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Original article

The importance of physical activity in diabetes

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Summary

Introduction. Obesity is becoming a global urgent issue that is considered a health problem in developed and developing countries. Obesity is a major risk factor for many non-communicable diseases such as cardiovascular diseases, type 2 diabetes mellitus (DM2), hypertension, coronary heart disease, or certain types of cancer. Physical activity is crucial for a healthy lifestyle. The aim of this study was to determine whether there is a difference in the physical activity of obese people with type 2 diabetes and obese people without type 2 diabetes.

Methods. This cross-sectional study included 50 obese patients with type 2 diabetes and 57 obese patients without type 2 diabetes. All patients went through the questionnaire, anthropometric measurements and laboratory tests. Type 2 diabetes was diagnosed in accordance with the American Diabetes Association. Data on physical activity were collected using the IPAQ (International Physical Activity Questionnaire), which was composed of questions on various physical activities in the previous 7 days.

Results. Activities at work and on the way to work in patients with type 2 diabetes were significantly lower compared to these activities in patients without type 2 diabetes ($p < 0.001$). Also, leisure time physical activities were lower in people with DM2 ($p = 0.001$). Just in case of household chores, subjects with DM2 had more utilized metabolic equivalent (MET) minutes whose utilization rate was close to 1700 MET minutes compared to 1500 MET minutes in subjects without DM2.

Conclusion. The results of this study indicate that obese subjects with DM2 are less active than obese subjects without DM2. Therefore, they should be recommended regular physical activities for at least 150 minutes per week to overcome the problem of obesity and the problem of DM2.

Key words: physical activity, type 2 diabetes mellitus, obesity, IPAQ

Introduction

Obesity is a growing problem worldwide [1] and is considered a health problem in both developed and developing countries [2]. In 2014, more than 39% of adults were overweight and 13% were obese [3]. Today, being overweight and obese cause higher mortality than malnutrition [3]. Obesity is accompanied by increased economic costs, social problems, increased morbidity and mortality from various diseases, so it is important to take measures and stop this pandemic [4,5]. Obesity is known to be a major risk factor for a number of non-communicable diseases such as type 2 diabetes mellitus (DM2), hypertension, coronary heart disease, or certain types of cancer [6,7]. Overweight and obesity occur in 44% of cases of diabetes, 23% of patients with ischemic heart disease and about 7–41% of certain cancers (8,9). DM2 is most strongly associated with obesity, and the prevalence of obesity-related diabetes is expected to double to 300 million by 2025 [10]. Together, obesity and DM2 increase the risk of mortality in individuals 7 times [11]. It is estimated that by 2030, overweight and obesity will reach 89% and 85% in men and women, respectively [12,13]. This will result in an increase in the incidence of obesity-related coronary heart disease by 97%, cancer by 61% and DM2 by 21%. In addition, direct healthcare costs will increase significantly. It is estimated that if the body mass index (BMI) of the population were to decrease by 5% by 2030, obesity-related health care costs would be reduced by € 495 million over 20 years [12].

Physical activity is a key component of a healthy life. Aerobic exercise is the best way to lose fat. It has been shown that patients with DM2 have lower energy expenditure, fewer steps taken and shorter duration of physical activity [14], lower cardiorespiratory fitness [15,16], as well as lower muscle strength compared to subjects without this disease [17,18].

The aim of this study was to determine whether there is a difference in the level of physical activity of obese people with DM2 and obese people without DM2.

Methods

This cross-sectional study included 50 obese patients with DM2 and 57 obese patients without DM2 who were on medical nutrition therapy at the nutrition counseling institute of the Institute of Hygiene with Medical Ecology of the Faculty of Medicine in Belgrade. All patients were surveyed and underwent anthropometric measurements and laboratory tests.

A standardized questionnaire was used to estimate basic demographic data. In addition to basic demographic data (gender, age), the questionnaire also collected data on tobacco smoking.

In order to assess the nutritional status, all patients underwent anthropometric measurements to determine weight, height and waist circumference.

Body mass (BM) and body height (BH) were measured in the morning using a calibrated anthropometer after which the BMI (kg/m2) was determined. The recommendation of World Health Organization (WHO) was used to assess nutritional status [19]. The percentage of body fat was determined using bioelectrical impedance.

