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Association between smoking status and body composition parameters in a young adult population

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ABSTRACT: The purpose of this study was to analyze the association between smoking status and body composition parameters in 19–30 years old slovak population (mean age: 22,38 ± 2,34 years). The sample consisted of 379 individuals, including 143 men and 236 women. Body composition parameters were obtained using segmentation bioimpedance analysis. The results of our study showed that regular smokers had significantly higher values of waist circumference (p = 0.050), body mass index (p = 0.042), waist-to-height ratio (p = 0.027), fat mass index (p = 0.014) fat mass (p < 0.017), pecentual body fat (p = 0.008), trunk fat mass (FM, p = 0.008), leg fat mass (p = 0.029), and visceral fat area (p = 0.017) compared to non-smokers. Using correlation analysis, we detected an increase in FM (kg) values along with the frequency of smoking (r = 0,136; p = 0,009). Moreover, smoking positively correlated with coffee (r = 0.147; p = 0.002), energy drinks (r = 0.259; p < 0.001), and alcohol consumption (r = 0.101; p = 0.035). Smokers also added salt to their food more often (r = 0.132; p = 0.005) and worked less (r = -0.111; p = 0.025). In this study we confirmed the significant association of smoking with the body composition components, while it is responsible for higher adiposity in young adults.

KEY WORDS: fat mass, lifestyle, early adulthood, smoking.

Original article

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Introduction

The tobacco epidemic is one of the biggest public health threats in the world, killing more than 8 million people a year around the world (St Claire et al. 2020). Of these, more than 7 million deaths are attributed to direct tobacco use, while around 1.2 million deaths are caused by non-smokers being exposed to passive smoking (WHO 2021; Perez-Warnisher, Carballosa de Miguel and Seijo 2019; GBD 2019; Tobacco Collaborators 2021). In 2020, the global prevalence of smoking among adults was 32.6% for men and 6.5% for women (Dai, Gakidou and Lopez 2022). Despite the implementation of tobacco control policies that have led to a decrease in smoking prevalence in Europe (EU) over the past two decades, the number of smokers remains high, with 26% of the overall population and 29.0% of young Europeans aged 15–24 years being smokers (Gravely et al. 2017; Feliu et al. 2019; Teshima, Laverty and Filippidis 2022). Smoking-related mortality in the EU is higher (16.0% among adults aged 30 and over) than the global average of 12.0% (Zafar 2014; Janssen, El Gewily and Bardoutsos 2021). Moreover, the COVID-19 pandemic and the stress resulting from the economic crises have been identified as strong factors associated with an increase in smoking in recent years (Ghadban et al. 2022). In Slovakia, the overall smoking prevalence has increased since 2006, with 32.3% of the adult population being currently smoking. Smoking prevalence is higher among men (38.6%) compared to women (26.0%) (WHO 2019).

Cigarette smoking affects the body through the inhalation of carcinogenic substances, such as dusts and tar, as well as the consumption of nicotine and psychoactive chemical in tobacco that leads to dependence (West 2017). Smoking, especially when combined with unhealthy dietary patterns, increases the risk of chronic diseases (Haffner and Taegtmeyer 2003; Saha et al. 2007). Smoking, even on an occasional basis, significantly raises the risk of cardiovascular diseases. Smokers are two to four times more likely to develop coronary heart disease and twice as likely to experience a stroke compared to non-smokers. The risk of cardiovascular damage is influenced by the duration of smoking and the type and quantity of tobacco products consumed (Conklin et al. 2019). While the exact mechanisms of cardiovascular damage are not fully understood, the detrimental effects of smoking on endothelial function are well recognized. Smoking triggers oxidative processes and adversely affects platelet function, fibrinolysis, inflammation, and vasomotor function. These proatherogenic effects double the 10-year risk of fatal events in smokers compared to non-smokers (Gallucci et al. 2020). Futhermore, tobacco smoking is the major preventable cause of cancer in multiple organs. Despite the longstanding decline in smoking prevalence, lung cancer remains one of the most frequently diagnosed cancers in both sexes (Kulhánová et al. 2020). Several studies have also demonstrated the effects of tobacco smoking on the skeletal system. Specifically, recent evidence indicates that smoking disrupts the mechanisms of bone turnover, leading to lower bone mass and bone mineral density (BMD), which increases the vulnerability of bones to osteoporosis (Cusano 2015; Al-Bashaireh et al. 2018) and fractures (Vestergaard and

Mosekilde 2003; Cusano 2015; Zhang et al. 2022). Moreover, cigarettes are assumed to be a risk factor in sleep disorders, including breathing sleep disorders (Witek and Lipowicz 2021).

