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Examination of the relationship between skin autofluorescence and lifestyle habits in young adults

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ABSTRACT

This study investigates the relationship between skin autofluorescence (SAF) levels and lifestyle habits in healthy young adults. The study was conducted between January 2022 and December 2022 with 300 healthy young adults. The questionnaire form in which the participants' sociodemographic characteristics, general habits and dietary habits were questioned, Mediterranean Diet Adherence Scale (MEDAS), International Physical Activity Questionnaire-Short Form (IPAQ-SF), Pittsburgh Sleep Quality Index (PSQI) were applied, anthropometric measurements were taken by the researcher, and SAF levels were measured. At the end of the study, the mean SAF levels of the participants were observed to be 1.48±0.21 AU. SAF levels were found to be 1.49±0.21 AU in women and 1.47±0.21 AU in men. It was found that SAF levels did not differ significantly by gender ($p>0.05$). Smokers' SAF levels ($x=1.60$ AU) were statistically significantly higher than non-smokers' SAF levels ($\bar{x}=1.43$ AU) ($p<0.05$). A significant correlation was observed between SAF levels and BMI (body mass index), waist circumference, hip circumference, waist height ratio, adherence to a Mediterranean diet and physical activity levels ($p<0.05$). No significant correlation was observed between participants' sleep quality and their SAF levels. In conclusion, adopting healthy eating and lifestyle habits reduces SAF levels.

Keywords: advanced glycation end products, healthy adults, lifestyle habits, skin autofluorescence

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INTRODUCTION

Advanced glycation end products (AGEs) are a heterogeneous group of compounds produced endogenously from the non-enzymatic glycation of proteins, lipids, and nucleic acids. In addition to the endogenous formation of these products, smoking and consumption of AGE-rich foods also contribute to the AGE pool exogenously[1,2].

Advanced glycation end-products are part of normal metabolism but can become pathogenic if their accumulation in tissues increases. The pathogenic effects of AGEs affect the body through two mechanisms: AGE receptor-mediated and AGE receptor-free. AGEs can directly cross-link with body proteins and change their functions and structures. In addition, they have pro-inflammatory effects through AGE receptors[3,4].

Various methods are currently used to detect AGEs in tissues, biological fluids, and foods. Skin biopsies are the gold standard for determining AGE levels in tissues. Skin autofluorescence (SAF) is recommended as a simple, noninvasive way of assessing AGE tissue accumulation[5,6].

It is predicted that lifestyle habits such as eating habits, physical activity level, smoking, and sleep quality may affect the formation and accumulation of AGEs in the human body. There are very few studies investigating SAF levels in the general population. These studies evaluated limited lifestyle habits.

There has been no study conducted on this subject among the Turkish population. With this study, it was planned to determine the mean SAF levels of young adults in the Turkish population. It was also planned to compare them with other countries' populations. The main purpose of the research is to evaluate the potential relationship between SAF levels and lifestyle habits in healthy young adults.

METHODOLOGY

This study is based on a cross-sectional research model. The study was conducted between January 2022 and December 2022 with 300 healthy young adults aged 18–30 years. Participants signed a consent form, stating that they voluntarily participated in the study. The inclusion criteria of the study were to be between 18-30 years old, volunteer to participate in the study. Exclusion criteria were having scars and/or tattoos on the inner arm and dark skin colour that has potential to interfere with SAF-AGE measurement, pregnancy and lactation, having chronic diseases and language barrier that makes it difficult to communicate.

The questionnaire form applied to the study participants consists of demographic characteristics, general health information, nutritional habits, anthropometric measurements, the Mediterranean Diet Adherance Scale (MEDAS), the International Physical Activity Questionnaire (IPAQ)-Short Form, and the Pittsburgh Sleep Quality Index (PSQI).

The skin autofluorescence levels were measured by the investigators using the "AGE Reader" device (DiagnOptics Technologies, Groningen, The Netherlands) from the dominant forearm, approximately 10-15 cm below the elbow bend, at room temperature and with the participants in a sitting position. The AGE Reader is a non-invasive device that uses the characteristic fluorescent properties of certain AGEs to calculate levels of AGEs deposited in the skin. Since the accumulation of AGEs in the body increases with age, each age has a normal AGE value. The software of the manufacturer considers a value lower than 1.53 AU in this age group as low risk.

