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THE ROLE OF PHYSICAL ACTIVITY AND DIETARY HABITS IN PREVENTING OBESITY IN ADULTHOOD

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ABSTRACT

Purpose: The paper discusses the evidence linking physical inactivity and dietary habits with obesity. The hypothesis is that low levels of physical activity and sedentary lifestyles favour a positive energy balance, therefore leading to obesity, low grade inflammation and weight gain.

Methods: A total of 96 individuals aged 25-49 years were interviewed by questionnaires for physical activity and eating habits. Based on body mass index (BMI) as well as their percentage of fat mass and waist circumference, the participants were divided into either an overweight or normal weight group. Anthropometric parameters, the biochemical variable C-reactive protein and life style factors were compared between the groups using both Student's t-test and the Pearson´s correlation test (r) to identify the correlation between BMI and lifestyle factors.

Results: When the BMI was examined in correlation with various lifestyle factors, a statistically significant difference regarding physical activity and physical fitness was found between the studied groups. In the case of dietary habits, a significantly lower number of consumed meals per day and a higher number of consumed units of meat and meat products were found in the overweight group. Furthermore, a statistical positive correlation was found between the number of meat and meat products consumed and general dissatisfaction with both weight and BMI. In contrast, a negative correlation was discovered between BMI and physical activity as well as physical fitness and the numbers of meal per day.

Conclusion: The increasing prevalence of physical inactivity seems to be an imperative explanation for increasing obesity and obesity related disorders.

Key words: *physical activity, BMI, dietary habits, obesity, inflammation*

VLOGA GIBALNE AKTIVNOSTI IN PREHRANJEVALNIH NAVAD PRI PREPREČEVANJU POJAVA DEBELOSTI PRI ODRASLIH

IZVLEČEK

Članek opisuje povezave med gibalno/športno neaktivnostjo in prehranskimi navadami s pojavom debelosti. Naša hipoteza je, da se gibalno/športna neaktivnost povezuje s pozitivno energijsko bilanco, nizko stopnjo vnetja in dvigom telesne mase.

Metode: 96 posameznikov, starih 25–49 let, je izpolnilo vprašalnike o prehranjevalnih navadah in gibalno/športni aktivnosti. Na podlagi ITM-ja, odstotka maščobne mase in obsega pasu so bili udeleženci razdeljeni na preiskovalno in kontrolno skupino. Antropometrične spremenljivke, biokemijsko spremenljivko CRP in dejavnike življenjskega sloga smo primerjali med dvema skupinama.

Rezultati so pokazali statistično pomembne razlike v telesni aktivnosti in fitnes indeksu med skupinama. Glede na prehranjevalne navade smo med preiskovanci opazili statistično nižje število zaužitih obrokov na dan in statistično višje število dnevnih zaužitih enot mesa in mesnih izdelkov. Povečan ITM je povezan z nižjo stopnjo gibalno/športne aktivnosti, nižjim fitnes indeksom in nižjim številom dnevno zaužitih obrokov ter večjim številom enot zaužitega mesa in mesnih izdelkov. Zadovoljstvo s telesno maso je večje pri nižjem ITM.

Zaključek: Telesna neaktivnost pomembno prispeva k pojavu debelosti in z njo povezanimi zapleti.

Ključne besede: *gibalna/športna aktivnost, ITM, prehranske navade, debelost, vnetje*

INTRODUCTION

Globally, obesity has reached epidemic proportions. In 2008, 1.5 billion adults, 20 years of age and older, were recognized as being overweight (WHO, 2011). In developed countries, obesity is increasing continuously, especially as obesity arises through a complex combination of lifestyle factors, among them decreasing levels of physical activity (Warburton, Nicol, & Bredin, 2006) and increasing emergence of unhealthy habits such as skipping breakfast and lunch (Berg et al., 2009) as well as an increase in the consumption of food with a highly concentrated caloric content resulting in an energy imbalance (Prentice & Jebb, 2001). Obesity is associated with a state of chronic low-grade inflammation due to changes in the function of adipocytes and macrophages (Weisberg et al., 2003) and with a variety of metabolic and hormonal dysfunctions such as insulin resistance and dyslipidaemia may lead to increased cardiovascular risk morbidity and mortality (Wexler et al., 2005). The C-reactive protein (CRP), one of the strongest markers of chronic inflammation, is associated with obesity and could be used as a diagnostic marker for cardiovascular diseases (Ridker, 2009).

