Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.50021

Association of physical activity status with dietary energy density and nutritional adequacy

Ozge YESILDEMIR[1]*, Feray GENCER BINGOL[1], Mehmet Arif ICER[1], Eda KOKSAL[1]

Abstract

This study evaluated the association of physical activity status with dietary energy density and nutritional adequacy. 205 individuals between the ages of 19-35 years (102 active, 103 inactive) (50% women) participated in the study. The individuals were grouped according to their physical activity status by gender. When the nutrient adequacy ratio (NAR) of the individuals' diets was evaluated, there was a significant difference between active and inactive men only in vitamin A and E adequacy ($p < 0.05$). On the other hand, energy, protein, calcium, iron, magnesium, zinc, niacin, vitamin E and folate intake adequacy were found to be lower in active women compared to inactive women ($p < 0.05$). While the mean adequacy ratio (MAR) of the diet did not differ among men, it was significantly higher in inactive women compared to active women ($p < 0.05$). Dietary energy density was found to be lower in all active individuals compared to inactive individuals ($p < 0.05$). A positive association was found between nutritional adequacy and body weight ($p < 0.05$), body mass index ($p < 0.05$), body fat percentage ($p < 0.05$) and fat free mass ($p < 0.05$) in inactive men. As a result, physical activity status can affect nutritional adequacy and dietary energy density, and this effect differs between genders.

Keywords: physical activity; nutritional adequacy; energy density; NAR; MAR.

Practical Application: Physical activity can reduce the risk of obesity by reducing dietary energy density.

1 Introduction

Physical activity is defined as any body movement produced by skeletal muscles that results in energy expenditure in everyday life (Du et al., 2019). Guidelines recommend that adults should engage moderate activity of 150 minutes or vigorous activity of 75 minutes per week (Piercy et al., 2018). Inadequate physical activity is associated with an increased prevalence of non-communicable chronic diseases such as obesity, diabetes and cardiovascular diseases (González et al., 2017). Another reason in the etiology of these diseases is nutritional habits and dietary history (Di Renzo et al., 2019; Marhuenda et al., 2019). It is thought that there may also be an association between physical activity status and the nutritional habits of individuals. And, it is anticipated that physically active individuals tend to choose healthier diets compared to inactive individuals. However, vigorous physical activities for weight loss can sometimes lead to restrictions in energy intake and imbalances in dietary pattern (Monteiro et al., 2019; Osman & Abumanga, 2019; Yousif et al., 2019).

One of the most important factors leading to improvement in quality of life is dietary quality (Ozturk & Dikmen, 2021). It is a concept that has recently gained importance in food and nutrition science. This concept covers many factors such as food safety, organoleptic properties and sociocultural elements. Food safety is a global public health priority and approximately 10% of people suffer from foodborne illnesses. Foodborne illnesses cause insufficient food and nutrient intake of individuals and as a result adversely affect dietary quality (Bumyut et al., 2021; Zhao & Talha, 2021). It is also known that organoleptic properties and taste sensitivity affects food intake and dietary quality (Ozturk & Dikmen, 2021). Nutrition-related factors affecting dietary quality include components such as adequacy, diversity, moderation, overall balance, nutrients, and energy density (Alkerwi, 2014; Hallström et al., 2018; Laitinen & Mokkala, 2019). Nutritional adequacy is defined as adequate intake of nutrients necessary for optimal health. The nutrient adequacy ratio (NAR) and mean adequacy ratio (MAR) are the main concepts used in the evaluation of nutritional adequacy (Doustmohammadian et al., 2020; Hjertholm et al., 2019). Another indicator of dietary quality is dietary energy density. Dietary energy density is a dietary indicator calculated by dividing the daily energy intake of individuals by the total weight of the amount of food consumed during that day (Maddahi et al., 2020). Studies have found that dietary energy density is positively associated with body mass index, daily energy and fat intake but negatively associated with fruit and vegetable consumption (Grech et al., 2017; Murakami et al., 2017; Sasaki et al., 2017). Energy density is often associated with weight loss and maintenance in individuals, and whether it is affected by physical activity status is not clear yet (Maddahi et al., 2020).

Based on this information, it was aimed to associate between physical activity status and dietary energy density and nutritional adequacy in this study.

Received 28 Jun., 2021
Accepted 03 Dec., 2021
[1] *Department of Nutrition and Dietetics, Faculty of Health Sciences, Gazi University, Ankara, Turkey*
*Corresponding author: ozgeyesildemir@gazi.edu.tr

2 Materials and methods

2.1 Study design and population

The study was conducted with a total of 205 volunteers, 102 active (51 men, 51 women) and 103 inactive individuals (51 men, 52 women) with similar age and BMI, who were between the ages of 19-35 years, members of a fitness center in Ankara/Turkey and exercising regularly. Moderate exercise of 150 minutes/week and above or vigorous exercise of 75 minutes/week and above for active individuals, and moderate exercise of 150 minutes/week and below or vigorous exercise of 75 minutes/week and below for inactive individuals were determined as the inclusion criteria. In addition, pregnant and lactating women, individuals with involuntary weight loss, chronic diseases (diabetes, cardiovascular diseases) and psychiatric medication use were excluded from the study. The study was conducted with the approval of Gazi University Ethics Commission, dated 05/06/2018 and numbered 77082166-604.01.02. Signed informed consent was obtained from all patients and this study was conducted in accordance with the Helsinki Declaration.

