ORIGINAL ARTICLE

Annals of Agricultural and Environmental Medicine 2014, Vol 21, No 2, 353–358
www.aaem.pl

Pedometer assessed physical activity of people with metabolic syndrome in Poland

Anna Owłasiuk[1], Sławomir Chlabicz[1], Anna Gryko[1], Alicja Litwiejko[1], Jolanta Małyszko[2], Dorota Bielska[1]

[1] *Department of Family Medicine and Community Nursing, Medical University, Bialystok, Poland*
[2] *Department of Nephrology and Hypertension with Dialysis Unit, Medical University of Bialystok, Poland*

Owłasiuk A, Chlabicz S, Gryko A, Litwiejko A, Małyszko J, Bielska D. Pedometer assessed physical activity of people with metabolic syndrome in Poland. Ann Agric Environ Med. 2014; 21(2): 353–358. doi: 10.5604/1232-1966.1108604

Abstract

Introduction. Metabolic syndrome is a contemporary disease of civilization, an effect of lack of healthy behaviour, a consequence of lifestyle devoid of physical activity, eating poor quality food rich in calories and excessive stress. Apart from a proper diet, physical activity remains an important part of metabolic syndrome management.
Objective. The main objective of the work was to evaluate the physical activity of an adult population of patients with metabolic syndrome.
Materials and method. Adults aged 35–70 fulfilling the criteria of metabolic syndrome according to International Diabetes Federation (IDF) were included. New Lifestyles NL-2000 pedometers were used to assess locomotive physical activity during an entire week.
Results. In the group of 100 subjects, as many as 61 people (61%) represented low or sedentary activity, while nearly one fourth of the respondents – 23 (32%) represented the negligible activity type. Average weekly physical activity of those in the study was 6,743 steps/day (in 100 individuals) and ranged from 1,781–15,169. A great diversity was found in the study group, since the highest number of steps per day was 23,347 and the lowest – 409. No significant differences in the number of steps on weekdays and at weekends were observed (mean: 6,676/day and 6,913/day, respectively). A statistically significant negative correlation (r = -0.29) was observed between age and physical activity, between the average daily number of steps in the week and Waist Hip Ratio (WHR) (r = 0.201), as well as between the average daily number of steps in the week and Body Mass Index (BMI) (r = 0.226).
Conclusions. The majority of people with metabolic syndrome represent a low or sedentary activity type and decrease of physical activity corresponds to increasing age, BMI and WHR. No significant differences in physical activity are observed between working days and free days (weekends).

Key words
physical activity, activity type, pedometer, metabolic syndrome

INTRODUCTION

Physical activity remains an important part of the management of metabolic syndrome and favourably affects lipid disorders, supports the treatment of diabetes or hypertension. Numerous studies have shown the impact of physical exercise of the appropriate frequency, length and intensity to reduce morbidity and mortality related to cardiovascular diseases, osteoporosis and metabolic disorders, among others [1, 2, 3, 4, 5, 6].

Data from Poland indicate that around 2.5–64% of adult Poles systematically take part in various forms of physical activity. These differences in percentage are the result of the application of different methods of measuring physical activity, and assuming different 'values' of physical activity at a recommended dose [7, 8].

Technology development and industrialization have significantly contributed to the elimination of physical activity, not only in everyday life, but also in many occupations. For many people who lead a sedentary life style, physical activity during their leisure time and commuting are the only forms of physical activity [9]. An appropriate level of systematic physical activity is necessary in order to maintain or improve health. Therefore, increasing physical activity is one of the main objectives of modern public health strategy [10]. WHO experts emphasize that improving physical activity levels of society is as important as treating hypertension, lipid metabolism disorders, and smoking addiction.

The main aim of the study was evaluation of the physical activity of people with metabolic syndrome.

MATERIALS AND METHOD

Study group. The study consisted of a total of 100 people aged 35–70 years (mean age 54.6, median 55 years, interquartile range – 16.75 RQ), with women predominating (70%). Most (40%) declared having a secondary education, 23% college level or higher and 37% primary. Almost half (45%) were pensioners or retirees, 32% manual workers, 15% white-collar workers and 8% were unemployed. The majority of respondents (66%) lived in blocks of flats and 34% lived in own home.

