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BODY COMPOSITION, MUSCLE STRENGTH, DIET QUALITY AND EATING HABITS OF STUDENTS AT THE UNIVERSITY OF ZAGREB, CROATIA

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Summary

Diet quality directly influences body composition, specifically the proportions of muscle, fat, and visceral fat. Elevated levels of body fat increase the risk of chronic, non-communicable diseases such as cardiovascular disease and type 2 diabetes. The Mediterranean diet is considered a sustainable model for preventing chronic diseases. This study aimed to assess the diet quality and body composition of 38 university students (63% female; mean age 24.4 ± 1.4 years) with varying levels of formal nutritional knowledge from four different faculties (social sciences, humanities, kinesiology, and nutrition) in Zagreb, Croatia. The Mediterranean diet served as the model for optimal diet quality. Data collected from May to September 2024 included anthropometric measurements (height, body weight and composition, and circumferences), three-day food diaries (analyzed using Prehrana software and the Mediterranean Diet Quality Index (MDQI)), a short questionnaire on health and dietary habits, and dominant handgrip strength testing (using Camry EH101 and Jamar Plus dynamometers). Students were generally adequately nourished (mean BMI: 23.2 kg/m²), with moderate muscle strength (*Camry*: 32.4 kg; *Jamar*: 33.2 kg), which was significantly higher in males (43.5 kg/44.4 kg) than in females (25.9 kg/26.6 kg). Average energy intake was 1869.8 ± 559.8 kcal, with a high percentage of fat (41%), a low percentage of carbohydrates (40.5%), and low fiber intake (7.7 g/1000 kcal). MDQI scores placed all students in the moderately poor adherence category (range: 8.7 to 10), characterized by high fat and low fruit and vegetable consumption, although Nutrition students demonstrated the best diet quality. Finally, the Camry EH101 proved to be a cost-effective alternative to the *Jamar* Plus dynamometer.

Keywords: body composition, muscle strength, dietary habits, students, MDQI

Introduction

Body composition is a key determinant of overall health, disease risk, and prognosis. High levels of body fat, particularly visceral adipose tissue, are associated with a significant risk of developing chronic non-communicable diseases such as type 2 diabetes, cardiovascular diseases, and non-alcoholic fatty liver disease (Finicelli et al., 2022). These risks are modifiable primarily through proper nutrition and regular physical activity, with overall diet quality having a greater impact than the consumption of isolated components. The Mediterranean diet (MD) is a well-established healthy dietary pattern typical of countries bordering the Mediterranean basin, characterized by a high daily intake of whole grains, nuts, low-fat dairy, and olive oil as the main fat source, along with moderate consumption of fish and poultry and infrequent consumption of red meat (Finicelli et al., 2022). Regular physical activity is an essential complement to this pattern, which has been recognized by UNESCO as intangible cultural heritage (Granic et al., 2019; Trichopoulou, 2021). The MD's protective mechanisms are attributed to its richness in dietary fiber, omega-3 fatty acids, and polyphenols, which together promote improved gut microbiota composition, reduce inflammation, enhance cardiovascular health by modulating lipid profiles, and increase insulin sensitivity. Adherence to the MD specifically correlates with greater muscle mass, muscle strength, and bone mineral density, providing substantial protection against conditions such as sarcopenia and osteoporosis (Granic et al., 2019; Jennings et al., 2020; Papadopulou et al., 2023; Andreo-López et al, 2023).