2.2 Food consumption

24 hour dietary recalls were obtained in order to determine the energy and nutrient intakes of the individuals. The mean energy and nutritional values of daily consumed food were analyzed by the Computer Assisted Nutrition Program, Nutritional Information System 7.2 (2010) version.

2.3 NAR (Nutrient adequacy ratio)

The NAR value was calculated by comparing individual daily intake of nutrients with the dietary reference intake (DRI) levels categorized according to age and gender (Hjertholm et al., 2019). In this study, the NAR values were calculated for the selected 11 nutrients (protein, calcium, iron, magnesium, zinc, vitamin A, niacin, vitamin B12, vitamin C, vitamin E and folate) as percentages based on the recommended dietary allowance (RDA). In addition, the energy adequacy ratio was calculated using the estimated energy requirement (EER) (Krebs-Smith & Clark, 1989). NAR was calculated by Equation 1 below;

$$NAR: \left(Nutrient\ intake\ amount \times 100\right)\ /\ DRI \quad (1)$$

2.4 MAR (Mean adequacy ratio)

Nutritional adequacy of the individuals was evaluated using the mean adequacy ratio (MAR). The MAR value was obtained as percentage by taking the mean of the NAR values calculated for 11 nutrients. When calculating the MAR, the NAR value of 100% and above were accepted as 100% (Krebs-Smith & Clark, 1989). MAR was calculated by Equation 2 below;

$$MAR: Total\ NAR\ value\ of\ the\ selected\ nutrients\ /\ Number\ of\ nutrients \quad (2)$$

2.5 Dietary energy density

Dietary energy density was calculated by dividing the total energy values of the food (including beverages) consumed by the individuals by the total amount of the food (Maddahi et al., 2020). MAR was determined by Equation 3 below;

$$Dietary\ energy\ density\ \left(food\ and\ beverages\right): Total\ energy\ \left(kcal\right)\ /\ Total\ amount\ \left(g\right) \quad (3)$$

2.6 Body composition and anthropometric measurements

Anthropometric measurements [height (cm), waist circumference (cm)] and body compositions of the individuals were measured by the researchers in accordance with the technique. A "Tanita BC 532" body analyzer was used to measure the body weight and body compositions [body weight (kg), body fat percentage (%), fat free mass (kg)] of the individuals participating in the study. The BMI (kg/m^2) values of the individuals were calculated.

2.7 Statistical analysis

Numerical variables were expressed as mean ($\overline{X}$) and standard deviation (SD), while qualitative variables were expressed as number (N) and percentage (%). The chi-square test was used for the comparison of qualitative data (number and percentage). Whether there was a difference between numerical variables was examined by the independent sample t-test when numerical variables showed normal distribution and by the Mann-Whitney U test when they did not show normal distribution. The Pearson correlation coefficient and Spearman correlation coefficient were used to examine the correlations between variables. Statistical analyzes were performed using Statistical Package for the Social Sciences (SPSS) 15.0 package program (IBM, Armonk, USA). All statistical calculations were evaluated at 95% confidence interval and $p < 0.05$ significance level.

3 Results

The mean ages of active and inactive men were 23.6 ± 3.88 and 24.9 ± 3.85 years, respectively, while the mean ages of active and inactive women were 23.1 ± 3.77 and 22.4 ± 1.99 years, respectively. When the activity duration of the individuals was evaluated, it was observed that men exercised for 302.9 ± 113.29 minutes/week, while women exercised for 273.5 ± 127.79 minutes/week in the physically active group. The mean activity duration of men was 27.0 ± 31.35 minutes/week, while this period was 44.5 ± 45.28 minutes/week for women in the inactive group. When the demographic characteristics of the individuals were evaluated, it was seen that the majority of them were single (89.3%), university graduates (59%) and had middle income (73.2%). In addition, active individuals were found to skip more meals than inactive individuals (67.6% and 46.6%, respectively) ($p < 0.05$).

When the anthropometric measurements and body compositions of the individuals were evaluated, the fat free mass of the active group was found to be higher compared to the inactive group in women ($p < 0.05$). There was no significant difference between the groups in other anthropometric measurement and body composition findings ($p > 0.05$) (Table 1).