Studies regarding the effects of smoking on body composition are conflicting. Some studies have found that smokers have a lower Body mass index (BMI) compared to non-smokers, which may be attributed to the metabolic properties of nicotine, leading to increased oxidation and reduced fat accumulation at higher levels (Bamia et al. 2004; Akbartabartoori, Lean and Hankey 2005). However, regular smoking has been found to be associated with higher BMI (Dare, Mackay and Pell 2015; Pruszkowska-Przybylska et al. 2016). Heavy smoking has an impact on fat distribution and is linked to abdominal obesity and insulin resistance (Chiolero et al. 2008). Additionally, unhealthy lifestyle behaviors are often prevalent among heavy smokers, potentially contributing to weight gain and fat accumulation. Pisinger, Toft and Jørgensen (2009) demonstrated a positive correlation between cigarette consumption and an unhealthy diet, higher energy intake, sedentary lifestyle, and alcohol consumption. Cigarette smoke components play a significant role in reducing muscle mass, reducing the amount of oxygen supplied to muscles, and disrupting mitochondrial function. Studies indicate that smokers have lower fat-free mass compared to non-smokers. Substances present in cigarette smoke can stimulate muscle protein breakdown and disrupt protein synthesis. Aldehydes in cigarette smoke enter the circulation and directly impact skeletal muscle by reducing protein synthesis in human muscle cells, inducing muscle atrophy and myosin breakdown (Montes de Oca et al. 2008; Wüst et al. 2008; van den Borst et al. 2011; Kok, Hoekstra and Twisk 2012; Degens, Gayan-Ramirez and van Hees 2015).

The aim of our pilot cross-sectional study is to establish the relationships between smoking status and anthropometric characteristics, obesity indices and body composition parameters in Slovak young adults.

Material and methods

The sample comprised 379 Slovak young adults ranging in age from 19 to 30 years (with mean age 22.38 ± 2.34 y), who were enrolled in this cross-sectional research during 2019–2020. All study participants were evaluated in the Biomedical laboratory of Department of Anthropology at Comenius University during the morning. Women and men were approached and recruited using a nonrandom procedure (based on volunteering and convenience). Each participant provided written informed consent for this study which adhered to the Declaration of Helsinki principles. Biomedical research was also approved by the ethics committee of the Faculty of Natural Sciences at Comenius University with number ECH19021.

Data on lifestyle were collected from participants using a questionnaire (a modified version of the STEPS questionnaire WHO v.3.2), which was part of a study designed for research purposes. Probands were asked to complete a questionnaire containing questions related to their socio-demographics background and lifestyle. All socio-demographic and lifestyle variables were measured by self-reporting. Smoking status was categorised as regular (smoking once a week to every day) and non-smokers (never smoking).

Anthropometric measurements were taken using standard anthropometric techniques by trained anthropologists. Body height was measured with participants standing without shoes and heavy outer garments by anthropometer. Waist and hip circumferences were measured to the nearest 0.5 cm using a non-elastic tape. Waist circumference (WC) was measured at the level of the umbilicus, and the hip circumference (HC) was measured at the maximum posterior protrusion of the buttocks. BMI was calculated as body weight in kilograms divided by height squared (WHO 2000) and values below 24.9 kg/m^2 were considered as optimal. Waist-to-hip ratio (WHR) was calculated as the circumference of the waist divided by the circumference of the hips (WHO 2000) and values less than 0.84 for women and less than 0.89 for men were considered as optimal. Waist-to-height ratio (WHtR) was calculated as the circumference of the waist divided by height squared (Schneider et al. 2010) and values below 0.48 for women and less than 0.52 for men were considered as optimal. The InBody 770 body composition analyzer (Biospace Co., Korea) was used to detect the human body composition parameters based on the recommendation provided in the user manual. Participants were tested in the quiet state in the morning. Participants stood barefoot on the pedal plate electrode. The hands were naturally hanging and held the hand electrode gently, keeping the angle at 15° between the torso and the upper limbs. The test included measurements of body weight, lean body mass (LBM), intracellular fluid (intacellular water, ICW), extracellular fluid (extracellular water, ECW), body water content (total body water, TBW), skeletal muscle (skeletal muscle mass, SMM), body fat (FM) and body cell mass (BCM). Fat mass index (FMI) was calculated as FM divided by height squared (kg/m^2). Visceral Fat Area (VFA) is based on the estimated amount of fat surrounding internal organs in the abdomen, and values below 100 cm^2 were considered optimal. These detailed body composition variables were displayed on a computer using the LookinBody programme software.