While proteins are essential for cellular function and the maintenance of muscle mass, long-term excessive intake (above 1.5 g/kg body weight) may pose a risk to renal function by inducing hyperfiltration and increasing metabolic byproducts such as urea (Martin et al., 2005), although this remains an area of ongoing research (Van Elswyk et al., 2018). High-protein, low-carbohydrate diets such as the ketogenic diet, while potentially beneficial for short-term reductions in glucose and triglycerides, often lead to unfavorable increases in LDL cholesterol and nutrient deficiencies (Levran et al., 2023; Budoff et al., 2024). Anthropometric parameters such as body mass index (BMI), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), and neck-to-height ratio (NHR) are reliable indicators of metabolic syndrome and other non-communicable diseases (Vaishya et al., 2024). Additionally, muscle strength, routinely measured by a hand-held dynamometer, is a crucial marker of

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overall muscle function and a strong predictor of health outcomes, especially in the aging population (Vaishya et al., 2024; Chai et al., 2024).
Non-invasive measurement of visceral adipose tissue, the endocrinologically active fat stored around internal organs, is typically performed using bioelectrical impedance analysis (BIA) and is essential for assessing metabolic risk. Optimal body composition and the prevention of associated diseases are closely linked to lifestyle choices. The aim of this study was to assess the diet quality of the student population, their adherence to the Mediterranean diet, and their body composition. Additionally, the objective was to evaluate the muscle strength of students using two different hand-held dynamometers (the analog *Jamar* and the digital *Camry*) to determine the acceptability and validity of these devices in the young adult population.

Materials and methodology

Participants

The study population included 38 students from the University of Zagreb, specifically selected from the Faculty of Economics (EFZG), Faculty of Law (PFZG), Faculty of Kinesiology (KIF), and Faculty of Food Technology and Biotechnology (PBF), due to differences in the formal knowledge about proper nutrition they receive during their studies. Participation was voluntary, with recruitment conducted by distributing an application form electronically through various online student platforms and social media. Data collection occurred over five months, from May to September 2024. In this study, basic anthropometric data and handgrip strength were measured for each student, followed by completion of a self-administered questionnaire on dietary and lifestyle habits. Participants then received detailed instructions and maintained a three-day food diary to enable approximate evaluation of dietary intake quality and estimated adherence to the Mediterranean diet pattern.

Methods

1. Anthropometric methods
Anthropometric parameters were collected to assess body size, body composition, and the risk of developing non-communicable chronic diseases. Body height was measured using a SECA 217 mobile stadiometer, with participants standing without shoes and the head positioned in the Frankfort horizontal plane. Body mass and body composition were assessed using an OMRON BF511 diagnostic scale, which operates on the BIA principle. Participants stood barefoot on the four foot electrodes, wore light clothing without jewelry, and held the four hand electrodes at chest level. This analyzer provided data for body mass, BMI, muscle mass percentage, fat mass percentage, and visceral fat amount. Circumferences of the neck, upper arm, waist, hips, and lower leg were measured to the nearest 0.1 cm using a non-elastic measuring tape placed at the midpoint of the neck, upper arm, and lower leg, the narrowest point of the waist, and the widest part of the hips. The following ratios were then calculated to evaluate fat mass distribution: WHR, which classifies fat mass distribution as android (accumulating more fat in the abdominal area) or gynoid type (accumulating more fat in the hip area); WHtR, which indicates fat mass distribution; and NHR, which serves as an indicator of metabolic syndrome risk.

2. Dynamometry
Muscle strength was assessed in the dominant hand by measuring handgrip strength with two instruments: the analog *Jamar* and the digital *Camry* EH101 dynamometer. During data collection, participants sat in a chair with a backrest. The knees, hips, and elbow of the dominant hand were each positioned at a 90° angle. The dynamometer handle size was individually adjusted for each student as needed. Measurements with each dynamometer were performed in three consecutive attempts, separated by equal time intervals. The final strength value was calculated as the arithmetic mean of the three recorded measurements.