When the daily energy and nutrient intake of the individuals were examined, there was no difference between active and inactive men in terms of daily energy intake ($p > 0.05$), while the daily energy intake of inactive women (1817.1 ± 496.71 kcal/day) were found to be higher compared to active women (1245.2 ± 486.86 kcal/day) ($p < 0.05$). The percentage of energy from carbohydrates was higher in inactive individuals compared to active individuals for both men and women ($p < 0.05$). In contrast, the percentage of energy from protein was higher in active individuals for both men and women ($p < 0.05$). When the percentage of energy from fat was examined, there was no statistically significant difference between active and inactive individuals ($p > 0.05$). While there was no difference between active and inactive men in terms of calcium, iron, magnesium and zinc intakes, the intakes of these nutrients were higher in inactive women compared to active women ($p < 0.05$). Vitamin A intake was higher, and vitamin E intake was lower in active men ($p < 0.05$). Niacin, vitamin E and folate intakes were statistically lower in active women compared to inactive women ($p < 0.05$) (Table 2).

When the individuals were evaluated in terms of nutrient adequacy, there was a statistically significant difference between active and inactive men only in the NAR values of vitamin A and E ($p < 0.05$). In women, energy, protein, calcium, iron, magnesium, zinc, niacin, vitamin E and folate adequacy were lower in active women compared to inactive women ($p < 0.05$). While the mean adequacy ratio (MAR) did not differ among men, it was significantly higher in inactive women compared to active women ($p < 0.05$). Dietary energy density was lower in the active groups of both genders ($p < 0.05$) (Table 3).

When the individuals were evaluated according to gender, the mean dietary energy density was calculated as 1.5 ± 0.47 in men and 1.4 ± 0.43 in women. The dietary energy density of men was found to be significantly higher compared to women ($p < 0.05$).

When the association of nutritional adequacy with age and anthropometric measurements was evaluated, there was no significant association between active men and active and inactive women ($p > 0.05$), while nutritional adequacy was found to be positively associated with body weight (r:0.394, $p < 0.05$), BMI (r:0.448, $p < 0.05$), body fat percentage (r:0.278, $p < 0.05$) and

Table 1. Anthropometric measurements and body composition values of the individuals.

	Men (n:102)			Women (n:103)		
	Active (n:51)	Inactive (n:51)	p	Active (n:51)	Inactive (n:52)	p
	X ± SD	X ± SD		X ± SD	X ± SD	
Height (cm)	177.2 ± 4.32	178.9 ± 6.19	0.110	164.2 ± 5.18	163.0 ± 5.60	0.234
Body weight (kg)	77.2 ± 12.43	76.7 ± 13.09	0.995	57.9 ± 6.23	57.0 ± 7.72	0.462
Body mass index (kg/m^2)	24.6 ± 3.75	25.3 ± 11.36	0.510	21.5 ± 2.59	21.3 ± 2.63	0.695
Percentage of body fat (%)	16.3 ± 6.12	16.2 ± 5.42	0.946	23.7 ± 5.80	22.6 ± 6.91	0.383
Fat free mass (kg)	63.7 ± 7.07	61.1 ± 7.67	0.076	43.9 ± 3.55	40.3 ± 6.43	**0.001***
Waist circumference (cm)	85.0 ± 8.74	87.3 ± 11.10	0.163	70.5 ± 6.73	71.7 ± 7.09	0.422

Independent sample t-test, Mann-Whitney U test *$p < 0.05$

Table 2. Daily energy and some nutrient intakes of the individuals.

	Men (n:102)			Women (n:103)		
	Active (n:51)	Inactive (n:51)	p	Active (n:51)	Inactive(n:52)	p
	X ± D	X ± SD		X ± SD	X ± SD	
Energy (kcal)	1995.2 ± 896.77	21978 ± 649.96	0.054	1245.2 ± 486.86	1817.1 ± 496.71	**0.000***
Carbohydrate (g)	198.4 ± 99.61	254.3 ± 89.93	**0.002***	133.1 ± 65.59	211.0 ± 61.82	**0.000***
Carbohydrate (%)	40.8 ± 10.03	47.3 ± 6.90	**0.000***	43.1 ± 12.85	48.0 ± 7.31	**0.021***
Protein (g)	84.3 ± 39.52	72.1 ± 23.95	0.090	52.0 ± 24.74	63.3 ± 17.33	**0.011***
Protein (%)	17.6 ± 4.03	13.6 ± 2.75	**0.000***	17.3 ± 5.50	14.3 ± 2.46	**0.001***
Total lipid (g)	92.3 ± 49.6	95.3 ± 30.59	0.171	52.3 ± 49.6	77.8 ± 27.29	**0.000***
Total lipid (%)	41.6 ± 9.39	39.1 ± 6.01	0.114	37.9 ± 11.12	37.7 ± 7.02	0.909
Calcium (mg)	680.3 ± 385.54	603.1 ± 326.55	0.440	485.2 ± 248.14	610.1 ± 263.56	**0.025***
Iron (mg)	11.1 ± 5.72	11.9 ± 4.49	0.110	7.1 ± 2.91	11.5 ± 4.33	**0.000***
Magnesium (mg)	265.3 ± 167.5	275.7 ± 118.13	0.218	172.0 ± 63.33	287.1 ± 115.46	**0.000***
Zinc (mg)	10.4 ± 5.01	10.3 ± 3.79	0.766	6.7 ± 3.64	9.1 ± 2.92	**0.000***
Vitamin A (mcg)	1159.1 ± 1522.83	689.4 ± 405.79	**0.007***	655.9 ± 423.96	898.3 ± 1154.80	0.297
Niacin (mg)	30.2 ± 18.85	24.0 ± 9.11	0.080	17.7 ± 9.50	22.9 ± 7.29	**0.001***
Vitamin B12(mcg)	5.5 ± 6.78	4.4 ± 2.97	0.563	3.3 ± 3.06	3.4 ± 2.06	0.307
Vitamin C (mg)	77.1 ± 74.21	70.5 ± 60.3	0.886	67.4 ± 49.09	89.0 ± 62.59	0.061
Vitamin E (mg)	18.0 ± 12.33	25.6 ± 8.49	**0.000***	12.4 ± 7.85	22.5 ± 7.89	**0.000***
Folate (mcg)	278.4 ± 171.24	304.9 ± 155.75	0.188	169.4 ± 72.88	334.2 ± 136.63	**0.000***