It has been demonstrated that the risk of being overweight and/or obese are directly associated with physical inactivity and sedentary habits. These include the amount of time spent sitting per week during leisure time (Proper et al., 2006) as well as the time spent in cars and miles travelled by car per week (Frank, Andresen, & Schmid, 2004). Moreover, low levels of physical activity have been shown to be associated with an increased level of body weight (Hughes et al., 2002; Chaput et al., 2011) and with an increased risk of overall mortality and several common diseases and disorders including coronary heart disease, stroke, osteoporosis, diabetes, and so on (Lee et al., 2012). Alternatively, a simple remedy such as the daily implementation of routine physical exercise prevents the occurrence of several chronic diseases (Wadden et al., 2012). In addition, it has been shown that routine physical activity improves body composition (reduced abdominal adiposity and improved weight control), glucose homeostasis and insulin sensitivity, autonomic tone, coronary blood flow and cardiac function, enhances endothelial function, lipid lipoprotein profiles, and reduces blood pressure and systemic inflammation (Vogesser et al., 2007; Greene, Martin, & Crouse, 2012). Chronic inflammation, as indicated by elevated circulating levels of inflammatory mediators such as CRP, has also been shown to be strongly associated with most chronic diseases of which prevention has benefited from exercise (Warburton, Nicol, & Bredin, 2006).

In addition to physical inactivity, suboptimal consumption of fruit and vegetables, an increased consumption of "fast food" or convenience meals (the highly concentrated caloric content foods) leave the modern human in a skewed balance, i.e., when one's energy intake exceeds their energy expenditure. Subsequent studies have shown that an average energy expenditure of approximately 1000 kcal (4200 kJ) per week is associated with a 20-30 % reduction in all-cause mortality (Paffenbarger et al., 1993).

The aim of our study was to investigate the potential association between physical inactivity and food intake with obesity and obesity related disorders in middle-aged adults.

METHODS

Participants

96 healthy participants (66 % females and 34 % males) aged 25-49 years with no history of disorders participated in our cross-sectional study. The study was approved by the Slovenian National Medical Ethics Committee and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki. All volunteers were fully informed of the procedures before written consent was obtained. The project (A Multidisciplinary Approach in the Treatment of Obesity) was carried out between October and December of 2011 at the University of Primorska, Faculty of Health Sciences in Isola, Slovenia.

Study Instruments and Data Collection

Anthropometric and Other Measurements

The subjects' height was measured to the nearest 0.1 cm in a standing position, without shoes, using Leicester Height Measure (Invicta Plastics Limited, Oadby, England). The body weight of the participants wearing common light indoor clothing without shoes was measured with precision of 0.1 kg. Their body composition was assessed by using the bioelectrical impedance analysis (BIA) Tanita BC 418MA (Tanita Corporation, Arlington Heights, IL). Waist and hip circumferences were measured with measuring tapes to the nearest 0.1 cm. Their pulse rates were measured in a sitting position after a minimum of five minutes of acclimatization. All standardized protocol measurements were performed by the same trained dietician or nurse examiner. The serum concentrations of CRP were measured using Olympus reagents and performed on an AU 680 analyser (Beckman Coulter).

Classification of Obesity

The body mass index (BMI) was calculated using the formulae: weight (kg)/height (m^2). The concepts of overweight and obesity were defined as BMI 25-29 kg/m^2 and $\geq$ 30 kg/m^2 (20), respectively, by a larger than average waist circumference (WC) ($\geq$ 94 cm in men and $\geq$ 80 cm in women), and by a high % of total body fat ($\geq$ 21,5 % in men and $\geq$ 32 % in women). Participants with at least two of these characteristics were classified as members of the overweight group.

Assessment of Physical Activity and Physical Fitness

Physical Activity Estimation by Questionnaire

The Physical Questionnaire AMA, accessible through the web site (http://www.

ama-assn.org), was used to assess physical activity. The questionnaire collected information on the time spent performing physical activities (number of sessions and average time per session), sedentary pursuits; essentially sitting, and physical activity barriers.