Waist circumference was measured in the middle of the distance between the lowest point of the costal arch (arcus costalis) and the anterior upper femoral spine (spina iliaca anterior superior), while the patients were in a standing position. Abdominal obesity was determined based on the value of the waist circumference, also according to WHO recommendations [19]. The following limit values were used to determine obesity: 1) waist circumference equal to or greater than 102 cm for men, or greater than or equal to 88 cm for women; 2) percentage of body fat equal to or greater than 25% for men, or equal to or greater than 33% for women [20].

The diagnostic criteria for DM are fasting glucose ≥7 mmol/l or plasma glucose value ≥ 11.1 mmol/l 120 min after the oral glucose tolerance test (OGTT) [21].

Data on physical activity were collected using the IPAQ (International Physical Activity Questionnaire), a questionnaire composed of questions about different physical activities in the past 7 days. The questionnaire is composed of 27 questions which are divided into 5 parts. The first part is composed of questions related to physical activities at work. The second part is composed of questions related to transportation. The third part consists of questions related to housework. The intensity of physical activity was estimated based on MET minutes. A healthy adult while at rest is considered to consume 3.5 ml of O2/kg body weight per minute, which represents an energy expenditure of 1 kcal and is referred to as MET minute [22]. The fourth part is consisted of questions about recreation and the last fifth part are the questions related to sitting. Physical activity scores were calculated according to the instructions in the Scorecard calculation manual on the International Physical Activity Questionnaire (IPAQ).

IBM SPSS 23 program was used for data processing. The average, standard deviation, minimum, maximum, and coefficients of skewness and kurtosis were calculated from the descriptive parameters. A Chi-square test was used to test the association between the presence of diabetes and obesity. To determine the existence of differences between patients who do not have diabetes and those who have diabetes according to different activity parameters, the Mann-Whitney U test was used, and the Eta-squared (h2) coefficient was shown as a size of the effect.

Results

107 respondents participated in this research, of which three quarters (a total of 80) are female. Out of a total of 50 respondents who have diabetes, 80% are female, while out of 57 respondents who are not diagnosed with diabetes, 70% are female. The average age of patients without diabetes is 47 ± 13 years, while the patients with diabetes are slightly older and their average age is 54 ± 10 ($p < 0.001$), (Table 1).

Comparing body height, weight and waist circumference, no statistically significant differences were found between people with and without diabetes, while the percentage of body fat was significantly higher in people with diabetes ($p < 0.001$), (Table 2).

Activity at work, as well as activity during transport of patients with diabetes were significantly lower compared to the activities of the patients without diabetes ($p < 0.001$) (Figure 1).

Also, activities during free time had lower values in the subjects with diabetes than in the subjects without diabetes ($p = 0.001$) (Figure 2).

Table 1. Basic demographic data in relation to the presence of diabetes

Parameters		Groups		P value
		D	N	
Gender	40 (80 %)	40 (70.2 %)	40 (80 %)	0.272
	10 (20 %)	17 (29.8 %)	10 (20 %)	
Age – average value ± SD		54.34 ± 9.63	46.56 ± 12.53	< 0.001

Table 2. Anthropometric indicators in the examined groups

Parameters	Groups (average values ± SD)		P value
	D	N	
Body height (cm)	165.3 ± 8.8	168.6 ± 10.8	0.082
Body weight (kg)	97.1 ± 20.1	96.6 ± 20.8	0.913
Waist circumference (cm)	118.9 ± 14.2	115.4 ± 15.1	0.216
Body fat (%)	38.9 ± 6.5	34 ± 6.4	<0.001