Independent sample t-test, Mann-Whitney U test *$p < 0.05$.

Table 3. Evaluation of the nutrient adequacy and dietary energy density of the individuals.

	Men (n:102)			Women (n:103)		
	Active(n:51)	Inactive(n:51)	p	Active(n:51)	Inactive(n:52)	p
	X ± SD	X ± SD		X ± SD	X ± SD	
NAR (%)						
Energy	65.1 ± 29.24	71.7 ± 21.19	0.054	52.2 ± 20.46	75.6 ± 20.67	**0.000***
Protein	150.5 ± 70.57	128.8 ± 42.77	0.090	113.8 ± 54.08	137.5 ± 37.68	**0.004***
Calcium	68.0 ± 38.55	60.3 ± 32.66	0.440	49.4 ± 25.77	61.0 ± 26.36	**0.025***
Iron	138.5 ± 71.47	148.3 ± 56.15	0.110	39.9 ± 16.32	63.7 ± 24.04	**0.000***
Magnesium	66.3 ± 41.88	68.9 ± 29.53	0.218	56.3 ± 20.78	92.6 ± 37.24	**0.000***
Zinc	94.2 ± 45.58	93.3 ± 34.49	0.766	84.3 ± 45.82	113.2 ± 36.51	**0.000***
Vitamin A	128.8 ± 169.20	76.6 ± 45.09	**0.007***	93.8 ± 60.63	128.3 ± 164.97	0.297
Niacin	188.8 ± 117.80	150.1 ± 56.94	0.080	127.7 ± 68.06	163.8 ± 52.06	**0.001***
Vitamin B12	230.7 ± 282.36	184.8 ± 123.59	0.563	140.0 ± 128.92	142.6 ± 85.84	0.307
Vitamin C	85.7 ± 82.45	78.3 ± 67.03	0.886	89.9 ± 65.50	118.7 ± 83.46	0.061
Vitamin E	120.0 ± 82.22	170.7 ± 56.61	**0.000***	82.2 ± 52.36	150.0 ± 52.59	**0.000***
Folate	69.6 ± 42.81	76.2 ± 38.94	0.188	42.3 ± 18.18	83.6 ± 34.16	**0.000***
MAR (%)	79.0 ± 16.39	79.7 ± 13.64	0.984	65.4 ± 17.60	81.9 ± 15.21	**0.000***
MAR (%)	79.3 ± 15.00			73.7 ± 18.33		
Energy density (kkal/g)	1.3 ± 0.33	1.8 ± 0.41	**0.000***	1.1 ± 0.28	1.7 ± 0.40	**0.000***
Energy density (kkal/g)	1.5 ± 0.47			1.4 ± 0.43		**0.019***

Independent sample t-test, Mann-Whitney U test *p < 0.05.

fat free mass (r:0.396, p < 0.05) in inactive men. No statistically significant association was found between dietary energy density and age and anthropometric measurements in both active and inactive individuals for both genders (p > 0.05).

4 Discussion

Non-communicable diseases are among the most important health problems of the 21st century (Gupta & Xavier, 2018). Inadequate physical activity and obesity are the most important risk factors for non-communicable diseases (Ahmed et al., 2019; Reilly et al., 2019). In addition, physical activity level is associated with the energy intake, expenditure and body compositions of individuals (Miles, 2007). In this study, it was aimed to examine the association between the dietary energy density, nutritional adequacy and anthropometric measurements of physically active individuals and to compare them with physically inactive individuals.

Nutrients should be taken to the body at certain time intervals to ensure adequate and balanced nutrition. The body's energy and metabolic balance may be adversely affected in cases of fasting for a long time or overeating at short intervals. Therefore, the number of main meals and snacks is quite important for maintaining health and ensuring adequate and balanced nutrition (Butler & Barrientos, 2020). Changing physical activity habits were determined to cause no significant changes on main meal patterns in a study evaluating the associations between physical activity habits and meal patterns (Driskell et al., 2005). Similarly, no statistically significant association was found between being physically active and the frequency of main meal in this study (p > 0.05). This result suggests that physical activity may not be effective on the main meal frequencies of individuals.