The study was conducted in two general practice clinics in Poland between June 2009 – October 2010. Adults visiting their general practitioner who met the following criteria were included:
1) age: 35–70 years old;
2) criteria fulfilled for metabolic syndrome according to the International Diabetes Federation (IDF);

Address for correspondence: Slawomir Chlabicz, Department of Family Medicine and Community Nursing, Medical University, Mieszka I 4B, 15-054 Białystok, Poland
e-mail: schlabicz@poczta.onet.pl

Received: 1 January 2013; accepted: 1 February 2012

All patient consented to participate in the study.

Patients with musculoskeletal impairments substantially limiting their physical activity, pregnant women, persons with acute infections, who were recommended to stay at home, were excluded from the study.

Study protocol. After obtaining informed consent to participate in the study, measurements of body weight, height, waist and hip circumference were taken. For evaluation of type of fat distribution, the Waist to Hip Ratio (WHR) was calculated using the formula: WHR = waist circumference (cm)/hip circumference (cm). Body mass index BMI (BMI = body weight (kg)/[height $(m)^2$]) and body fat percentage (% Fat) were calculated using the Omron BF306 Body Fat Monitor (Omron Healthcare Co., Ltd. Kyoto, Japan). Results of biochemical tests were obtained from patient medical records. New Lifestyles NL-2000 (New-Lifestyles, Inc. Lee's Summit. MO, USA) pedometers were used for the study of physical activity during the entire week. The patients were informed about how to use the pedometer. The device was placed at the waist and attached to the belt. The participants were asked to wear the pedometer at all times during the day, but not during sleep. After seven days of physical activity registration, a researcher read directly from the pedometer the number of steps, jumps and changes in body position during physical activity.

The study was approved by the Bioethics Committee of the Medical University of Białystok on 30 March 2009 (Approval No. R-I-002/197/2009).

Statistical analysis of results. Arithmetic mean, standard deviation and minimum and maximum values for measurable characteristics consistent with normal distribution were assessed using the Shapiro-Wilk test. For characteristics inconsistent with this distribution, the median and interquartile range (RQ) was calculated. Qualitative data were presented as their quantity and percentage distribution.

For characteristics consistent with normal distribution, the Student's t-test or one-way analysis of variance (ANOVA) were used for comparisons between the groups. For features inconsistent with the normal distribution, the Mann-Whitney or Kruskal-Wallis test were used, respectively. The Chi^2 test was used to compare qualitative characteristics between the groups. Pearson's correlation coefficients was also calculated for characteristics consistent with normal distribution, or Spearman's for the characteristics of different distribution.

A level of $p < 0.05$ was considered statistically significant. Calculations were performed using the SPSS statistical package.

RESULTS

Presence of metabolic syndrome criteria. Of the 100 participants with metabolic syndrome, the great majority – 97 patients (97%) – had arterial blood pressure ≥ 130/85 mmHg or were being treated for hypertension; 93 (93%) were diagnosed with TG ≥ 150 mg/dl or were being treated for hypertriglyceridaemia; 85 patients (85%) were diagnosed with HDL (males < 40 mg/dl, females < 50 mg/dl or treatment of hypo HDL). The least frequently occurring metabolic syndrome criterion was glycaemia > 100 mg/dl or previously diagnosed diabete – 45 patients (45%).

Most people in the study group (40% of all respondents) had I° obesity; their body mass index (BMI) ranged between 30.0–34.9 kg/m². A quarter of the respondents (25%) were overweight (Tab. 1). Average body weight among the participants was 94.5 kg (median 95; RQ 20.5) and ranged from 65–158 kg, while the average BMI was 33.8 kg/m² (median 32.7; RQ 7.95), and ranged from 24.5 kg/m² – 54.1 kg/m².