3. Dietary methods
On the day of anthropometric and muscle strength assessment, participants completed a brief 15-item questionnaire to collect comprehensive information about their dietary and lifestyle habits. The questionnaire included questions on the presence of chronic diseases and current medication use, lifestyle habits (smoking, weekly alcohol consumption, and daily coffee consumption), use of dietary supplements (vitamin/mineral supplements, meal replacements, energy/protein bars, and protein blends), consumption of protein-enriched foods, adherence to special dietary regimens, and the frequency of daily meal consumption (breakfast, lunch, snack, and dinner), rated from “never” to “seven times per week.”
To examine dietary habits and quality in more detail, participants maintained a three-day food diary on three non-consecutive days (two weekdays and one weekend day). To ensure accuracy, participants received detailed instructions. All consumed food and drink quantities were determined either by weighing with a kitchen scale or by estimation using standard kitchen utensils (e.g., spoon, teaspoon, glass, cup). For portioned

packaged products, information was taken directly from the label declarations. For all complex dishes, participants provided detailed recipes, and standard recipes were used when specific preparation instructions were unavailable. Consumed foods and drinks were entered into the *Prehrana* software (Infosistem d.d., Zagreb), which is based on national food composition tables (Kaić-Rak and Antonić, 1991). To assess adherence to the Mediterranean dietary pattern, the MDQI was calculated for each participant. The MDQI includes seven components: fruit and vegetables (g), cereals and products (g), fish (g), meat (g), olive oil (mL), cholesterol (mg), and saturated fatty acids (% kJ). Each component was scored 0, 1, or 2 points based on compliance with dietary guidelines (scoring method detailed in Table 1). The total MDQI score, ranging from 0 to 14 points, was obtained by summing the scores of the seven components (Bach et al., 2006). A lower total score indicates better dietary quality. Nutrition quality was classified into four categories: good nutrition (0–4 points), medium-good nutrition (5–7 points), medium-poor nutrition (8–10 points), and poor nutrition quality (11–14 points).

Table 1. MDQI scoring method (*according to* Bach et al., 2006)

Parameters of MDQI	Number of points		
	0	**1**	**2**
fruits and vegetables (g)	> 700	700 - 400	< 400
cereals and products (g)	> 300	300 - 100	< 100
fish (g)	> 60	60 - 30	< 30
meat (g)	< 25	25 - 125	> 125
olive oil (mL)	> 15	15 - 5	< 5
cholesterol (mg)	< 300	300 - 400	> 400
saturated fatty acids (% kJ)	< 10	10 - 13	> 13

Results and discussion

General participants' information

A total of 38 students (N = 38), aged 20 to 28 years (mean 24.4 ± 1.4 years), participated in this study. The mean age by faculty was 25.1 years for EFZG students, 24.1 years for PFZG and KIF students, and 24 years for PBF students. Regarding health status, only one individual reported an autoimmune disease. Additionally, six participants were using hormonal therapy, and one participant was using antidepressant medication at the time of data collection. The majority of participants, specifically 42%, reported living with their parents, while 13% lived in an apartment with roommates. Students living with their parents were more likely to consume home-prepared food compared to those living alone, with roommates, or in student dormitories. Regular physical activity was defined as engaging in organized training, gym, or home exercise at least once per week. Overall, 63% of participants reported being regularly physically active, while 37% were not regularly active. EFZG students had the lowest rate of regular physical activity, with only 37.5% regularly active. Only 40% of PFZG students reported regular physical activity. In contrast, 70% of PBF students were regularly physically active. As expected, all KIF students reported being regularly physically active. These results are consistent with findings from student populations internationally, where physical activity prevalence commonly ranges from approximately 55% to 65%, (Chaabana et al., 2022; Alhammad et al., 2023), and are also comparable to Croatian data showing that around 70% of university students meet recommended physical activity guidelines (Pedišić et al., 2014).

Body composition

The analysis of basic anthropometric parameters (Table 2) revealed that all students' groups were within the normal range for body mass index (BMI).