Overweight and obesity are defined as excessive or abnormal accumulation of fat at a level to put health at risk (Schetz et al., 2019). Body fat percentage is expected to be lower in active individuals compared to inactive individuals. Studies have shown that physical activity is inversely associated with body fat percentage (Anyżewska et al., 2020; Bradbury et al., 2017). It is also stated that increased physical activity is associated with an increase in fat free mass (Takae et al., 2019). In this study, active women were found to have higher fat free mass compared to inactive women (p<0.05). However, there was no significant difference between the groups in terms of body fat percentage in this study. It is an expected result that variables such as waist circumference and body fat percentage did not differ between the groups while the individuals in the inactive group were included in the study, since they were selected in accordance with the BMI of the physically active group. In line with these data, it is thought that increased physical activity may lead to an increase in fat free mass as well as a decrease in body fat percentage.

When energy intake is more than energy expenditure; that is, when energy balance shifts positively, weight gain begins (Mahan & Raymond, 2016). Hatamoto et al. concluded in their study that significantly different daily physical activity did not energy intake (Hatamoto et al., 2019). In this study, no significant difference was found between physically active and inactive men in terms of energy expenditure, while physically inactive women had statistically significantly higher energy intake compared to active women (p < 0.05). In line with the current results, it is thought that men performed physical activities for bodybuilding purposes, and therefore their energy intake was very similar to inactive individuals, while the reason why women performed physical activities was mostly to lose weight, and therefore they may have restricted their energy intake.

It is very important that the rates of dietary energy from macronutrients are within the desired range in order to maintain health and gain healthy eating habits (Mahan & Raymond, 2016). A study concluded that increased physical level did not affect the macronutrient intake of individuals (Motamed et al., 2019). In the present study, it was found that the rate of daily energy intake from carbohydrate was lower ($p < 0.05$), the rate from protein was higher ($p < 0.05$), and there was no difference in the rate from fat ($p > 0.05$) in active men compared to inactive men. It can be thought that active men may frequently exercise for bodybuilding purposes and try to contribute to muscle development by consciously increasing their protein intake. It should not be ignored that this increase in protein intake will indirectly lead to a decrease in carbohydrate intake. However, it is an expected situation that inactive women will have higher daily carbohydrate, protein and fat intakes due to higher daily energy intake compared to active women. Although inactive women had higher daily protein intake ($p < 0.05$), the rate of daily energy from protein was lower ($p < 0.05$). This suggests that physically active women were trying to increase their protein intake. In addition, it should not be disregarded that the rate of energy from carbohydrate was lower, while the rate of energy from fats was higher in all groups according to healthy nutrition recommendations. In line with these data, the dietary pattern was observed to be impaired due to the increased daily total fat intake as a result of the low-carbohydrate diet consumed by the individuals.

Adequate intake of micronutrients is extremely important along with adequate intake of macronutrients (Mahan & Raymond, 2016). In this study, the percentage of meeting vitamin A requirement was found to be lower, and the percentage of meeting vitamin E requirement was found to be higher in inactive men compared to active men ($p < 0.05$). This result suggests that inactive men consumed more sources rich in vitamin E. In addition, it was found that both active and inactive men did not have any nutritional deficiencies when the percentages of meeting daily nutritional requirements were evaluated. As for women, the percentage of meeting daily energy requirement was found to be higher in the inactive group ($p < 0.05$). This suggests that physically active women consciously turned to energy restrictions in their diets. The percentages of meeting calcium, iron, magnesium, zinc, niacin, vitamin E and folate requirements and their amount of intake with daily diet were also significantly higher in inactive women compared to active women ($p < 0.05$). However, it should not be ignored that physically inactive women had higher daily energy intake with their diets compared to active women, and this may have affected the result.

Nutritional adequacy and energy density are among the main methods used in determining dietary quality (Mahan & Raymond, 2016). Cho et al. (2011) found that the active group had higher MAR values compared to the inactive group, but this difference was not statistically significant in their study. In the present study, the MAR values were not different between the two groups of men, while they were higher in the inactive group of women ($p < 0.05$). It can be thought that the daily energy intakes of physically inactive women are higher, and therefore their MAR values may be higher.

In addition to the amount of energy in a diet, the ratio of daily energy intake to the total weight of the amount of food consumed during that day is quite important. This ratio, called dietary energy density, facilitates making general comments on the diet consumed (Grech et al., 2017; Maddahi et al., 2020). Furthermore, many studies have reported that increased dietary energy density is associated with obesity (Arango-Angarita et al., 2019; Vernarelli et al., 2018). In the present study, the dietary energy density of active individuals was found to be significantly lower in both genders ($p < 0.05$). In line with these data, it can be concluded that increased physical activity can reduce dietary energy density and decrease the risk of obesity with this mechanism. However, the lack of studies investigating the association between physical activity level and dietary energy density complicates the evaluation.