The research data were analyzed using SPSS (Statistical Package for Social Sciences) for Windows 22.0 program. Numbers, percentages, means, and standard deviations were used as descriptive statistical methods. In the comparison of quantitative continuous data between two independent groups, the t-test was used. For comparing quantitative continuous data among more than two independent groups, the one-way ANOVA test was employed. Following the ANOVA test, Scheffe's post hoc analysis was conducted to determine the differences. Pearson correlation analysis was applied to the study's continuous variables. The significance level (p) for comparison tests was taken as 0.05. The correlation coefficients (r) are evaluated as follows: 0.00-0.25 very weak; 0.26-0.49 weak; 0.50-0.69 moderate; 0.70-0.89 high; 0.90-1.00 very high.

RESULTS and DISCUSSION

A total of 300 people, 150 women and 150 men, participated in the study. Table 1 shows the demographic characteristics and general habits of the participants.

The average body weight for women was 59.19±12.07 kg, and for men, it was 77.14±10.33 kg. The average height was 163.24±5.59 cm for women and 177.18±5.65 cm for men. The average BMI values were 22.22±4.45 kg/m^2 for females and 24.55±2.92 kg/m^2 for males. Furthermore, the average waist circumference for females was 71.09±8.39 cm, while for males, it was 86.11±8.22 cm. The average hip circumference was 94.76±9.76 cm for females and 102.32±7.38 cm for males. The waist/hip ratios were 0.75±0.05 for females and 0.84±0.05 for males. The waist/height ratios were 0.43±0.05 for females and 0.48±0.04 for males. The anthropometric measurements of men were found to be statistically higher ($p<0.05$).

According to BMI data, 64.7% of women and 54.7% of men were classified as normal. 41.3% of men were overweight. Waist circumference measurements showed that 89.3% of women and 82.7% of men were normal. In regards to waist-hip ratios, 98.7% of women and 82.0% of men were found to be normal. According to waist-to-height ratios, 68.0% of women were healthy, 59.3% of men were healthy, and 39.3% were overweight.

Table 1. The demographic characteristics and general habits of the participants

Demographic characteristics and general habits	Female (n=150)		Male (n=150)		Total (n=300)	
	(X±SD)		(X±SD)		(X±SD)	
Age (years)	22,07±1,91		23,76±3,41		22,92±2,89	
Marital status	n	%	n	%	n	%
Married	5	3,3	11	7,3	16	5,3
Single	145	96,7	139	92,7	284	94,7
Smoking						
Yes	23	15,3	62	41,3	85	28,3
No	127	84,7	88	58,7	215	71,7
Alcohol intake						
Yes	4	2,7	36	24,0	40	13,3
No	146	97,3	114	76,0	260	86,7

n: Number, X±SD: mean±standard deviation

The study examined the frequency of main meals, snack consumption, and skipped main meals among the participants. Results showed that 56.0% of the participants had two main meals, while 34.3% had three main meals. Among females, 59.4% had two main meals, and 25.3% had three main meals. Among males, 52.7% had two main meals, and 43.3% had three main meals. Regarding snacks, 44.0% of the participants had one snack, and 33.0% had two snacks. Furthermore, 64.9% of the participants skipped breakfast, while 30.7% skipped lunch.

According to the scoring of the MEDAS, the average score for females was 6.06 ± 2.38, while for males it was 6.25 ± 2.08 ($p>0.05$). In terms of adherence to the MD, 71.0% of the participants had inadequate adherence, 10.7% had acceptable adherence, and 18.3% had a high level of adherence. It was found that 72.0% of females and 70.0% of males had inadequate adherence to the Mediterranean diet.

The average MET score for females was 1426.46 ± 1371.55 MET-min/week, while for males it was 1922.01 ± 1767.34 MET-min/week ($p<0.05$). In terms of physical activity levels, 28.0% of females were classified as inactive, 64.0% as moderately active, and 8.0% as active. Among males, 29.3% were classified as inactive, 48.7% as moderately active, and 22.0% as active.

The average PSQI score for females was 7.14 ± 3.74, while for males it was 5.52 ± 4.19 ($p<0.05$). It was found that 34.0% of females had good sleep quality, while 66.0% had poor sleep quality. Among males, 55.3% had good sleep quality, while 44.7% had poor sleep quality.

The study found that the average total SAF level of the participants was similar between genders, with no significant difference observed ($p>0.05$). The SAF levels are provided in Table 2.

Table 2. Skin autofluorescence levels according to gender

SAF levels	Female (n=150)	Male (n=150)	Total (n=300)	p value
	(X±SD)	(X±SD)	(X±SD)	
SAF (AU)	1,49±0,21	1,47±0,21	1,48±0,21	0,470

Independent Samples T-Test, n: Number, X±SD: mean±standard deviation

Significant differences were found in SAF levels based on smoking status ($p<0.05$). The SAF levels of smokers ($\bar{x}$=1.60 AU) were higher than those of non-smokers ($\bar{x}$=1.43 AU). However, no significant difference was observed in SAF levels based on alcohol intake ($p>0.05$). The SAF levels based on smoking and alcohol intake status are provided in Table 3.