Table 2. Average anthropometric parameters of the study population

Anthropometric parameter	Faculty name*			
	EFZG	**PFZG**	**KIF**	**PBF**
Average body mass (kg)	72.86	68.82	67.53	63.9
Average body height (cm)	174.1	169.4	172.3	166.9
Average BMI (kg/m^2)	23.75	23.80	22.57	22.67

**EFZG – UNIZG Faculty of Economics; PFZG – UNIZG Faculty of Law; KIF – UNIZG Faculty of Kinesiology; PBF – UNIZG Faculty of Food Technology and Biotechnology*

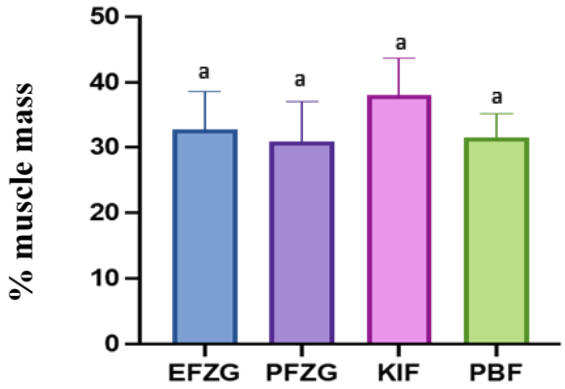

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Figure 1. Average proportion of muscle mass (%) in the studied population

EFZG students had the highest average body mass (72.86 kg) and height (174.1 cm), while PBF students reported the lowest values (63.9 kg and 166.9 cm). However, BMI is a primary indicator of body composition. The highest average BMI was observed in PFZG students (23.80 kg/m²), while the lowest was recorded in KIF students, despite the expectation that a group with a majority of male participants would have a higher BMI. Similar BMI results were found in an earlier study of Croatian students, where the average BMI was 23.19 ± 3.59 kg/m² (Štefan et al., 2017). Although the group BMI averages were adequate, 11 of the 38 participants had BMI values above 24.9 kg/m², placing them in the overweight category. A more accurate representation of body composition is provided by the proportions of muscle and fat mass, as well as NHR, WHR, and WHtR ratios.

Fig. 1. shows the results of the average proportion of the muscle mass expressed in percentages (%).

As expected, KIF students had the highest average muscle mass proportion at 38.01 ± 5.31%, classifying this group as having a very high amount of muscle mass. In contrast, PFZG students had the lowest average muscle mass proportion at 30.97 ± 5.79%. PBF and EFZG students had intermediate values of 31.60 ± 3.39% and 32.75 ± 5.38%, respectively. The average muscle mass in previous research conducted by Štefan et al. (2017) was similar to that obtained in this study, at 32.12 ± 6.07%. The lower muscle mass in the PBF student group is likely due to the high proportion of female students, who generally have lower relative muscle mass compared to men.

Analysis of average fat mass proportions using the Kruskal-Wallis test showed a statistically significant difference among the four participant groups (Fig. 2). PFZG students had the highest average fat mass proportion at 29.44 ± 8.06%. Within this group, male participants had an average body fat mass of 22.4%, while females had 32.46%. EFZG students followed with an average of 27.26 ± 8.41%, with males at 25%—classified as having a very high body fat percentage – and females at 28.62%. A similar result was observed for male PBF participants, who also fell into the very high body fat percentage group with an average of 25.95%, while female participants in this group maintained an adequate average body fat percentage (27.62 ± 3.75%). In contrast, KIF students had the lowest average body fat percentage at 19.32 ± 5.42%, which aligns with adequate values for both sexes. Previous research found that the average percentage of body fat in students is around 27.86 ± 7.90% (Štefan et al., 2017), which is higher than the average of the surveyed population.

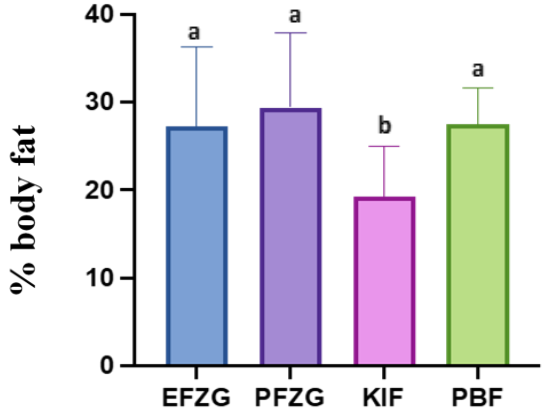

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Figure 2. Body fat percentage (%) in the studied population