Gender is stated to have an effect on nutritional habits (VanKim et al., 2019). Leblanc et al. found that men had a higher dietary energy density compared to women in their study (Leblanc et al., 2015). In the present study, the dietary energy density of men was found to be statistically significantly higher compared to women ($p < 0.05$). In the light of these data, it can be thought that gender may have an effect on dietary energy density.

Another important research topic is the study of the association between the mean adequacy ratio of diet and anthropometric measurements. Kelishadi et al. (2019) found that the MAR was positively associated with BMI in their study of 5000 participants ($p < 0.05$). Increased dietary diversity was found to be associated with higher BMI in a study conducted by Fernandez et al. (2016). In this study, a significant positive association was found between nutritional adequacy and body weight, BMI, body fat percentage and fat free weight in inactive men. In line with these data, it can be thought that there is an association between nutritional adequacy and some anthropometric measurements. However, further studies are needed on this subject.

5 Conclusions

In this study, it was concluded that increased physical activity might be associated with increased fat free mass, decreased daily energy and carbohydrate intake and increased daily protein intake. Different results were observed in gender groups, especially between nutritional adequacy and physical activity. Moreover, it can be said that increased physical activity has a reducing effect on dietary energy density. In addition, the results of this study indicate that increasing the level of physical activity can reduce the risk of obesity by increasing fat free mass and reducing dietary energy density and energy intake.

Acknowledgements

This study did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

Ahmed, S. H., Meyer, H. E., Kjøllesdal, M. K., Marjerrison, N., Mdala, I., Htet, A. S., Bjertness, E., & Madar, A. A. (2019). The prevalence of selected risk factors for non-communicable diseases in Hargeisa, Somaliland: a cross-sectional study. *BMC Public Health*, 19(1), 878. http://dx.doi.org/10.1186/s12889-019-7101-x. PMid:31272414.

Alkerwi, A. (2014). Diet quality concept. *Nutrition (Burbank, Los Angeles County, Calif.)*, 30(6), 613-618. http://dx.doi.org/10.1016/j.nut.2013.10.001. PMid:24800663.

Anyżewska, A., Łakomy, R., Lepionka, T., Szarska, E., Maculewicz, E., Tomczak, A., & Bertrandt, J. (2020). Association between diet, physical activity and body mass index, fat mass index and bone mineral density of soldiers of the polish air cavalry units. *Nutrients*, 12(1), 242. http://dx.doi.org/10.3390/nu12010242. PMid:31963454.

Arango-Angarita, A., Shamah-Levy, T., & Rodríguez-Ramírez, S. (2019). Dietary energy density is associated with body mass index-for-age in Mexican adolescents. *Maternal and Child Nutrition*, 15(2), e12664. http://dx.doi.org/10.1111/mcn.12664. PMid:30225859.

Bradbury, K. E., Guo, W., Cairns, B. J., Armstrong, M. E., & Key, T. J. (2017). Association between physical activity and body fat percentage, with adjustment for BMI: a large cross-sectional analysis of UK Biobank. *BMJ Open*, 7(3), e011843. http://dx.doi.org/10.1136/bmjopen-2016-011843. PMid:28341684.

Bumyut, A., Makkaew, P., Yadee, K., Hlamchoo, S., Binyoosoh, I., & Precha, N. (2021). Assessment of food safety conditions at food service premises using Thai survey form and field fecal indicator testing in Pakpoon municipality of Nakhon Si Thammarat, Thailand. *Food Science and Technology (Campinas)*. http://dx.doi.org/10.1590/fst.47521.

Butler, M. J., & Barrientos, R. M. (2020). The impact of nutrition on COVID-19 susceptibility and long-term consequences. *Brain, Behavior, and Immunity*, 87, 53-54. http://dx.doi.org/10.1016/j.bbi.2020.04.040. PMid:32311498.

Cho, K. O., Nam, S. N., & Kim, Y. S. (2011). Assessments of nutrient intake and metabolic profiles in Korean adolescents according to exercise regularity using data from the 2008 Korean National Health and Nutrition Examination Survey. *Nutrition Research and Practice*, 5(1), 66-72. http://dx.doi.org/10.4162/nrp.2011.5.1.66. PMid:21487499.

Di Renzo, L., Gualtieri, P., Romano, L., Marrone, G., Noce, A., Pujia, A., Perrone, M. A., Aiello, V., Colica, C., & De Lorenzo, A. (2019). Role of personalized nutrition in chronic-degenerative diseases. *Nutrients*, 11(8), 1707. http://dx.doi.org/10.3390/nu11081707. PMid:31344895.

Doustmohammadian, A., Omidvar, N., Keshavarz-Mohammadi, N., Eini-Zinab, H., Amini, M., Abdollahi, M., Amirhamidi, Z., & Haidari, H. (2020). Low food and nutrition literacy (FNLIT): a barrier to dietary diversity and nutrient adequacy in school age children. *BMC Research Notes*, 13(1), 286. http://dx.doi.org/10.1186/s13104-020-05123-0. PMid:32532341.

