and low physical activities. Both groups were given food that tended to cause obese. The results showed that there were no significant differences in body weight between the two groups, hence, obesity is more related to homeostasis regulation between nutrient intake and energy expenditure [15]. Other studies also show that central obesity conditions shown by waist circumference have a greater impact on low physical activity in patients with diabetes mellitus [16].

Friend *et al.* (2017) proposed that low physical activity is not the reason for obesity. On the contrary, their study stated that low physical activity is precisely caused by the condition of obesity. They argued by showing a basal ganglia dysfunction in regulating the arousal and excitement when doing physical activities

through serotonin secretion in mice. Thus, obese mice do not feel happy and are not eager to perform physical activity. This is also indicated by the small amount of serotonin secretion in the obese group compared to the control group [1].

In our study, mean of exercise motivation score in obese group was 58.46 ± 1.6 and control group was 62.38 ± 1.5 . From a statistical analysis using independent t-test (Table 2), there was no significant difference in exercise motivation score between two groups ($p = 0.09$). Although not significant, this study shows that the motivation score in the obese group is lower than the control group. These results are probably caused by bias that can occur when filling out questionnaire. Subject with high school education is minimal in both groups. The distribution of education levels between two groups is also uneven. The level of education and access to information are possible to influence the subjects in filling out exercise motivation questionnaire.

Motivation and pleasure are influenced by the specific neurotransmitters in the brain, dopamine. Dopaminergic neurons are mainly located in the ventral tegmental area of the midbrain, the substantia nigra, and the hypothalamus nucleus. Dopamine neurons have broad projections with varying effects on each of these projections. For example, the projection of dopaminergic neurons to mesolimbic causes feelings of pleasure, and reinforcement of pleasant stimuli (food, sex, medicine, or exercise and other pleasant things). Decreased or impaired dopamine transmission causes a disturbing effect to be able to feel happiness, decrease motivation, and impaired motor function as is commonly seen in depression state [17].

Our study documented the dopamine levels the obese and control groups were 71.19 ± 3.0 ng/ml and 81.15 ± 3.2 ng/ml, respectively. The analysis using independent t-test (Table 2) showed significant differences of dopamine levels ($p = 0.032$). This result is in line with the research of Friend *et al.* previously described above [1]. In addition, another study also suggested a weak action of type 2 dopamine receptors in conditions of low physical activity [2].

There are five forms of dopamine receptors which are divided into type 1 and type 2. Type 1 modulates adenylyl cyclase activity consisting of D1 and D5, whereas type 2 consists of D2, D3, and D4. Each form of dopamine receptors is located on a different location of the brain. In addition to the brain organs, dopamine receptors are also found in the retina and pituitary gland. Other studies have also shown the presence of dopamine receptors in the kidneys, adrenal glands, gastrointestinal tract, blood vessels, and heart [18].

Specifically, dopamine D2 receptors are responsible for behavior because its main domain is in the striatum. The inhibition of receptor activity results in a decrease in animal movements which make the obese mice tend to be more passive than controls [2].

Other studies also suggested that an increase in D2 receptor activity triggers a migraine as an imbalance of vasodilation and vasoconstriction of blood vessels in the head area [19]. This condition will indirectly affect emotions and behavior in both experimental animals and humans [20].

Detection of dopamine in the human body can be done using several samples such as the brain, urine, and blood plasma. Normal adult dopamine levels in blood plasma are <10 ng/mL or 0.065 nmol/L for supination and 20 ng/mL to 0.13 nmol/L for ambulatory [21]. The dopamine quantitative analysis method can be performed through various types of methods such as ELISA [22].

Conclusion

In brief, dopamine levels in the obese group were lower than the control group. There were significant differences in dopamine levels between the obese group and the control group. Motivation scores in the obese group were lower than the control group, although there were no significant differences between the two. There is no relationship between dopamine levels and exercise motivation scores. We suggested that obesity is a possible cause that leads to low physical activity and not the other way around.

Our study needs further confirmation regarding the dopamine level measurement and its receptors activity. This is to ensure that the increase in this particular neurotransmitter is originated from the stimulated area of the brain triggered by the exercise video exposure. Other modalities that can be used as confirmation tools including magnetic resonance spectrophotometry, functional magnetic resonance imaging, and brain mapping. Biochemical confirmation can also be done using other hormones or neurotransmitters related to dopamine and exercise.

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