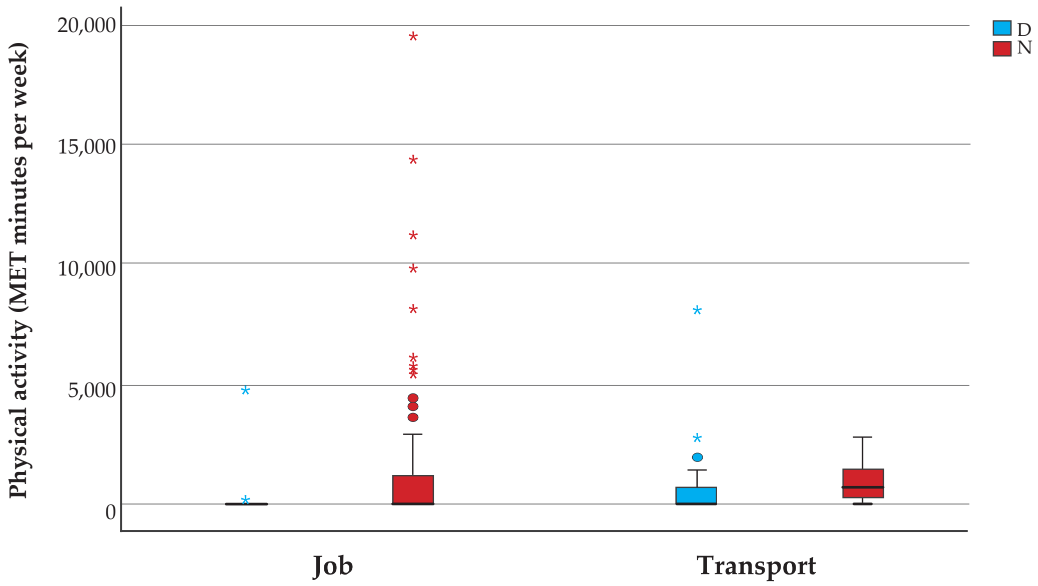

Figure 1. Comparison of activities at work and transport activities between the tested groups. D - subjects with diabetes, N - subjects without diabetes. ** - p <0.01

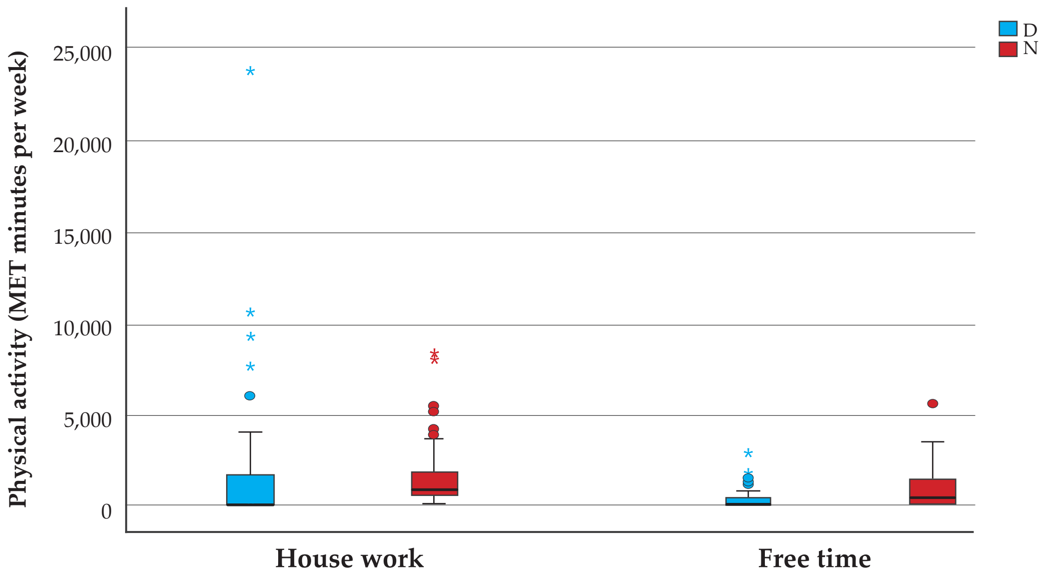

Figure 2. Comparison of activities during housework and free time between the tested groups. D - subjects with diabetes, N - subjects without diabetes. ** - p <0,01

When it comes to the intensity of activities, regardless of whether they are walking, moderate or vigorous activities, people with diabetes on average have fewer MET minutes for these activities than peple without diabetes (p <0.001, p <0.001, p = 0.001, respectively). Moreover, none of the subjects who have diabetes engaged in any of the vigorous activities during the week (Figure 3). Namely, patients with diabetes are active on average about 2900 MET minutes, in contrast to patients who do not have diabetes, who are active on average about 5100 MET minutes (Figure 3).