Testing Physical Fitness

Physical fitness was assessed to predict maximal oxygen uptake and to measure the ability of brisk walking. Functional status was assessed by reported estimate on ability to low intensity walking for 2 km according to UKK walk test programme (Institute for Health Promotion Research, Tampere, Finland. The walking time was recorded; the pulse rate was measured on cervical aorta by 15 seconds and multiplied by 4. Fitness index (FI) was calculated on the base of the mentioned programme developed by UKK, based on age, BMI, walking time and pulse using the following formulas:

for male: [FI = 420 + A*0.2 – T*11.6 – P*0.56 – BMI*2.6] and

for female: [FI = 304 + A*0.4 – T*8.5 – P*0.32 – BMI*1.1],

whereas A = age; T = time of walking in minutes, seconds; P = pulse; BMI = body mass index. Interpretation of FI measurements is: 1) FI < 70 (significantly low); 2) FI 70-89 (under average); 3) FI 90-100 (average); 4) FI 111-130 (above average); and 5) FI > 130 (significantly high).

Resting Metabolic Rate Measurement

Hand-held indirect calorimeter (MedGem® Microlife) (Medical Home Solutions, Inc., Golden, CO) was used for measuring resting metabolic rate (RMR). RMR measurement conditions were standardized for all subjects, by following a standardized protocol the day before the measurement took place: no eating, drinking, physical exercise and smoking for 12 hours and resting for 10 minutes prior to the measurements.

Dietary Assessment Using 3-day Weighted Food Records

The subjects were instructed to record their food intake for three consecutive days (two weekdays and one day during the weekend). Where possible, subjects were asked to include food labels and recipes for mixed dishes and were encouraged to avoid any alterations to their normal diet. They were taught to weight and record all food and beverages immediately before eating and to weigh and describe any leftovers (EFSA, 2009). Dietary data were analysed using a web application for the analysis of food diary, named Open Platform for Clinical Nutrition. The consumption of units of milk and milk products, vegetables, fruits, starchy food, legumes, meat and meat products, fat and fatty foods and sugars were calculated from this 3-day food record. A food unit represents the net amount consumed without waste, and each unit of the selected food group contains similar amounts of carbohydrates, proteins, fats and energy. Therefore, a unit from a selected food group can be substituted with a unit from any other food group (Table 1).

Table 1: Nutritional composition and energy value of one unit of food from each group.

Group	Carbohydrates/ (g)	Proteins/ (g)	Fats/ (g)	Energy/ (kJ)	Energy/ (kcal)
Milk and milk products/	10	7	3	400	95
Vegetable	5	2	-	118	28
Fruit	15	-	-	250	60
Starchy food	15	2	-	300	70
Legumes	15	5	-	370	83
Meat and meat products	-	7	7	390	93
Fat and fatty food	-	-	5	200	48
Sugars	10	-	-	170	40

Questionnaire on Eating Habits and Satisfaction with Weight

The questionnaire on eating habits is a self-administered questionnaire that contains 4 questions. The subjects were asked about the frequency of meals on weekdays and at weekends, the frequency of consumption of meals away from home and to report how often in the past month they ate fast food, convenience food and junk food. In addition, participants were asked about the satisfaction with their current weight which was assessed through the answers to the question "Are you satisfied with your current weight?", which needed to be answered according to a 5-point scale ranging from 1 (completely) to 5 (never).

Statistical Methods

To describe the characteristics of the overweight and normal weight group, the mean values with standard deviations and proportions were calculated and statistically analysed using the IBM SPSS version 19.0 (SPSS Inc, Chicago, IL, USA). Two groups were formed in respect to BMI, percentage of total fat, and WC. All anthropometric variables and lifestyle factors were compared between the studied groups and by gender using the Student´s t-test. The p value of less than 0.05 was taken as a statistically significant difference between the tested parameters. The Pearson´s correlation test (r) was used in the second stage for identifying the correlation between the BMI and lifestyle factors.

RESULTS

Table 2 summarizes the anthropometric and life style parameters of 48 normal weight and 48 overweight participants. No significant difference of age was observed between the studied groups. Statistically significant differences between these two groups were observed in BMI, WC, the percentage of fat mass, visceral fat rating, RMR, CRP, satisfaction with weight, and pulse rate values being higher in the overweight group compared to the normal weight group (Table 2). The higher RMR observed in the overweight is consistent with a higher cost of activities, probably due to a higher body weight.