Table 1. BMI classification categories according to WHO (1998) and number of respondents in each catagory

CATEGORY	BMI (kg/m²)	N=100 n (%)
Underweight	<18.5	0 (0.0)
Proper weight	18.5–24.9	1 (1.0)
Overweight	25.0–29.9	25 (25.3)
I° Obesity	30.0–34.9	40 (40.4)
II° Obesity	35.0–39.9	18 (18.2)
III° Obesity	≥40	16 (16.2)

Anthropometric measurements. Table 2 presents the results of anthropometric measurements: waist circumference, hip circumference, percentage of body fat in terms of gender of participants. Mean waist circumference for men was 111.7 cm (median 110; RQ 16.3), and 103.9 cm for women (median 102.5; RQ 14.3).

Table 2. Results of anthropometric examinations and gender

Sex		Waist circumference (cm)	Hip circumference (cm)	Percentage of body fat (%) (Omron)	Percentage of body fat (%) (skinfold caliper)
F N = 70	Average	103.9	117.0	43.4	44.3
	Min.	83	96	33.8	36.7
	Max.	130	150	50	50
	SD	11.4	12.7	4.5	3.4
	Median	102.5	113.5	42.8	44.5
	RQ	14.3	19.0	7.0	5.3
M **N = 30**	Average	111.7	112.6	33.4	35.8
	Min.	95	100	25.1	28.2
	Max.	133	130	42	43.6
	SD	10.6	8.2	4.5	3.7
	Median	110	112	33.3	37.4
	RQ	16.3	11.8	6.2	5.8

Weekly physical activity. Mean weekly physical activity of the 100 participants was about 6,261 steps/day and ranged from 1,781–15,169. The largest number of steps was 23,347/day (the participant confirmed a very high level of physical activity), while the lowest was 409 steps/day. There were no significant differences between the number of steps on weekdays and weekends (average of 6,676/day and 6,913/day, respectively) (Tab. 3).

Average daily number of steps for females (n=70) was 6,906±3,030 (median 5,969; RQ 4992–8283), and for men (n=30) – 6,534 ± 2,786 (median 6,846; RQ 4039–8330).

Only 16 people (16%), of whom the majority (68.8%) were within the age group <= 50 years, represented the group of

Table 3. Average daily number of steps measured by pedometer on weekdays and weekends

Time of measurement	N=100					
	Average	SD	Median	Min.	Max.	RQ
Monday	6,453.6	3,652.5	5,726.5	409	18,312	4,614
Tuesday	7,118.0	4,282.3	6,305.5	1,014	20,338	6,038.8
Wednesday	6,460.3	4,059.6	5,284.5	861	23,347	4,916.5
Thursday	6,892.5	3,963.5	6,123	841	19,858	4903
Friday	6,456.1	3,996.9	5377	1,130	18,994	5,446
Mon-Fri	6,676.1	2,963.8	6,307.8	1,865.8	14,791.8	3,952.3
Saturday	7,356.0	4,506.4	6,434	853	2,0413	5,231.5
Sunday	6,470.4	3,583.9	5,889	875	16,010	4,312
Sat-Sun	6,913.2	3,474.1	6,343.8	1,526.5	16,191	4,470.8
Whole week	6,743.8	2,883.7	6,261.6	1,781.9	15,169.9	3,656.4

active people. The average number of steps per week in this group was equal to or greater than 10,000. Eighty-four people (84%) were less active, i.e. their average number of steps was less than 10,000. Respondents aged 50–59 (70.2%) dominated in this group. The percentage of people with >=10,000 steps in the age group <= 50 years was 68.8%, and in the age group > 50 years – 31.3% (p <0.05).

Figure 1 shows the correlation between the age and physical activity of the participants with metabolic syndrome.

A statistically significant negative correlation (r=-0.29) was found between age and physical activity (Fig. 1).