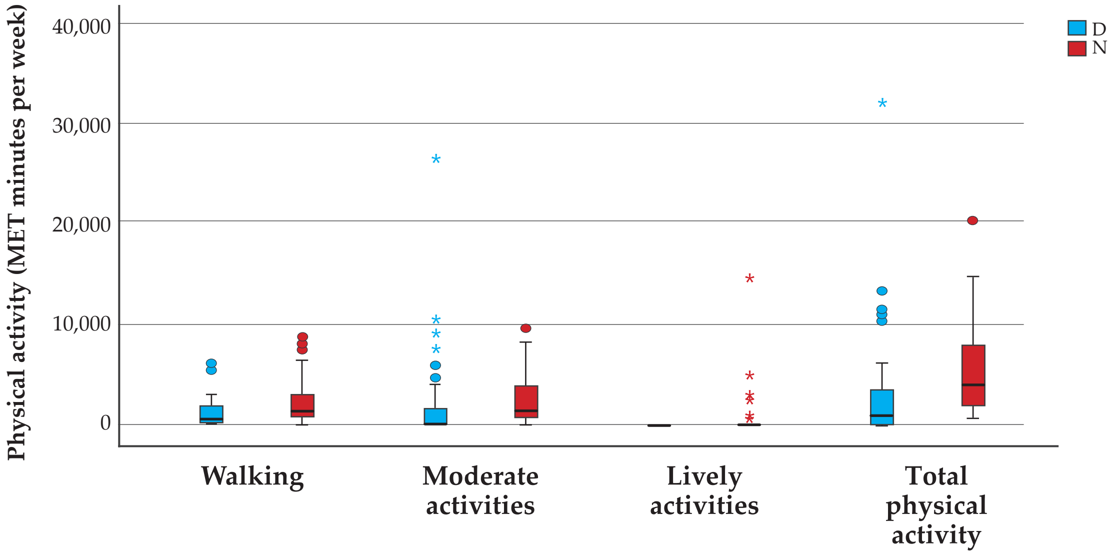

Figure 3. Comparison of the intensity of physical activities between the tested groups. D - subjects with diabetes, N - subjects without diabetes ** - p <0.01

When testing the differences between non-diabetic and diabetic patients in terms of different activity measures, the results show that by all parameters, non-diabetic patients are more active than the diabetic patients. When it comes to differentiation according to activities in different contexts (work, transportation, household chores, leisure time), the greatest effect occurs when comparing these two groups by activities at work, where 22% of variability of activities at work can be covered by differences between patients who do not have diabetes and patients who have this disease. The effect sizes of activities in other contexts are lower and range from 0.10 to 0.13.

When it comes to the intensity of activities, the sizes of the effect of walking (η^2 = 0.18) and moderate activities (η^2 = 0.17) are slightly larger than the size of the effect of vigorous activities (η^2 = 0.11). Finally, looking at total physical activity, the size of the effect is about 20% of the shared variance, or about 20% of the variability in total physical activity can be attributed to differences between non-diabetic and diabetic patients (Table 3).

Discussion

The test results show that the tested group of DM2 patients was older than the group without DM2. Comparing differences in genders, it was determined that women were represented more in both groups.

Subjects of both tested groups weighed on average about 97 kg. Based on the measurement of the percentage of body fat, it was determined that the respondents who do not have diabetes have 34% of body fat, while in people who have diabetes that value is slightly higher and amounts to 39%. Body fat is a metabolic organ that performs many functions such as lipid storage, protective and thermal insulation, immune response, endocrine functions and thermoregulation [23,24]. Recent research has concluded that body fat acts as an endocrine organ [25,26]. Obesity is often a precursor to DM2 and it is important to take steps to regulate obesity to prevent DM or reduce the complications of this disease. Body composition and body fat distribution are risk factors and can be considered a cause of DM2 [27]. An analysis of the literature has

Table 3. Differences in types of physical activity in relation to the presence of diabetes