All statistical analyses were performed with IBM SPSS for Windows (Statistical Package for the Social Science, version 25.0, Chicago, IL) and statistical significance was defined as $p \leq 0.05$. The assumption of normal distribution was tested by the one-sample Kolmogorov-Smirnov test. We used covariate-adjusted generalized linear models (GLMs) to analyze the effects of smoking (no = 0, and yes = 1) on body composition parameters (as dependent variables), with age and gender as the covariates. Correlation analysis was used to test the strenght of association between two variables and the direction of the relationship. To assess correlation between smoking frequency and body composition parameters the Pearson's chi-square test was used in case of normally distributed variable and Spearman nonparametric test for data with non-normal distribution. Kendall's tau-b correlation coefficient was used to measure strength and direction of association between two variables measured on at least an ordinal scale. This type of correlation was used to correlate the mutual relationships of lifestyle factors.

Results

Characteristics of the study participants, anthropometric characteristics and obesity indices according to smoking status in young adults

The sample consisted of 379 individuals – 143 men (37.7%) and 236 women (62.3%). Among the participants, 12.8% were regular smokers, while 87.2% were non-smokers. The prevalence rate of alcohol consumption was 33.3%. Anthropometric characteristics, obesity indices according to smoking status in young adults are summarized in Table 1. After adjustment for age and gender, we found statistically significant differences between regular smokers and non-smokers. Regular smokers attained significantly higher values of waist circumference than non-smokers (smokers: 78.24 ± 9.97 cm vs. non-smokers: 74.22 ± 9.89 cm; $p = 0.050$). Additionally, results indicated that regular smokers had statistically significantly higher BMI ($p = 0.042$), WHtR index ($p = 0.027$) and FMI ($p = 0.014$).

Table 1. Anthropometric characteristic and obesity indices according to smoking status in young adults

Number of participants	*Regular smokers*			Non-smokers			p^*
	N = 47			*N = 320*			
	Mean		SD	Mean		SD	
Height, cm	172.63	±	9.74	171.83	±	9.17	0.423
Weight, kg	72.89	±	15.03	67.72	±	14.79	0.130
Waist circumference, cm	78.24	±	9.97	74.22	±	9.89	0.050
Hip circumference, cm	99.53	±	8.91	96.89	±	8.41	0.131
BMI, kg/m^2	24.32	±	3.85	22.79	±	3.89	0.042
WHR	0.79	±	0.08	0.76	±	0.06	0.104
WHtR	0.45	±	0.05	0.43	±	0.05	0.027
FMI, kg/m^2	6.45	±	2.70	5.61	±	2.80	0.014

Note: N, number of participants; SD, standard deviation; p*, value of statistical significance adjusted for age and sex; BMI, body mass index;

WHR, Waist-to-hip ratio; WHtR, Waist-to-height ratio; FMI, Fat mass index

Body composition characteristics according to smoking status in young adults

The mean values of bioelectric impedance variables are shown in Table 2. After adjustment for age and gender, statistically significant differences were observed between regular smokers and non-smokers in terms of body composition parameters. Regular smokers had higher mean values of FM (smokers: 19.01 ± 7.47 kg vs. non-smokers: 16.36 ± 7.84 kg; $p < 0.017$), PBF (smokers: 25.81 ± 8.29 % vs. non-smokers: 24.02 ± 8.48 %; $p = 0.008$), trunk FM (smokers: 9.70 ± 4.01 kg vs. non-smokers: 8.06 ± 4.03 kg; $p = 0.008$), leg FM (smokers: 2.85 ± 1.07 kg vs. non-smokers: 2.55 ± 1.08 kg; $p = 0.029$), and VFA (smokers: 83.16 ± 37.38 cm^2 vs. non-smokers: 70.56 ± 38.93 cm^2; $p = 0.017$) compared to non-smokers.