When relating BMI to various subjects' lifestyles, no statistically significant differences in the prevalence of obesity by spending time sitting were found, but a statistically significant difference regarding physical activity and physical fitness was found. In terms of minutes per week, physical activity was significantly higher in the normal weight group compared with the overweight group. Similar results were obtained in terms of the frequency of physical activity per week and for the physical fitness.

Table 2: Basic anthropometrical, physical, and biochemical parameters of the overweight and normal weight group.

	Overweight group	Normal weight group	*p*
	M± SD	M± SD	
Participants (n)	48	48	ns
Age (y)	38.8 ± 6.1	36.5 ± 6.3	ns
BMI (kg/m2)	29.4± 2.7	21.9 ± 2.4	0.0001**
Waist circumference (cm)	94.4 ± 7.7	76.1 ± 8.1	0.000***
Hip circumference (cm)	107.5 ± 7.8	92.6 ± 6.5	0.000***
Fat mass (%)	33.7 ± 7.7	21.4 ± 6.4	0.000***
Visceral fat rating	7.8 ± 2.1	3.3 ± 1.7	0.000***
Systolic blood pressure	126.7 ± 18.5	122.3 ±15.4	ns
Diastolic blood pressure	76.1 ± 10.2	70.5 ±12.1	0.016*
Pulse rate (beat per min)	64.5 ± 21.2	53.9 ± 27.7	0.038*
Body temperature (°C)	36.8 ± 0.5	36.5 ± 0.5	0.025*
RMR (kcal/day)	1604 ± 350	1459 ± 300	0.032*
CRP (mg/l)	3.02 ± 3.00	0.84 ± 0.82	0.000***
Physical activity (frequency per week)	1.8 ± 1.5	3.0 ± 2.1	0.001**
Physical activity (min per week)	110 ± 82	180 ± 156	0.008**
Fitness index	82.3 ± 15.6	107.9 ± 14.9	0.000***
Sitting time (h/day)	6.9 ± 3.3	7.4 ± 3.7	ns
Dissatisfaction with weight	3.73 ± 1.14	2.15 ± 0.96	0.000**
No. of meals (per day)	3.3 ± 0.8	3.7 ± 0.8	0.012*
No. of junk food meals (per week)	0.6 ± 1.1	0.7 ± 1.5	ns
No. of convenience food meals (per week)	0.8 ± 1.5	0.5 ± 0.9	ns
No. of meals eaten outside (per week)	3.8 ± 4.3	3.9 ± 3.5	ns

Note: RMR, resting metabolic rate; CRP, C reactive protein.
*The mean difference is significant at the 0.05 level; ***p < 0.001, **p < 0.01, *p < 0.05.*

Figure 1 presents the most common barriers for overweight participants to be physically active: lack of time, being lazy, being at work/working a lot, and in the case of women, not having enough motivation.

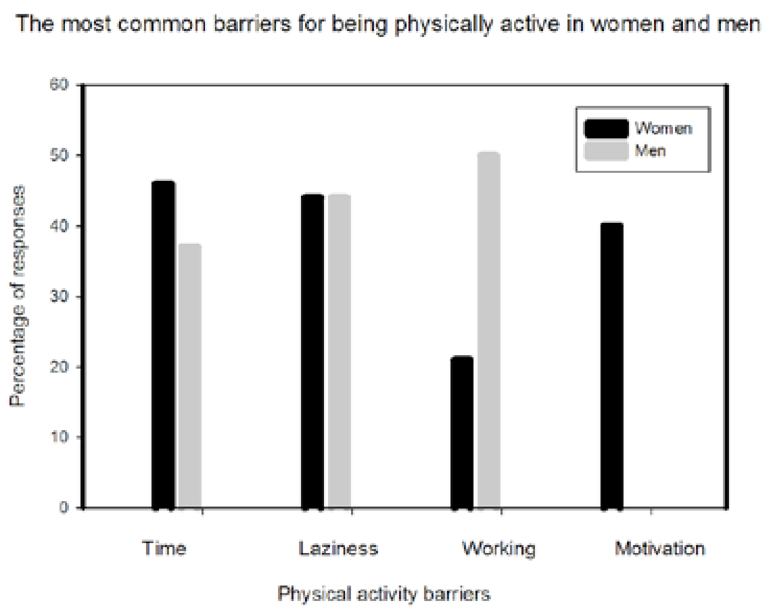

Figure 1: The most common barriers for being physically active in overweight participants.