Dependent variable (type of activity)	U	P	η^2	Distinguishing groups			
				The presence of diabetes	N	Average rank	Sum of ranks
Job	817.00	< 0.001	0.22	(D)	50	41.84	2092.00
				(N)	57	64.67	3686.00
Transport	835.50	< 0.001	0.13	(D)	50	42.21	2110.50
				(N)	57	64.34	3667.50
Housework	889.50	< 0.001	0.11	(D)	50	43.29	2164.50
				(N)	57	63.39	3613.50
Free time	922.00	< 0.001	0.10	(D)	50	43.94	2197.00
				(N)	57	62.82	3581.00
Walking	738.00	< 0.001	0.18	(D)	50	40.26	2013.00
				(N)	57	66.05	3765.00
Moderate activities	758.50	< 0.001	0.17	(D)	50	40.67	2033.50
				(N)	57	65.69	3744.50
Lively activities	1125.00	< 0.001	0.11	(D)	50	48.00	2400.00
				(N)	57	59.26	3378.00
Total physical activity	681.00	< 0.001	0.20	(D)	50	39.12	1956.00
				(N)	57	67.05	3822.00

U – Mann-Whitney test; η^2 - measure the size of the effect

shown that insufficiently intense aerobic exercise does not have a high probability of losing weight [28]. A ten-year cohort study from the early 1970s to the early 1980s, when obesity was a health problem at the beginning, suggests the following conclusion. Moderate activity, according to the American National Health and Nutrition Examination Survey, was associated with a 3-fold greater risk of large increase of body mass in men and almost 4-fold in women [29]. In a three-year study, in 34,079 women with an average age of 52.2 it is noticed an 11% higher risk of weight gain in those who had less than 7.5 MET hours of physical activities per week compared to the group of women who had more than 21 MET hours per week, or who had about 300 minutes of moderate physical activities per week [30]. Body exercise with a load or a combination of this type of exercise with running or walking significantly reduces risk factors for DM2 such as waist circumference, abdominal adiposity, HDL level and others [31,32,33]. In this paper, the statistical difference in age between two groups of respondents can be problematic. What may be correlated with this difference is the association of aging, obesity, and DM2 with declining pancreatic beta cell function with age [34]. Aging is also associated with decreased mitochondrial function and cartilage degradation, which contributes to DM2 [35-39]. Numerous impairments occur with obesity, aging and DM2 as a consequence of a sedentary lifestyle and poor eating habits. Physical activity is the only intervention that can positively affect all impairments, including the pathophysiology of all consequences and symptoms [40]. A Spanish study of 412 patients with DM2 indicates that a small number of respondents adhere to the principle of a healthy lifestyle. Namely, less than a quarter adhere to a proper diet, and less than half exercise regularly [41].

Compared with obese patients without DM2, obese patients with DM2 have a less favorable distribution of body fat with an increase in visceral fat [42]. Excess visceral adipose tissue is known to worsen insulin resistance [42] and, therefore, increases the risk of complications of diabetes. A 5% reduction in body fat percentage in patients with DM2 was associated with improved glycemic control as assessed with glycosylated hemoglobin [43]. In this study, there was no difference in abdominal obesity estimated based on waist circumference between the two groups tested. However, when obesity was assessed on the basis of body fat percentage, the ratio of obese and non-obese individuals differed significantly between subjects with diabetes and subjects without diabetes. About 90% of patients with diabetes are obese according to the criterion of body fat percentage, while only 58% of patients who do not have diabetes are obese according to this criterion.

Obesity is known to significantly increase the risk of developing metabolic disorders, hypertension, cardiovascular diseases, stroke and cancer. However, up to 30% of obese patients are metabolically healthy. These individuals have preserved insulin sensitivity and a lower visceral fat content compared to most metabolically "unhealthy" obese patients [44]. Fluctuations in insulin sensitivity occur throughout the life cycle. For example, insulin resistance is observed during puberty, pregnancy and aging [45]. In addition, lifestyle variations, such as increased carbohydrate intake and decreased physical activity, have been associated with fluctuations in insulin sensitivity [46]. Insulin sensitivity is also determined by the distribution of fat in the body. Individuals who have more peripheral distribution of fat are more sensitive to insulin than those who have a central fat distribution [45]. Visceral fats have a greater ability to secrete various proteins and hormones [46].