Table 2. Body composition characteristics according to smoking status in young adults

Number of participants	*Regular smokers* N = 47			Non-smokers *N = 320*			p^*
	Mean		SD	Mean		SD	
Skeletal Muscle Mass, kg	30.15	±	7.28	28.54	±	7.49	0.964
Fat Free Mass, kg	53.47	±	11.81	51.36	±	12.29	0.590
Lean Body Mass, kg	50.71	±	11.29	48.32	±	11.60	0.896
Lean Body Mass Right Arm, kg	2.88	±	0.88	2.66	±	0.90	0.733
Lean Body Mass Trunk, kg	23.77	±	5.26	22.38	±	5.36	0.600
Lean Body Mass Right Leg, kg	8.45	±	1.87	8.19	±	1.94	0.400
Fat Mass, kg	19.01	±	7.47	16.36	±	7.84	0.017
Percentual Body Fat, %	25.81	±	8.29	24.02	±	8.48	0.008
Visceral Fat Area, cm^2	83.16	±	37.38	70.56	±	38.93	0.017
Fat Mass Right Arm, kg	1.23	±	0.67	1.06	±	0.81	0.080
Fat Mass Right Leg, kg	2.85	±	1.07	2.55	±	1.08	0.029
Fat Mass Trunk, kg	9.70	±	4.01	8.06	±	4.03	0.008
Total Body Water, l	39.43	±	8.72	37.59	±	8.97	0.888
Intracellular Water, l	24.65	±	5.58	23.52	±	6.09	0.761
Extracellular Water, l	14.78	±	3.15	14.17	±	3.24	0.776
Body Cell Mass, kg	35.30	±	8.00	33.55	±	8.23	0.956

Note: N, number of participants; SD, standard deviation; p*, value of statistical significance adjusted for age and sex

Correlation analysis between smoking frequency and body composition parameters

Subsequently, the participants were divided into six groups based on smoking frequency: non-smokers (n = 308), smoking less than once a month (n = 12), smoking one to two days a week (n = 10), smoking three to four days a week (n = 9), smoking five to six days a week (n = 4), and smoking daily (n = 24). We investigated how smoking frequency correlateed with body composition parameters. Statistically significant correlations are shown in Table 3. The positive correlation coefficients indicate that all adiposity parameters increases with the higher frequency of smoking.

Correlation analysis between smoking status and selected lifestyle factors

By performing a correlation analysis, we found that smokers had a higher frequency of coffee consumption (r = 0.147; *p* = 0.002), energy drinks consumption (r = 0.259; *p* < 0.001), and alcohol drinking (r = 0.101; *p* = 0.035) compared to non-smokers. Smokers also added salt to their food more often (r = 0.132; *p* = 0.005) and worked less (r = -0.111; p = 0.025; data not shown in table).

Table 3. Correlation analysis between smoking frequency and body composition parameters

	r	*p*
Waist circumference, cm	0.131	0.012
Hip circumference, cm	0.124	0.018
BMI, kg/m^2	0.134	0.010
WHR	0.105	0.044
WHtR	0.158	0.002
FMI, kg/m^2	0.121	0.021
Fat Mass, kg	0.136	0.009
Fat Mass Trunk, kg	0.151	0.004
Visceral Fat Area, cm^2	0.135	0.009

Note: r, correlation coefficient; p, value of statistical significance; BMI, body mass index; WHR, Waist-to-hip ratio; WHtR, Waist-to-height ratio; FMI, Fat mass index

Discussion

In our study, we recorded higher values of all anthropometric parameters and indexes in smoking young adults than in non-smokers, with statistically significant differences in waist circumference, BMI, WHR, WHtR and FMI indexes. Studies examining the effect of smoking on anthropometric parameters are contradictory. Some previous studies have shown negative correlation between obesity and smoking. For example, in an older study of Akbartabartoori et al. (2005) on Scottish adolescents and adults aged 16 to 74 years, statistically significantly lower average values of BMI and hip circumference were recorded in the smokers group (BMI men = 25.6 kg/m2, BMI women: 25.2 kg/m2; hips men: 101.2 cm, hips women = 100.5 cm) compared to non-smokers (BMI men = 26.8 kg/m2, BMI women = 26.2 kg/m2; hips men = 101.9 cm, hips women = 101.9 cm). In our study, we observed statistically significantly higher BMI values in smokers (24.32 ± 3.85) than in non-smokers (22.79 ± 3.89). Also, hip circumference was higher in smokers (99.53 ± 8.91 cm) than in non-smokers (96.89 ± 8.41 cm), but the difference was not statistically significant. Assyov et al. (2008) found that smoking was associated with WC, while smokers had higher values than non-smokers (105.5 ± 7.84 cm vs. 99.73 ± 9.65cm), which was consistent with the results of our study (smokers: 78.24 ± 9.97 cm; non-smokers: 74.22 ± 9.89 cm). Chiolero et al. (2007) in their study of the Swiss population aged 25 to 44 years recorded a lower average BMI value in non-smoking men (24.6 ± 0.1) than in heavy smokers (24.9 ± 0.2), but higher than in light smokers (24.1 ± 0.2) and the same as in moderate smokers (24.6 ± 0.2). Smokers were defined based on the number of cigarettes smoked per day. Light smokers were defined as those smoking one to nine cigarettes per day, moderate smokers smoked ten to 19 cigarettes, and heavy smokers smoked 20 or more cigarettes per day. Also, Dare et al. (2015) found out that among smokers, the risk of obesity increased with the quantity of cigarettes smoked and former heavy smokers were more likely to be obese compared to former light smokers (adjusted OR 1.60, 95% 1.56 – 1.64, $p < 0.001$). Additionally, Pruszkowska-Przybylska et al. (2016) revealed a significant influence of nicotinism on BMI: regular cigarette smoking was associated with higher BMI values in students aged between 19 and 26. The different results of smoking studies may indicate that endogenous factors and other lifestyle factors may be more important in influencing body composition than the direct effects of smoking (Efendi et al. 2018).