In the overweight group, other reasons for not being physically active are the following: relying on cars and public transportation instead of walking or cycling to their place of work. In the overweight group only 2 % of the participants reported walking or cycling to and from work, while in the normal weight group this percentage was 25 % (data not shown). Regarding dietary habits a statistically significant lower number of meals per day were found in the overweight group. No statistically significant differences were found in the prevalence of obesity by consuming fast food, convenience food and junk food meals in terms of numbers per week and by meals eaten outside home. Table 3 presents the amount of nutrient intake evaluated from the 3-day food record. No statistically significant differences were found in energy intake, consumption of milk and dairy products, vegetables, fruits, legumes, starchy food, fat and fatty foods and sugars between overweight and the control group. On the other hand, a statistically significant higher value was found regarding the number of units of meat and meat products consumed per day in the overweight group.

Table 3: The amount of nutrient intake evaluated from the 3-day food record for the overweight and normal weight group.

Characteristic	**Mean ± standard deviation**		***p***
	Overweight group	**Normal weight group**	
Energy intake (kcal/day)	2083 ± 696	2016 ± 560	ns
The no. of units of milk and dairy products (per day)	2.51 ± 1.46	2.74 ± 1.44	ns
The no. of units of vegetables (per day)	1.66 ± 1.41	1.9 ± 1.8	ns
The no. of units of fruit (per day)	1.9 ± 1.6	2.3 ± 1.9	ns
The no. of units of starchy food (per day)	8.8 ± 4.2	8.3 ± 2.7	ns
The no. of units of legumes (per day)	0.55 ± 1.8	0.46 ± 1.1	ns
The no. of units of meat and meat products (per day)	4.6 ± 2.7	3.2 ± 1.5	0.003**
The no. of units of fat and fatty foods (per day)	9.2 ± 4.2	9.2 ± 3.9	ns
The no. of units of sugars (per day)	4.2 ± 5	4.3 ± 3.2	ns

*Note: The mean difference is significant at the **$p < 0.01$.*

As evident from Table 4, Pearson's correlations were performed to investigate the possible associations between BMI and lifestyle parameters (frequency of physical activity, number of meals per day, meat and meat products), and satisfaction with weight. A negative correlation was found between BMI and the frequency of physical activity (minutes per week and frequency per week), and number of meals per day. On the other hand, positive correlations were found between BMI and dissatisfaction with weight and consumption of meat and meat products.

Table 4: Correlation between BMI and lifestyle factors

		Frequency of physical activity	**No. of meals per day**	**Dissatisfaction with weight**	**Meat and meat products**
BMI	Pearson correlation (r)	-0.273	-0.237	0.396	0.335
	Statistical significance (*p*)	0.008**	0.02*	0.000**	0.001**

*Note: * Correlation is significant at the $p < 0.05$; ** $p < 0.01$*

DISCUSSION

Physical inactivity, changed eating habits, and eating in fast food restaurants are the most important reasons for an increasing number of people in Europe being at risk in reaching overweight and obesity (Rosenheck, 2008; Axelsen et al., 2012). From the aspect of unhealthy habits, the findings of our study provide evidence for the high prevalence of low level of physical activity of the participants from the overweight group. Although increasing physical activity is an effective therapy for weight loss, higher physical fitness may also emerge as a promising treatment for reducing overall inflammation and contribute to clinical benefits (Beavers et al., 2010). Given that physical activity and obesity are inversely related, it is not clear as to whether the anti-inflammatory health benefits of a physically active lifestyle are due to exercise per se or are the result of favorable changes in body composition (Calder et al., 2011). Indeed, we observed a significantly higher value of CRP in the overweight group compared to the normal weight group.