Both DM2 and obesity are associated with insulin resistance. The basic factor that affects insulin resistance is the release of non-esterified fatty acids. Increased release of non-esterified fatty acids has been observed in DM2 and obesity, and has been associated with insulin resistance in both conditions [46]. Shortly after the acute increase in plasma non-esterified fatty acid levels, humans begin to develop insulin resistance. In contrast, when the level of non-esterified fatty acids in plasma falls, as in the case of the use of antilipolytic agents, the value of peripheral insulin and the level of glucose improves [47]. There is evidence that BMI, central adiposity, and weight gain indicate an increased risk of developing DM2 [48,49]. A meta-analysis of prospective studies has provided evidence that an increase in upper-body adiposity increases the risk of metabolic syndrome and DM2 development [50]. The duration of obesity in younger people compared to older individuals is also associated with a higher risk of DM2 [51]. Weight gain, especially between the ages of 25 and 40, increases the risk of developing DM2 [52]. Weight loss is obviously helpful in reducing the risk of developing diabetes. In a diabetes prevention program, it was found that a medium weight loss of 5.5% over 2.8 years reduced the risk of progression from prediabetes to diabetes by 58% [53].

Although exercise is an important component of any effective weight loss strategy, several studies have reported additive effects on weight loss when exercise is combined with reduced food intake. This can be achieved either by reduced fat intake, or by reduced carbohydrate intake or by the Mediterranean diet [54,55,56]. The Mediterranean diet has been shown to have beneficial metabolic effects, as well as to delay the need for antihyperglycemic drugs in patients with newly diagnosed DM2 [57].

The results of our study show that in all parameters, people without diabetes are more active than people with diabetes. By comparing total physical activities, it was found that obese people without DM2 are more active than people with DM2. Namely, patients who have DM2 are active on average about 2900 MET minutes, unlike patients who do not have DM2 who are active on average about 5100 MET minutes. Decreased physical activity is known to be one of the risk factors for DM. Lack of physical activity and a sedentary lifestyle are risk factors for cardiovascular diseases, DM2, and overall mortality [58,59]. The American Diabetes Association has recommended that patients with DM spend a maximum of 90 minutes a day on a sedentary basis [60]. Changing a sedentary lifestyle to a more active lifestyle is a key to better DM2 management. Patients with DM2 have lower physical and cardiorespiratory fitness, lower energy expenditure, fewer steps taken, and shorter duration of physical activity compared with subjects without this disease [14,15,16]. By comparing muscle strength, it was found that people with DM also have less muscle strength compared to people who did not get sick [17,18]. By testing limb muscle strength and the connection of this parameter with DM complications, it was shown that muscle strength was negatively connected with the degree of DM complications [61]. This explains that due to the progression of DM, a decrease in physical activity can occur more and more, and a decrease in physical activity leads to an even greater progression and complications of DM. Physical activity plays a major role in the prevention and treatment of DM2. Studies have shown that aerobic exercise (walking, running, cycling) or strength training reduced the absolute value of hemoglobin A1c by about 0.6% [62], while the incidence of microvascular complications decreased by 37% [63]. It is assumed that the decrease in hemoglobin A1c would be significantly higher if, in addition to aerobic exercise, strength exercises were applied [62]. One large study showed that DM patients who performed low-intensity physical activity (90 min per week) had a significantly lower (14%) risk of mortality from all causes. In these subjects, there was an increase in life expectancy by 3 years [64]. Since the often recommended planned physical activity for patients with DM is a burden, it is important to emphasize that performing daily activities of low to moderate intensity is an important treatment for this group of people, because it has been shown to have positive effects [64]. Daily activities include various activities that lead to increased energy expenditure and that are carried out in work and leisure time. Those are most often: walking, working at the desk, washing, cooking and recreational sports. They can be of varying intensity, and can sometimes be of the same intensity as a planned structured exercise [67]. The results of our study show that walking was significantly less prevalent in people with DM2 compared to those without DM2. Although walking should be the most common daily activity, one study found that 55% of patients with DM2 reported that walking is not their regular physical activity [68]. Other studies have shown that walking at moderate speeds reduced the risk of DM2 by 20-30% in women who did not do any other intense physical activity [69]. Patients with DM who walked for at least 2 hours per week had a 39% reduction in all-cause mortality and a 34% reduction in mortality from cardiovascular compared with sedentary patients [70]. Also, moderate-intensity physical activity such as brisk walking, at least 150 minutes per week, reduced the incidence of diabetes by 58% after less than 3 years of follow-up [71]. In the United States, it has been found that about 40% of patients with DM use exercise therapy [72], however, only 28% of patients achieved the recommended level of physical activity [73].