Driskell, J. A., Kim, Y. N., & Goebel, K. J. (2005). Few differences found in the typical eating and physical activity habits of lower-level and upper-level university students. *Journal of the American Dietetic Association*, 105(5), 798-801. http://dx.doi.org/10.1016/j.jada.2005.02.004. PMid:15883559.

Du, Y., Liu, B., Sun, Y., Snetselaar, L. G., Wallace, R. B., & Bao, W. (2019). Trends in adherence to the physical activity guidelines for Americans for aerobic activity and time spent on sedentary behavior among US adults, 2007 to 2016. *JAMA Network Open*, 2(7), e197597. http://dx.doi.org/10.1001/jamanetworkopen.2019.7597. PMid:31348504.

Fernandez, C., Kasper, N. M., Miller, A. L., Lumeng, J. C., & Peterson, K. E. (2016). Association of dietary variety and diversity with body mass index in US preschool children. *Pediatrics*, 137(3), e20152307. http://dx.doi.org/10.1542/peds.2015-2307. PMid:26908657.

González, K., Fuentes, J., & Márquez, J. L. (2017). Physical inactivity, sedentary behavior and chronic diseases. *Korean Journal of Family Medicine*, 38(3), 111-115. http://dx.doi.org/10.4082/kjfm.2017.38.3.111. PMid:28572885.

Grech, A. L., Rangan, A., & Allman-Farinelli, M. (2017). Dietary energy density in the Australian adult population from national nutrition surveys 1995 to 2012. *Journal of the Academy of Nutrition and Dietetics*, 117(12), 1887-1899.e2. http://dx.doi.org/10.1016/j.jand.2017.08.121. PMid:29173347.

Gupta, R., & Xavier, D. (2018). Hypertension: the most important non communicable disease risk factor in India. *Indian Heart Journal*, 70(4), 565-572. http://dx.doi.org/10.1016/j.ihj.2018.02.003. PMid:30170654.

Hallström, E., Davis, J., Woodhouse, A., & Sonesson, U. (2018). Using dietary quality scores to assess sustainability of food products and human diets: a systematic review. *Ecological Indicators*, 93, 219-230. http://dx.doi.org/10.1016/j.ecolind.2018.04.071.

Hatamoto, Y., Takae, R., Goya, R., Yoshimura, E., Higaki, Y., & Tanaka, H. (2019). Effects of different physical activity levels during a single day on energy intake, appetite, and energy balance: a preliminary study. *Nutrients*, 11(3), 690. http://dx.doi.org/10.3390/nu11030690. PMid:30909563.

Hjertholm, K. G., Holmboe-Ottesen, G., Iversen, P. O., Mdala, I., Munthali, A., Maleta, K., Shi, Z., Ferguson, E., & Kamudoni, P. (2019). Seasonality in associations between dietary diversity scores and nutrient adequacy ratios among pregnant women in rural Malawi–a cross-sectional study. *Food & Nutrition Research*, 63(0). http://dx.doi.org/10.29219/fnr.v63.2712. PMid:30837821.

Kelishadi, R., Hemati, Z., Khoshhali, M., Mohebpour, F., & Heidari-Beni, M. (2019). Association between Mean Adequacy Ratio as diet quality index and anthropometric indices in children and adolescents. *Mediterranean Journal of Nutrition and Metabolism*, 12(4), 377-387. http://dx.doi.org/10.3233/MNM-190320.

Krebs-Smith, S., & Clark, L. (1989). Validation of a nutrient adequacy score for use with women and children. *Journal of The American Dietetic Association,* 89(6), 775-783. PMID: 2723299.

Laitinen, K., & Mokkala, K. (2019). Overall dietary quality relates to gut microbiota diversity and abundance. *International Journal of Molecular Sciences*, 20(8), 1835. http://dx.doi.org/10.3390/ijms20081835. PMid:31013927.

Leblanc, V., Bégin, C., Corneau, L., Dodin, S., & Lemieux, S. (2015). Gender differences in dietary intakes: what is the contribution of motivational variables? *Journal of Human Nutrition and Dietetics*, 28(1), 37-46. http://dx.doi.org/10.1111/jhn.12213. PMid:24527882.

Maddahi, N. S., Yarizadeh, H., Setayesh, L., Nasir, Y., Alizadeh, S., & Mirzaei, K. (2020). Association between dietary energy density with mental health and sleep quality in women with overweight/obesity. *BMC Research Notes*, 13(1), 189. http://dx.doi.org/10.1186/s13104-020-05025-1. PMid:32228677.

Mahan, L. K., & Raymond, J. L. (2016). *Krause's food & the nutrition care process-e-book*. USA: Elsevier Health Sciences.

Marhuenda, J., Villaño, D., Cerdá, B., & Zafrilla, M. P. (2019). *Cardiovascular disease and nutrition nutrition in health and disease-our challenges now and forthcoming time*. London: IntechOpen.

Miles, L. (2007). Physical activity and health. *Nutrition Bulletin*, 32(4), 314-363. http://dx.doi.org/10.1111/j.1467-3010.2007.00668.x.