Table 3. Skin Autofluorescence levels based on smoking and alcohol intake

Variables	Age (AU) (X±SD)	p value
Smoking		
Yes	1,60±0,21	**<0.001**
No	1,43±0,19	
Alcohol intake		
Yes	1,50±0,18	0,550
No	1,47±0,22	

Independent Samples T-Test, X±SD: mean±standard deviation

The skin autofluorescence levels of the participants showed a significant difference according to their BMI values ($p<0.001$). The levels were highest in obese individuals ($\bar{x}=1.76$), above average in overweight individuals ($\bar{x}=1.54$), and lowest in both normal weight ($\bar{x}=1.43$) and underweight individuals ($\bar{x}=1.43$). There was no significant difference found between SAF levels and waist-hip ratio ($p>0.05$). However, there was a significant difference in SAF levels according to waist-to-height ratio ($p<0.05$). The SAF levels of individuals classified as overweight based on waist-to-height ratio ($\bar{x}=1.55$ AU) were higher than those classified as normal ($\bar{x}=1.44$ AU). The SAF levels based on anthropometric measurements are provided in Table 4.

Table 4. The skin autofluorescence levels according to the anthropometric measurements

Variables	AGE (AU)	p value
BMI[a] (kg/m²)	**(X±SD)**	
Underweight	1,43±0,17	**<0.001**
Normal	1,43±0,21	
Overweight	1,54±0,18	
Obese	1,76±0,19	
Waist-to-hip ratio[a]		
Normal	1,50±0,21	**0,063**
Risk	1,47±0,19	
Waist-to-height ratio[a]		
Underweight	1,50±0,18	
Healthy	1,44±0,22	**<0.001**
Overweight	1,55±0,19	

a: One-way analysis of variance (ANOVA) b: Independent samples t-test, X±SD: mean±standard deviation

The participants' SAF levels showed a significant difference according to their Mediterranean diet adherence ($p<0.05$). Participants with insufficient adherence to the Mediterranean diet had higher SAF levels ($x=1.50$) than those with acceptable adherence ($\bar{x}=1.41$). Additionally, participants with insufficient adherence had higher SAF levels ($x=1.50$) than those with strict adherence ($\bar{x}=1.41$). There was no significant difference found between SAF levels and physical activity levels based on IPAQ, as well as between SAF levels and sleep quality based on PSQI. Table 5 shows SAF levels according to different scales.

Table 5. Skin autofluorescence levels of the participants according to different scales

Variables	AGE (AU)	p value
	(X±SD)	
MEDAS[a]		
Insufficient adherence	1,50±0,21	**0,005**
Moderate adherence	1,41±0,18	
Strict adherence	1,41±0,20	
IPAQ[a]		
Inactive	1,52±0,23	**0,077**
Minimally Active	1,47±0,20	
Active	1,44±0,21	
PSQI[a]		
Good sleep	1,47±0,21	0,466
Poor sleep	1,48±0,21	

a: One-way analysis of variance (ANOVA) b: Independent samples t-test, X±SD: mean±standard deviation

When examining the correlation analyses, significant positive correlations were found between BMI, waist circumference, hip circumference, waist-to-height ratio, and SAF levels. Additionally, significant negative correlations were observed between adherence to the MD, physical activity levels, and SAF levels. The correlation relationships between other variables were not statistically significant ($p>0.05$). The correlation analysis between various variables and SAF levels is presented in Table 6.

Table 6. Pearson correlation coefficient (r) between skin autofluorescence and measured variables

Variables	Correlation coeffcient (r)	p value
BMI	**0.32****	**<0.001**
Waist circumference	**0.17****	**<0.001**
Hip circumference	**0.24****	**<0.001**
Waist-to-height ratio	**0.21****	**<0.001**
Waist-to-hip ratio	0,02	0,76
Meal frequency	-0,10	0,07
Snack frequency	0,05	0,41
MEDAS score	**-0.28****	**<0.001**
IPAQ score	**-0.14***	0,02
PSQI score	0,11	0,07

*<0.05; **<0.01; Pearson Correlation Analysis

This study represents a pioneering effort in establishing reference values for SAF in the young and healthy Turkish population. These reference values hold significant potential for application in various translational and clinical studies.