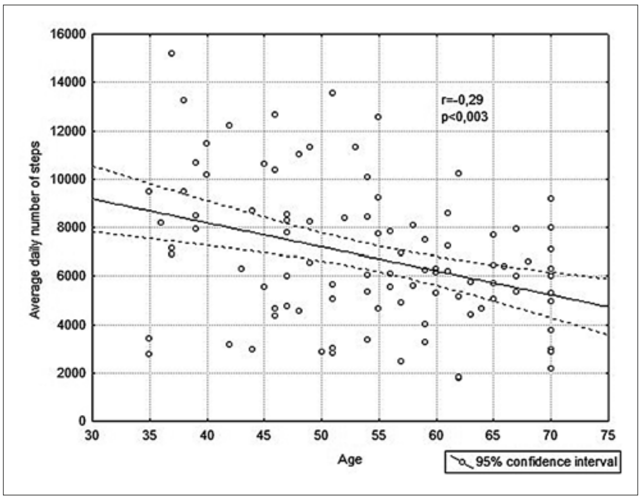

Figure 1. Correlation between average daily number of steps and age (years)

Analyzing the physical activity of participants based on gender, it appeared that in the group of 70 females (70%), the great majority (81.4%) presented physical activity of less than 10,000 steps/day. A similar situation occurred among the males: from a group of 30 respondents, 90% were active below the recommended level. The percentage of females with >=10,000 steps was 18.6%, and men – 10%.

A statistically significant negative correlation (r = -0.226) was found between the average daily number of steps during the week and BMI (Fig. 2), and a statistically significant negative correlation (r = -0.201) between the average daily number of steps and WHR (Fig. 3).

In the studied group, 61 people (61%) represented low or sedentary type of activity. Table 4 outlines the types of

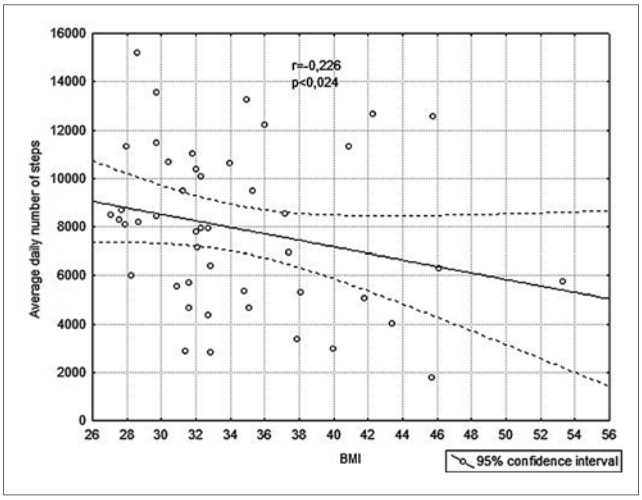

Figure 2. Correlation between the average daily number of steps and BMI (kg/m^2)

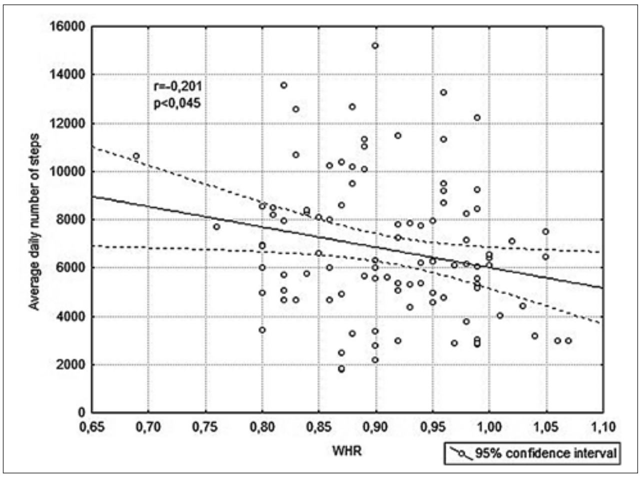

Figure 3. Correlation between average daily number of steps and WHR

Table 4. Types of activity and corresponding number of steps among 100 people with metabolic syndrome

Type of physical activity	Sedentary type <5,000 steps N (%)	Low activity type 5,000–7,499 N (%)	Negligible activity type 7,500–9,999 N (%)	Active type 10,000–12,499 N (%)	Highly active type ≥ 12,500 N (%)
N=100	27	34	23	11	5

activities and the corresponding number of steps with the number of persons qualified to each of these levels.

DISCUSSION

Recently, physical activity levels are increasingly assessed using objective methods such as pedometers, which are already widely available devices for calculating the daily number of steps.