Increasing aerobic physical activity reduces visceral fat, increases lean mass, reduces depression, and improves glucose tolerance, insulin sensitivity, and physical fitness. It is therefore not surprising that all scientific guidelines recommend at least 150 min/week of moderate aerobic exercise in combination with resistance training to increase muscle strength done three times a week [1,74,75,76]. According to these recommendations, no form of activity should last less than 10 minutes [77]. Applied physical activity will lead to a decrease in fat mass, and thus to an improvement in DM and a slowdown in the development of DM complications.

This study had limitations, of which the design of the study itself should be especially emphasized, as well as the relatively small number of respondents.

Conclusion

The results of our study show that obese people with diabetes are less physically active than obese people who are not diagnosed with diabetes. As obesity and diabetes represent a growing epidemic in modern society, it is suggested that the simultaneous treatment of these two metabolic disorders would lead to significant improvements. Therefore, all people, especially obese people who also have type 2 diabetes, should be recommended to exercise regularly, for at least 150 minutes a week.

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Ethical approval. The Ethics Committee of the Institute of Hygiene with Medical Ecology of the Faculty of Medicine in Belgrade approved the study and informed consent was obtained from all individual respondents. The research was conducted according to the Declaration of Helsinki.

Conflicts of interest. The authors declare no conflict of interest.

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Značaj fizičke aktivnosti kod obolelih od šećerne bolesti

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Uvod. Gojaznost postaje globalno urgentno pitanje koje se smatra zdravstvenim problemom u razvijenim i zemljama u razvoju. Gojaznost je glavni faktor rizika za mnoge nezarazne bolesti poput kardiovaskularnih bolesti, dijabetes melitus tipa 2 (DM2), hipertenziju, koronarnu bolest srca, ili određene vrste karcinoma. Fizička aktivnost je presudna za zdrav način života. Cilj ove studije bio je da se utvrdi da li postoji razlika u fizičkoj aktivnosti gojaznih osoba sa šećernom bolesti tipa 2 i gojaznih osoba bez šećerne bolesti tipa 2.

Metode. U ovoj studiji preseka uključeno je 50 gojaznih pacijenata sa šećernom bolesti tipa 2 i 57 gojaznih pacijenata bez šećerne bolesti tipa 2. Svi pacijenti su prošli upitnik, antropometrijska merenja i laboratijska ispitivanja. Dijabetes tipa 2 je dijagnostikovan u skladu sa Američkim udruženjem za dijabetes. Podaci o fizičkoj aktvnosti prikupljeni su pomoću IPAQ upitnika (International Physical Activity Questionnaire), koji je bio sastavljen od pitanja o raznim fizičkim aktivnostima u prethodnih 7 dana.

Rezultati. Aktivnosti na poslu i na putu do posla kod pacijenata sa šećernom bolesti tipa 2 bile su značajno niže u poređenju sa ovim aktivnostima kod pacijenata bez šećerne bolesti tipa 2 ($p < 0.001$). Takođe, fizička aktivnost u slobodno vreme je manja kod osoba sa DM2 ($p = 0.001$). Samo u slučaju kućnih poslova, pacijenti sa DM2 imali su više iskorišćenih metaboličkih ekvivalenata (MET) minuta čija je stopa iskorišćenosti bila blizu 1700 MET minuta u odnosu na 1500 MET minuta kod osobe bez DM2.

Zaključak. Rezultati ove studije ukazuju na to da su gojazne osobe sa DM2 manje aktivne od gojaznih osoba bez DM2. Samim tim, trebalo bi im preporučiti redovnu fizičku aktivnost najmanje 150 minuta nedeljno u prevazilaženju problema bolesti gojaznosti i DM2.

Ključne reči: fizička aktivnost, dijabetes melitus tip 2, gojaznost, IPAQ