Visceral fat values between 0 and 9 are classified as normal. The highest average visceral fat level was observed in PFZG students, with a mean of 5.2 ± 3.63; two students exceeded the normal range, increasing their risk of chronic non-communicable diseases. A similar average was found among PFZG students (5.1 ± 3.18), with one participant showing an elevated level. In contrast, the average visceral fat levels for KIF and PBF students were 4.3 ± 1.73 and 4.4 ± 2.37, respectively, with all individuals maintaining values within the normal range. Because measurements relied on the OMRON BF511 body composition analyzer and could not be standardized (ideally taken in the morning, before eating, and after voiding), most measurements were conducted in the afternoon due to students' obligations, which may have introduced variability compared to actual results.

A one-way ANOVA test indicated that there was no statistically significant difference between the four groups of participants for the measured circumference parameters (neck, upper arm, waist, hip, and lower leg), and the results are shown in Table 3.

Table 3. Results of circumference measurements in the studied population

Parameters	Faculty name*			
	EFZG	PFZG	KIF	PBF
Neck circumference (cm)	33.8	33.73	35.29	32.43
Upper arm circumference (cm)	29.39	28.31	29.18	28.22
Waist circumference (cm)	77.36	74.84	74.26	70.02
Hip circumference (cm)	102.30	99.06	96.36	97.01
Lower leg circumference (cm)	37.83	36.61	36.47	35.91

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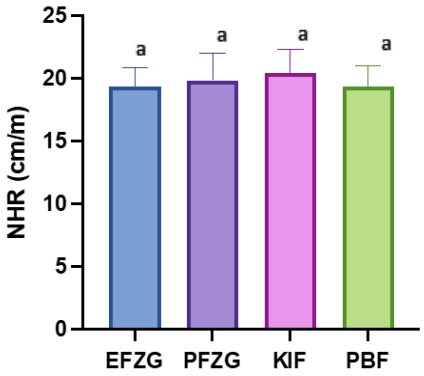

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Figure 3. NHR values in the studied population

The NHR (Fig. 3), an indicator of metabolic syndrome risk (Selvan et al., 2016) calculated by relating neck circumference (cm) to body height (m), also showed no statistically significant difference among the four groups according to ANOVA. The KIF students had the highest average NHR value (20.45 ± 1.76 cm/m), likely due to the majority of male participants in this group. The PBF and EFZG students had nearly identical average NHR values (19.37 ± 1.53 cm/m and 19.37 ± 1.34 cm/m), while the PFZG students averaged 19.88 ± 2.05 cm/m. Eleven participants (nine men and two women) had elevated NHR values indicating a significant risk of metabolic syndrome (Selvan et al., 2016). Compared to the World Health Organization guidelines (≤ 0.85 for women and ≤ 0.90 for men), the WHR analysis revealed no statistically significant difference among the four groups. All students were within the established non-risk category (WHO, 2011), with the lowest average WHR observed among PBF students. Similarly, no significant intergroup difference was found for the WHtR. Despite the group averages, four students had WHtR values above 0.5, indicating an elevated risk for chronic non-communicable diseases (Fig. 4).