On the basis of measurement of the number of steps taken during the day, the patient can be qualified to a group with a specific degree of physical activity. The classification, based on the number of steps, takes into account 5 types of physical activity. On the scale of spontaneous physical activity, proposed by Tudor-Locke and Bassett [11, 12], people with high levels of activity achieved > 12,500 steps/day. In contrast, for people leading a sedentary lifestyle, this figure was <5,000 steps/day, and in this group all activities leading to an increase in activity gave the best results and health benefits (reduction in blood pressure, BMI improvement). It is widely recognized that the target number of steps important for prophylaxis and/or treatment is 10,000 per day (a distance of 8 km). The range of 10,000–12,499 steps taken per day characterizes a person leading an active lifestyle. Highly active types are people whose daily number of steps taken is equal to or greater than 12,500. It is worth noting that physical activity that causes weight loss is between 12,000–-15,000 steps per day [11, 12, 13].

In the group of 100 participants, 61 persons (61%) represented low or sedentary type of activity, while nearly a quarter of respondents – 23 (23%), were classified as negligible activity type. The average weekly physical activity of the participants was 6,743 (in 100 people) steps/day and ranged from 1,781–15,169; however, a great variation was observed in the study group. The largest number of steps taken was 23,347/day, while the smallest was 409 steps/day.

These results are similar to the results of other researchers. In studies conducted in Łódż, Poland, the average number of steps in a group of healthy adult males aged 45–64 years was 6,707/day. The largest number of steps taken was 12,080/day, while the lowest was 2,191 steps/day [13]. Other authors present the results of studies in healthy individuals representing the general population aged 18–60 years, where the average number of steps taken measured with a pedometer was 6,838/day (the lowest number of steps taken was 5,766 on a Sunday, but the greatest number of steps was taken on a Tuesday – 7234) [14]. Tudor-Locke et al. [15] obtained values of 7,370±3,080 steps/day in a group of 109 healthy persons, in which the average age was 44.9±15.8.

However, in the long-term monitoring of physical activity, Tudor-Locke et al. [16] achieved higher values; the average number of steps taken by the respondents was 10,082± 3,319/day.

Le Masurier et al. [17] observed that patients with chronic diseases tend to reach only 3500–5500 steps/day. The study by Nowicki et al. [18] demonstrated that chronically dialyzed patients took approximately 3450 steps during daily physical activity. The cross-sectional study conducted in a group of 60 chronically hemodialyzed patients and 16 healthy persons showed highly statistically significant differences in the degree of physical activity assessed by the number of steps measured using a pedometer. The total number of steps between midweek dialysis in hemodialyzed persons was 6896±2357, while in the control group of healthy persons, 14181±5383 ($p <0.01$).

The respondents of the Tudor-Locke et al. [3] study, among 160 people aged 52.4±5.3 years with type II diabetes, showed physical activity similar to the presented study. The average daily number of steps taken by patients in that study was 6,662±3,077 In a study conducted on 30 patients aged 33–69 with type II diabetes, Araiza et al. [4] found that the average daily number of steps of patients was 6,239±2,985 in the control group (not informed of the recommended daily number of steps) and 7,220±2,792 steps/day in the active group (subjects were encouraged to take at least 10,000 steps for five or more days a week).

A similar average number of steps was attained by Chan et al. in patients with diagnosed metabolic syndrome, or increased risk of metabolic syndrome [19], and by Sequeira et al. in the general population [20]. Chan et al [19] observed that the participants declaring at least one element other than obesity associated with metabolic syndrome (diagnosed heart disease, hypertension, hypercholesterolemia, or diabetes) took fewer steps per day (6,311 ± 3,051) than participants without these diseases (7,655 ± 3,674 steps/day).

The relationships between physical activity, insulin resistance and metabolic syndrome were assessed in a cross-sectional study of 1,144 people aged 65–91, living in northern Italy. In regression analysis, metabolic syndrome was more frequent in persons leading a sedentary lifestyle than in the rest of the population of more active people. A negative correlation occurred between physical activity and insulin resistance and metabolic syndrome, even in the elderly [21].