Furthermore, we observed a significant negative association between physical activity and BMI, probably because the "modern environment" is one in which technological advances have eliminated many reasons of physical activity (Ng & Popkin, 2012). Many personal variables, including physiological, behavioural, and psychological factors, may affect the participants' plans to become more/less physically active. Three most common reasons which participants cite for not adopting more physically active lifestyles are lack of time, laziness, work, and also motivation. Similar results were also shown in other studies (Paffenbarger et al., 1993; Proper et al., 2006; Wadden et al., 2012).

The equivalent of at least 150 min/wk of moderate-intense physical activity is necessary to realize health-related improvements (Pate et al., 1995). We found that the quantity of physical activity in the overweight group was under the minimum of official public health recommendations. These findings suggest that especially the overweight individuals should be encouraged to exercise.

Physical fitness, which generally increases with increased physical activity, may also attenuate obesity-related mortality (Wadden et al., 2012). The perceived physical fitness is an integrated result of the functional status and health of many organ systems, in which particularly the cardio-vascular system plays a pivotal part. In our study we observed different physiological effects of exercise which in normal weight group resulted in lower pulse rate and lower systolic and diastolic blood pressure. Similar results were described by other research groups (Monteiro & Sobral Filho, 2002; Huang et al., 2013). Interestingly, the results of our study didn't show any statistically significant differences in time spent sitting in the overweight group in comparison with the normal weight group. The reason for this is probably a small sample size and probably over-reporting of physical activity by the overweight participants compared to normal weight participants.

Besides physical inactivity, unhealthy dietary habits have also contributed to the explanation of the observed obesity pandemia. Naturally, dietary patterns are an important risk factor, which can be easily modified, and the recent efforts of public health institutions have been directed towards implementing healthy eating patterns in order to improve the health of general population (Hamer & Mishra, 2010). We found a statistically significant difference in terms of number of meals per day, where the overweight group reported fewer meals per day than the normal weight group. Conflicting results can be seen in the relationship between eating frequency and obesity (McCrory & Campbell, 2011). Leidy and Campbell suggest that increased eating frequency (more than 3 meals/day), has minimal, if any, impact on appetite control and food intake, whereas reduced eating frequency of less than 3 meals/day negatively affects the control of appetite (Leidy & Campbell, 2011). In the case of energy intake evaluated from the 3-day food record, no statistically significant difference was found between the overweight and normal weight group. Similar results have also been reported in the Berg's study (Berg et al., 2009). A possible explanation for our results may be a deliberate underreporting of dietary intake by the obese participants. Similar findings have also been shown by Goris (Goris et al., 2000). Indeed, the participants in our study reported that weighing food discouraged them from eating. Furthermore, no statistically significant differences were found between the two groups in the consumption of starchy food, fruits, vegetables, sweets, fats, legumes and milk. In our study, especially the consumption of vegetables was very low in both groups. A significant positive correlation was found between BMI and consumption of meat and processed meat between the overweight and the normal weight group. This could be explained by the fact that meat and processed meat is associated with high-fat, especially saturated fatty acids consumption, and such dietary patterns, including higher proportions of energy from meat proteins were shown to be associated with the risk for obesity (Murtaugh et al., 2007; Wang & Beydoun, 2009). Moreover, the increased consumption of higher caloric foods, like fast food and convenience meals is also known to induce changes in the control of appetite in the human organism (Prentice & Jebb, 2011) and those who consume fast food less than once a week show a higher probability of having a healthier nutrition than those who consume fast food once or more per week (Moore et al., 2009). Interestingly, in our study no differences were found in the consumption of fast food, junk food and convenience meals between the overweight and the normal weight group.

CONCLUSION

Our study provides evidence on the high prevalence of low level of physical activity of the participants from the overweight group compared to the normal weight group and bad dietary habits in both groups.

Since poor dietary habits and physical inactivity are associated with many adverse health outcomes, most adults could benefit from interventions designed to improve their eating habits and increase their daily activity levels. Such interventions include the promotion of active life style and good eating habits early in life. A regular consumption of fruits and vegetables is one of the good eating habits, moreover, adequate daily intake of foods from these groups has a positive impact on the health and helps fighting obesity (Sartorelli et al., 2008). Our recommendation is that the fruit and/or vegetables must be present in every meal of the day. This provides a lower energy density of meals and prevents overeating.

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