Monteiro, L. Z., Varela, A. R., Lira, B. A., Contiero, L. C., Carneiro, M. L. A., Souza, P., Nóbrega, J. O. T., & Júnior, F. B. (2019). Weight status, physical activity and eating habits of young adults in Midwest Brazil. *Public Health Nutrition*, 22(14), 2609-2616. http://dx.doi.org/10.1017/S1368980019000995. PMid:31148525.

Motamed, S., Mazidi, M., Safarian, M., Ghayour-Mobarhan, M., Moohebati, M., Ebrahimi, M., Azarpazhooh, M. R., Heidari-Bakavoli, A., Esmaily, H., Baghestani, A., Pascal Kengne, A., & Ferns, G. A. (2019). Macronutrient intake and physical activity levels in individuals with and without metabolic syndrome: an observational study in an urban population. *ARYA Atherosclerosis*, 15(3), 136-145. http://dx.doi.org/10.22122/arya.v15i3.1303. PMid:31452662.

Murakami, K., Livingstone, M. B. E., Okubo, H., & Sasaki, S. (2017). Energy density of the diets of Japanese adults in relation to food and nutrient intake and general and abdominal obesity: a cross-sectional analysis from the 2012 National Health and Nutrition Survey, Japan. *The British Journal of Nutrition*, 117(1), 161-169. http://dx.doi.org/10.1017/S0007114516004451. PMid:28112076.

Osman, A. A., & Abumanga, Z. M. (2019). The relationship between physical activity status and dietary habits with the risk of cardiovascular diseases. *The European Journal of Cardiovascular Medicine*, 7(2), 72-78. http://dx.doi.org/10.32596/ejcm.galenos.2019.00008.

Ozturk, E. E., & Dikmen, D. (2021). Association between fat taste sensitivity and diet quality in healthy male Turkish adults. *Food Science and Technology (Campinas)*. http://dx.doi.org/10.1590/fst.66820.

Piercy, K. L., Troiano, R. P., Ballard, R. M., Carlson, S. A., Fulton, J. E., Galuska, D. A., George, S. M., & Olson, R. D. (2018). The physical activity guidelines for Americans. *Journal of the American Medical Association*, 320(19), 2020-2028. http://dx.doi.org/10.1001/jama.2018.14854. PMid:30418471.

Reilly, J. J., Hughes, A. R., Gillespie, J., Malden, S., & Martin, A. (2019). Physical activity interventions in early life aimed at reducing later risk of obesity and related non-communicable diseases: a rapid review of systematic reviews. *Obesity Reviews*, 20(Suppl 1), 61-73. http://dx.doi.org/10.1111/obr.12773. PMid:31419046.

Sasaki, K. M., Wada, K., Zeredo, J. L. L., & Nagata, C. (2017). Prospective study of dietary energy density and weight gain in a Japanese adult population. *The British Journal of Nutrition*, 117(6), 822-828. http://dx.doi.org/10.1017/S0007114517000484. PMid:28397626.

Schetz, M., De Jong, A., Deane, A. M., Druml, W., Hemelaar, P., Pelosi, P., Pickkers, P., Reintam-Blaser, A., Roberts, J., Sakr, Y., & Jaber, S. (2019). Obesity in the critically ill: a narrative review. *Intensive Care Medicine*, 45(6), 757-769 http://dx.doi.org/10.1007/s00134-019-05594-1. PMid:30888440.

Takae, R., Hatamoto, Y., Yasukata, J., Kose, Y., Komiyama, T., Ikenaga, M., Yoshimura, E., Yamada, Y., Ebine, N., Higaki, Y., & Tanaka, H. (2019). Physical activity and/or high protein intake maintains fat-free mass in older people with mild disability; the Fukuoka Island City Study: a cross-sectional study. *Nutrients*, 11(11), 2595. http://dx.doi.org/10.3390/nu11112595. PMid:31671741.

VanKim, N. A., Corliss, H. L., Jun, H.-J., Calzo, J. P., AlAwadhi, M., & Austin, S. B. (2019). Gender expression and sexual orientation differences in diet quality and eating habits from adolescence to young adulthood. *Journal of the Academy of Nutrition and Dietetics*, 119(12), 2028-2040. http://dx.doi.org/10.1016/j.jand.2019.05.014. PMid:31375461.

Vernarelli, J. A., Mitchell, D. C., Rolls, B. J., & Hartman, T. J. (2018). Dietary energy density and obesity: how consumption patterns differ by body weight status. *European Journal of Nutrition*, 57(1), 351-361. http://dx.doi.org/10.1007/s00394-016-1324-8. PMid:27738811.

Yousif, M. M., Kaddam, L. A., & Humeda, H. S. (2019). Correlation between physical activity, eating behavior and obesity among Sudanese medical students Sudan. *BMC Nutrition*, 5(1), 6. http://dx.doi.org/10.1186/s40795-019-0271-1. PMid:32153920.

Zhao, Y., & Talha, M. (2021). Evaluation of food safety problems based on the fuzzy comprehensive analysis method. *Food Science and Technology (Campinas)*. http://dx.doi.org/10.1590/fst.47321.