No significant differences were noted in the number of steps on weekdays and weekends (6,676/day and 6,913/day, respectively). Whereas, Tudor-Locke et al. [14] found differences in the number of steps taken on weekdays and weekends (7,108 and 6,162, respectively). In another study, Tudor-Locke et al. [15] also observed that respondents were more active on weekdays than on weekends (10,479 and 9,091, respectively). Physical activity also depended on the type of day (working = 1,1168 >, free day = 9,448 steps/day) and on the season (in summer more than winter). One could expect that on weekends physical activity will be greater than on weekdays, but the presented study did not confirm this and the results of other authors are inconsistent.

In presented study, the group of active people whose average number of steps a week was equal to or greater than 10,000 was represented by only 16 people (16%), of whom the majority (68.8%) was within the age group <= 50 years. Eighty-four people (84%) were less active, i.e. their average number of steps was less than 10,000. Respondents aged 50–59 (70.2%) dominated in this group. A statistically significant negative correlation was found between age and physical activity.

Age correlated negatively with physical activity of patients in the study by Zahiri et al. [22]. Persons < 60 years old took an average of 5,933 steps/day and were about 34% more active than patients ≥ 60-years-old, whose average daily number of steps was 4,434. In another study, the number of physically active people also changed with the age of the respondents. The authors observed that the proportion of women exercising decreased with age from 37.62% to 28.92% (in the age groups ≤ 40 years and > 40 years, respectively). [10]. Also, Sequeira et al. [20] observed that the number of steps/day depended on the age of the respondents – the lowest recorded was in the oldest age group of 65–74 years of age.

Based on analysis of 42 studies carried out using a pedometer, Bohannon [23] reports that a higher average daily number of steps was reached in a group of people younger than 65, (9,448) compared with a group of people aged 65 and over (6,565). Thus, mainly people aged 65 and older were characterized by taking fewer steps than the recommended 10,000 steps a day.

The study by Stel et al. [24], conducted among 439 elderly people aged 69–92, showed that the average daily number of steps measured by pedometer was 3,577±2,235, but showed great variation in the study group. The greatest number of steps taken was 9,980/day, while the lowest was 21 steps/day.

Tudor-Locke et al. [15] demonstrated that physical activity decreases with increasing BMI and percentage of body fat.

The average number of steps performed by a person with a BMI <25 (percentage of body fat – 24.8) was 8,325/day, while the results of overweight and obese people were 7,035 steps per day (percentage of body fat – 28.3) and 6,006 steps per day (percentage of body fat – 38.3), respectively. In the presented study, it was found that the highest percentage of persons with physical activity >=10,000 steps/day were overweight, (20%) and the lowest among those with second degree obesity (11.1%). A statistically significant negative correlation was found between the average daily number of steps and BMI, as well as a statistically significant negative correlation between the average daily number of steps and WHR. Studies conducted among people with diabetes also show that physical activity decreases with increasing BMI [3]. The authors of the cited study found significant differences in the number of steps/day between the BMI categories (from normal weight to third degree obesity). These differences were most apparent between higher degrees of obesity (2nd and 3rd) and normal weight. Nowicki et al. also found statistically significant correlations between the number of steps during the period between dialysis and body weight, BMI, lean body mass and body fat [18]. Another study proved that the percentage of physically active respondents decreased with increasing BMI (from 35 to 31%) [10]. The number of steps/day measured with a pedometer was negatively correlated with BMI in the study by Chan et al. [19]. The authors of the cited study also observed that a smaller number of steps/day was associated with elevated BMI and higher waist circumference. The respondents' physical activity decreased with increasing BMI in other studies in which the average daily number of steps in persons with normal weight, overweight and obesity was 12,640, 12,155 and 8,923, respectively.

The results of the study by Clemens et al. [25], in which a pedometer was used as a research tool, clearly indicate the preference of a sedentary lifestyle among overweight people during days off from work, in which the average daily number of steps within five working days amounted to 10,350, and decreased to 9,100 during the two days off work. Clemens et al. demonstrated that a group of overweight people displayed a significantly lower average daily number of steps compared to a group of people of normal weight (10,002 and 11,273, respectively). Comparing the two studied groups in terms of average daily number of steps appropriate for each day of the week, the presented study was unable to show significant differences, except Sunday, when the group of overweight people displayed significantly lower number of steps compared to those of normal weight.