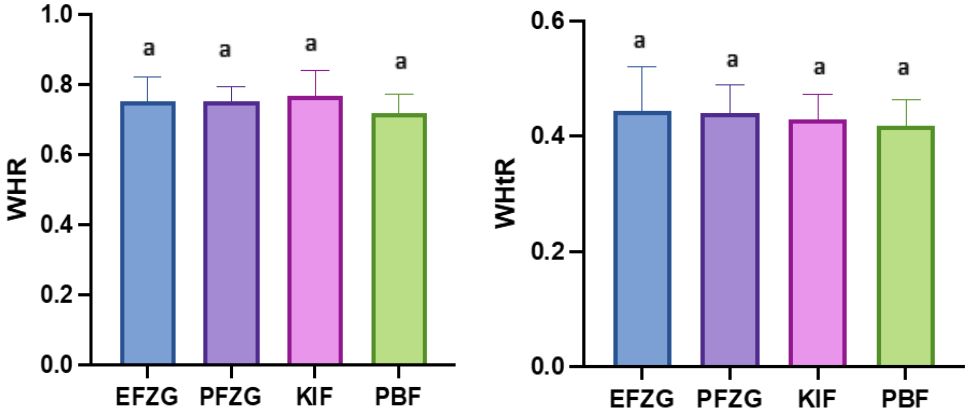

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Figure 4. WHR and WHtR values in the studied population

Muscle strength

Muscle strength was measured on the dominant hand using two devices: the analog Jamar and the digital Camry hand-held dynamometers (Table 4). The average of three consecutive measurements from each device was used for data analysis. The primary goal was to compare the measurements between the two devices and assess their consistency in measuring handgrip strength among young adults.

A one-way ANOVA test revealed a statistically significant difference in handgrip strength among the four groups. As expected, due to a higher physical activity rate, KIF students showed the highest average handgrip strength on both devices, while PFZG students recorded the lowest averages.

To compare the consistency of the *Jamar* and *Camry* dynamometers, participants were divided into two groups based on assumed physical activity levels: Group 1 (higher activity) included KIF and PBF students (Fig. 5), and Group 2 (lower activity) included PFZG and EFZG students (Fig. 6). In Group 2, the average strength was 29.29 ± 9.13 kg (*Jamar*) and 25.50 ± 9.72 kg (*Camry*). In Group 1, the average strength was 36.73 ± 12.53 kg (*Jamar*) and 35.00 ± 11.55 kg (*Camry*). In both groups, the results did not indicate a statistically significant difference between the handgrip strength measurements taken with the *Jamar* and *Camry* dynamometers, indicating that both devices have comparable precision when used to assess handgrip strength in the young adult population. In the study by Lupton-Smith et al. (2022) involving adults, two identical measuring devices were compared, and the results were consistent with those of this study. Additionally, the study found that the digital *Camry* device had good reproducibility compared to the analog *Jamar* (Lupton-Smith et al., 2022).

Table 4. Muscle strength in the studied population

Hand-held dynamometers	Faculty name*			
	EFZG	PFZG	KIF	PBF
***Camry* (kg)**	27,72	30,93	40,68	29,32
***Jamar* (kg)**	26,35	31,63	42,23	31,22

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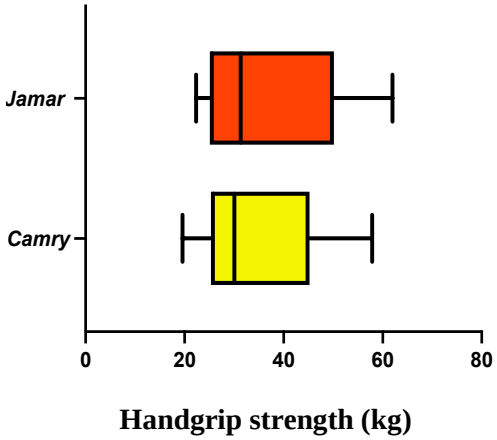