In terms of body composition parameters, statistically significant differences were observed in the case of FM (kg) as well as PBF (%). Significantly higher FM values were recorded in all compared body segments except for the arm (kg) FM. Smokers had a higher visceral fat area (83.16 ± 37.38 cm^2) compared to non-smokers (70.56 ± 38.93 cm^2). Correlation analysis confirmed a positive relationship between FM (kg) and smoking frequency. Assyov et al. (2008) obtained similar results in their study on the effect of smoking on body composition, where smokers had higher values of FM (36.62 ± 8.46 %) than non-smokers (32.66 ± 6.96 %). Stefan et al. (2017) examined the influence of lifestyle factors and body composition on Croatian adults (with a mean age of 19.81 years). The correlation analysis showed that FM (%) increased in both male and female smokers, with a statistically significant correlation observed only in females ($r = 0.230$; $p < 0.010$). In a study by Alkeilani et al. (2022)

on adults aged 18 to 89 years from the population in Qatar, smokers had higher mean FM values (29.0 ± 11.3 kg) compared to never smokers (23.4 ± 6.6 kg, $p < 0.001$), which was consistent with the findings of our study.

In our study we found that smokers had a higher frequency of coffee consumption, energy drinks, and alcohol compared to non-smokers. This unhealthy lifestyle could contribute to an increased BMI and FM observed among smokers in our study. Furthermore, we noticed a decrease in the number of worked participants among smokers, which could lead to lower energy expenditure and consequently an increase in FM values.

Previous studies have also reported higher caffeine intake in smokers compared to non-smokers in the general population (Hewlett and Smith 2006; Mahoney et al. 2019). Results from the Riera-Sampol et al.´study (2022) showed that the association between smoking and caffeine consumption may depend on the caffeine source. They found a higher prevalence of coffee, cola and energy drink consumption among smokers, while no differences were observed for other caffeine sources considered. Physiological, cognitive, and environmental factors may all contribute to the association between smoking and caffeine intake, because smoking increases the rate of caffeine metabolism, as a consequence, smokers must consume caffeine more frequently than non-smokers to maintain similar effects (Bjørngaard et al. 2017). Pisinger, Toft, and Jørgensen (2009) also recorded significantly higher consumption of unhealthy food, alcohol, overall energy intake, and a sedentary lifestyle among smokers ($p < 0.001$).

Despite our interesting findings, there are some limitations that need to be acknowledged. The study is cross-sectional and may have had selection bias during participation recruitment, and the particular study design may limit result generalization to all Slovak young adults. Since data collection was done using a self-answered questionnaire, some of the participants might not have been comfortable with reporting their true smoking status. Moreover, the study population was smaller ($n = 379$) and for future studies, it would be paramount to enlarge and divided by gender the study sample for a detailed analysis.

Conclusion

In this study, we have provided novel data that supports the significant association of smoking status and body composition parameters in Slovak young adults. The findings of this study may have important implications for public health, as they could help to inform interventions aimed at reducing smoking rates and promoting healthy body composition in young adults.

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Conflict of interest

The authors declare that there is no conflict of interest.

Authors' contribution

DF participated in collection of data, analysis and interpretation of data, and the writing of the manuscript. LV participated in collection of data, analysis and interpretation of data, and the writing of the manuscript. RB was responsible for the statistical analysis.

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