It is worth noting that the relationship between obesity and physical activity has a two-sided character – reduced activity leads to obesity, but obesity may result in limitation of physical activity. Chan et al. [19] also obtained the consistent observation that patients taking > 9,000 steps/day are more often of normal weight and people taking < 5,000 steps/day are more likely to be obese.

In Poland, studies of physical activity were previously performed with the use of the International Questionnaire of Physical Activity (IPAQ) in different population groups (young people, pregnant women, women at reproductive age) [26, 27, 28, 29]. Studies using objective measurements (pedometers, accelerators) are needed to validate those questionnaires.

CONCLUSIONS

1. The majority of people with metabolic syndrome represent a low or sedentary activity type.
2. There is a wide variety of physical activity among those with metabolic syndrome.
3. Decrease of physical activity corresponds to increasing age, BMI and WHR, but the presented study did not find differences between males and females.
4. No significant differences in physical activity were observed between working days and free days (weekends).

Acknowledgement
The study was funded by a Grant from the Medical University of Bialystok, Poland.

REFERENCES

1. Braksator W, Chybowska B, Mamcarz A. Zespół metaboliczny Anno Domini 2009/2010. Kardiologia na co Dzień. 2010; 5: 14–18 (in Polish).
2. Drygas W, Kostka T, Jegier A, Kuński H. Long term effects of different physical activity levels on coronary heart disease risk factors in middle-aged men. Int J Sports Med. 2000; 21: 235–241.
3. Tudor-Locke CE, Bell RC, Myers AM, Harris SB, Lauzon N, Rodger NW. Pedometer-determined ambulatory activity in individuals with type 2 diabetes. Diabetes Res Clin Pract. 2002; 55: 191–199.
4. Araiza P, Hewes H, Gashetewa C, Vella CA, Burge MR. Efficacy of a pedometer – based physical activity program on parameters of diabetes control in type 2 diabetes mellitus. Metabolism. 2006; 55: 1382–1387.
5. Dylewicz P, Borowicz-Bienkowska S, Deskur-Smielecka E, Kocur P, Przywarska J, Wilk M. Value of exercise capacity and physical activity in the prevention of cardiovascular diseases-brief review of the current literature. J Public Health. 2005; 13(6): 313–317.
6. Drygas W, Jegier A. Zalecenia dotyczące aktywności ruchowej w profilaktyce chorób układu krążenia. Czyn Ryz. 2003; 4: 76–84 (in Polish).
7. Stasiołek D, Jegier A. Ocena aktywności fizycznej osób dorosłych przy pomocy kwestionariuszy. Czyn Ryz. 2001; 3–4: 50–55 (in Polish).
8. Bergier J. Aktywnosć fizyczna społeczeństwa – współczesny problem (przegląd badań). Człowiek i zdrowie 2012;6(1): 5–14 (in Polish).
9. Wadden TA, Butryn ML, Wilson C. Lifestyle modification for the Management of Obesity. Gastroenterology 2007; 132: 2226–2238.
10. Zarzeczna-Baran M, Haasa-Wojdak E, Pęgiel-Kamrat J. Aktywność fizyczna jako metoda zapobiegania chorobom serca w opinii i praktyce uczestników sondażu reprezentatywnego w polskim projekcie 400 miast. Ann Acad Med Gedan. 2006; 36: 201–209 (in Polish).
11. Plewa M. Wybrane metody pomiaru aktywności fizycznej w otyłości. Wydawnictwo Akademii Wychowania Fizycznego im. Jerzego Kukuczki w Katowicach, 2008 (in Polish).
12. Tudor-Locke C, Bassett DR. How many steps/day are enough? Preliminary pedometer indices for public health. Sports Med. 2004; 34(1): 1–8.
13. Lipert A, Jegier A. Ocena aktywności ruchowej dorosłych mężczyzn w wieku 45–64 lata zamieszkałych w Łodzi, za pomocą krokomierza – badanie pilotażowe. Med Sport. 2009; 25: 59 (in Polish).
14. Tudor-Locke C, Burkett L, Reis JP, Ainsworth BE, Macera CA, Wilson DK. How many days of pedometer monitoring predict weekly physical activity in adults? Prev Med. 2005; 40(3): 293–298.
15. Tudor-Locke C, Ainsworth BE, Whitt MC, Thompson RW, Addy CL, Jones DA. The relationship between pedometer-determined ambulatory activity and body composition variables. Int J Obes. 2001; 25: 1571–1578.
16. Tudor-Locke C, Bassett DR, Swartz Ann M, Strath SJ, Parr BB, Reis JP, Dubose K D, Ainsworth BE. A preliminary study of one year of pedometer self-monitoring. Ann Behav Med. 2004; 28: 158–162.
17. Le Masurier GC, Sidman CL, Corbin CB. Accumulating 10,000 steps: does this meet current physical activity guidelines? Res Q Exerc Sport. 2003; 74: 389–394.
18. Nowicki M, Jagodzińska M, Murlikiewicz K, Niewodniczy M. Aktywność fizyczna chorych przewlekle dializowanych – porównanie skuteczności różnych metod jej zwiększania. Post Nauk Med. 2009; 10: 799–804 (in Polish).