Figure 5. Handgrip strength in Group 1

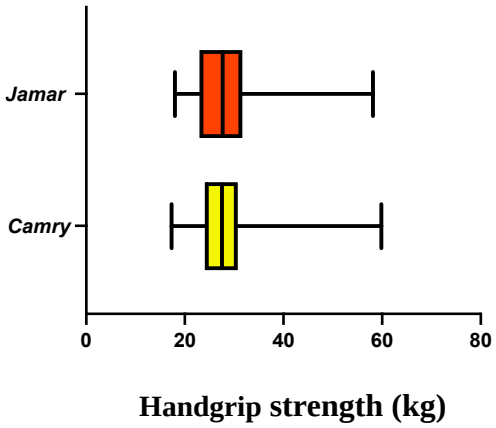

Figure 6. Handgrip strength in Group 2

Dietary quality

The quality of the participants' diets was evaluated by analyzing three-day food diaries. Using the *Prehrana* software, the average individual intakes of energy, macronutrients, and micronutrients were determined. To provide a more accurate representation of daily consumption, the average daily intake was calculated relative to the participants' average body mass (TM). KIF students recorded the highest energy intake per kilogram of body mass (29.62 kcal/kgTM), followed by PFZG students (28.52 kcal/kgTM), PBF students (25.94 kcal/kgTM), and EFZG students (25.67 kcal/kgTM), who consumed the least energy. he average intake of macronutrients (carbohydrates, fat, and protein) is shown in Table 5. While PBF students had the highest proportion of carbohydrates in total energy intake and KIF students had the lowest, no group met the recommended DRV for total carbohydrates or dietary fiber (25 g/day; EFSA, 2019).

Table 5. Average macronutrients intake in the studied population

Faculty name	Carbohydrates (% total energy intake)	Fat (% total energy intake)	Proteins (g/kgTM)
EFZG	37.95	43.28	1.05
PFZG	37.66	43.32	1.39
KIF	37.03	44.78	1.42
PBF	41.77	39.08	1.24
Average	38.60	42.62	1.28

**EFZG – UNIZG Faculty of Economics; PFZG – UNIZG Faculty of Law; KIF – UNIZG Faculty of Kinesiology; PBF – UNIZG Faculty of Food Technology and Biotechnology*

The compliance of the participants' diets with the Mediterranean dietary pattern was evaluated using the MDQI calculated from the three-day food diaries. An average MDQI score was determined for each student based on the daily values recorded. The MDQI scores, compared across the four groups (Fig. 7), classified nutritional quality into four categories: optimal (0 to 4 points), moderately good (5 to 7 points), moderately poor (8 to 10 points), and undesirable (11 to 14 points). The MDQI scores for all four groups indicated that their dietary compliance fell within the moderately poor category. The results are similar to those of Štefan et al. (2017), where low adherence to the Mediterranean diet was observed among young adults.

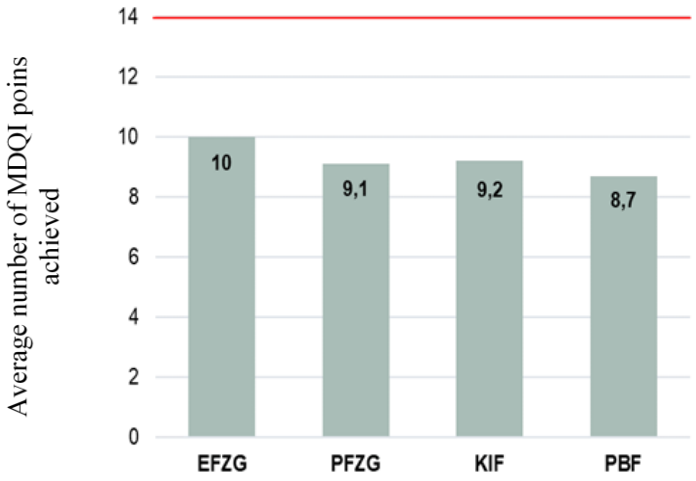

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Figure 7. MDQI scores compared among the four groups in the studied population

Conclusion

University students' health habits vary significantly by field of study, with those in science, biotechnology, and kinesiology showing more favorable trends in physical activity, body composition, muscle strength, and diet quality than students in social sciences and humanities. Additionally, both *Camry* and *Jamar* dynamometers provide equally valid results for assessing handgrip strength in young adults.

Limitations of this study include the relatively small sample size and self-reported dietary records, which may introduce reporting bias. Future studies should use larger cohorts and objective biomarkers of nutrient intake.

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