The average SAF values of individuals who participated in our study are lower compared to studies conducted in China, the Netherlands, and Japan[7-9]. It is uncertain whether these differences stem from demographic and/or ethnic variations among the studied groups.

The study found no significant differences in SAF levels between genders. This aligns with previous research that has also reported similar results, indicating that gender may not be a significant factor influencing SAF levels [8-10]. However, some studies have reported slight variations in SAF levels between genders, suggesting that there might be other factors associated with gender, such as skincare practices or hormonal differences, that could indirectly contribute to differences in SAF levels[11-12].

Consistent with previous research, our study found that smokers exhibited higher SAF levels compared to non-smokers, indicating a potential association between smoking status and increased accumulation of AGEs in the skin. The relationship between smoking and increased SAF levels has been consistently demonstrated in numerous studies[10-11]. Smoking contributes to the formation and accumulation of AGEs through several mechanisms. Firstly, smoking introduces exogenous AGEs into the body. Secondly, tobacco extracts and smoke

contain glycotoxins that enhance the formation of AGEs by interacting with proteins. Thirdly, smoking leads to increased oxidative stress, systemic inflammation, and endothelial dysfunction, all of which promote the formation of AGEs[12]. These mechanisms collectively contribute to the harmful effects of cigarette smoking on health.

In terms of anthropometric measures, our study revealed significant positive correlations between BMI, waist circumference, hip circumference, waist-to-height ratio, and SAF levels. These findings are in line with previous research, which consistently supports the link between adiposity measures and increased AGE accumulation reflected by higher SAF levels[11-13]. Adipose tissue, particularly in the abdominal region, is known to promote systemic inflammation, oxidative stress, and metabolic abnormalities, all of which contribute to the formation of AGEs[14].

In our study, we observed significant correlations between adherence to the MD and SAF levels. These findings are supported by other research indicating that the MD is inversely related to circulating AGE levels, particularly in populations with type 2 diabetes and older adults[15-17]. The diet's emphasis on fruits, vegetables, legumes, whole grains, nuts, and olive oil provides protective effects against AGE formation and oxidative stress [18]. Overall, adhering to a MD appears to be beneficial in reducing AGE levels and promoting better health outcomes.

Within the scope of our study, we discovered significant correlations between physical activity levels and SAF levels. Consistent with previous research, higher physical activity levels were associated with lower SAF levels, suggesting that regular physical activity may contribute to reducing AGE accumulation[17,19]. The benefits of physical activity in improving metabolism, insulin sensitivity, antioxidant defenses, and circulation likely play a role in reducing AGE formation and accumulation[20]. Incorporating regular physical activity into a healthy lifestyle can potentially contribute to maintaining health and minimizing AGE burden.

The absence of a significant correlation between PSQI and SAF levels in our study suggests that sleep quality may not directly impact the accumulation of AGEs, as reflected by SAF levels. The literature on the relationship between sleep quality and AGE accumulation reveals inconsistent findings. Some studies reported a positive association between poor sleep quality and high AGE accumulation[21], while others found no significant association[22]. These inconsistencies can be attributed to differences in study populations, methodologies

and/or other factors. Insufficient sleep time or poor sleep quality can increase oxidative stress and inflammation, potentially leading to higher AGE levels[23]. However, more research is needed to examine the relationship between sleep quality and SAF levels.

In our study, no statistically significant relationship was found between dietary habits and SAF levels. To date, limited research has been conducted to specifically investigate the potential correlation between eating frequency, meal skipping, and SAF levels. More studies are needed to explore the potential relationship between main meal frequency, snack consumption, and meal skipping, and SAF levels.

In conclusion, this study provides valuable information regarding SAF levels factors. The findings show that gender may not play a significant role in affecting SAF levels. In contrast, smoking, anthropometric measures, adherence to MD, and physical activity levels are associated with SAF levels. However, further research in larger and more diverse population samples is needed to confirm these findings and explore the underlying mechanisms.

STATEMENT OF ETHICS

The present study underwent a thorough and comprehensive ethical review by the Non-Interventional Clinical Research Ethics Committee of Istanbul Medipol University. The research protocol was granted approval, with the assigned approval number E 10840098 772.02 809, issued on 11/03/2021. This rigorous ethical review process ensured that the study design, procedures, and data collection methods met the required ethical standards and regulations. By obtaining ethical approval, the study prioritizes the protection of participants' rights, confidentiality, and overall well-being throughout the research process.

CONFLICT OF INTEREST STATEMENT

The authors of this paper declare no conflict of interest regarding its publication.

AUTHOR CONTRIBUTIONS

The authors of this paper made equal contributions to the study.

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