19. Chan CB, Spangler E, Valcour J, Tudor-Locke C. Cross-sectional relationship of pedometer-determined ambulatory activity to indicators of health. Obes Res. 2003; 11: 1563–1570.
20. Sequeira MM, Rickenbach M, Wietlisbach V, Tullen B, Schutz Y. Physical activity assesment using a pedometer and comparison with a questionnaire in a large population survey. Am J Epidemiol. 1995; 142: 989–999.
21. Bianchi G, RossI V, Muscari A, Magalotti D, Zoli M. Physical activity is negatively associated with the metabolic syndrome in the elderly. QJM. 2008; 101: 713–721.
22. Zahiri CA, Schmalzried TP, Szuszczewicz ES, Amstutz HC. Assessing Activity in Joint Replacement Patients. J Arthroplasty. 1998; 13: 890–895.
23. Bohannon RW. Number of pedometer-assessed steps taken per day by adults: a descriptive meta-analysis. PhysTher. 2007; 87: 1642–1650.
24. Stel VS, Smit JH, Pluijm SMF, Visser M, Deeg DJH, Lips P. Comparison of the LASA Physical Activity Questionnaire with a 7-day diary and pedometer. J ClinEpidemiol. 2004; 57: 252–258.
25. Clemens SA, Griffiths PL, Hamilton SL. Four-week pedometer-determined activity patterns in normal weight and overweight UK adults. Int J Obes. 2007; 31(2): 261–266.
26. Wojtyła A, Kapka-Skrzypczak L, Biliński P, Paprzycki P. Physical activity among women at reproductive age and during pregnancy (Youth Behavioural Polish Survey – YBPS and Pregnancy-related Assessment Monitoring Survey – PrAMS) – epidemiological population studies in Poland during the period 2010–2011. Ann Agric Environ Med. 2011; 18(2): 365–374.
27. Wojtyła A, Kapka-Skrzypczak L, Paprzycki P, Skrzypczak M, Biliński P. Epidemiological studies in Poland on effect of physical activity of pregnant women on the health of offspring and future generations – adaptation of the hypothesis Development Origin of Health and Diseases. Ann Agric Environ Med. 2012; 19(2): 315–326.
28. Łobaszewski J, Przewoźniak K, Zatońska K, Wojtyła A, Bylina J, Mańczuk M, Zatoński W. Patterns of leisure time physical activity and its determinants among a sample of adults from Kielce region, Poland – the 'PONS' study. Ann Agric Environ Med. 2011; 18(2): 241–245.
29. Bergier J, Kapka-Skrzypczak L, Biliński P, Paprzycki P, Wojtyła A. Physical activity of Polish adolescents and young adults according to IPAQ: a population based study. Ann Agric Environ Med. 2012; 19(1): 109–115.