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Assessment of dietary heme and non-heme iron intake among pharmacy student population

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Abstract

Iron deficiency is one of the most common nutrient deficiencies worldwide and the leading cause of anemia. Students, particularly females, are especially susceptible to anemia due to irregular diets, inadequate eating habits, and the demands of high physical and mental activity. Low iron levels can negatively impact the intellectual and cognitive abilities of students and jeopardize their overall health. Therefore, it is crucial to meet daily iron requirements primarily through diet. Due to a lack of information about students' lifestyles in Serbia, this study examined variations in iron intake among students focusing on differences by gender and year of study. Seventy students from the Faculty of Pharmacy, University of Belgrade participated in this cross-sectional study by completing an electronic structured questionnaire. The majority of participants were: female (81.4%), students of final year (61.5%), current non-smokers (91.4%), and engaged in physical activity 2 to 3 times per week (52.8%). We found that female students had an average total of 16.2±8.7 mg/day, which is below the recommended intake of 18 mg/day. Only 33.3% of female students met their daily iron requirements through food. In contrast, 69.3% of male students fulfilled their daily requirement of 8 mg/day from food, with an average total iron intake of 13.6±6.3 mg/day. Interestingly, female students consumed significantly more iron from cereals (p = 0.027) and fats (p = 0.035), which contain a non-heme form of iron that has lower bioavailability. This highlights the importance of educating students about the various forms of dietary iron and the factors influencing its absorption. Enhanced knowledge in this area can empower students to adopt healthier eating habits and effectively meet their iron intake needs.

Key words: *iron; students; deficiency; nutrition; dietary sources of iron.*

INTRODUCTION

Iron is the fourth most abundant element in the earth's crust [1]. Despite this fact, iron deficiency is one of the most common growth-limiting factors in the living world. This problem is most likely caused by its high reactivity with oxygen, which converts iron into insoluble oxide forms unavailable for resorption by organisms. Iron is a vital trace element for almost all organisms [2]. It is involved in a variety of metabolic processes, including oxygen transport and utilization by hemoglobin, synthesis, and repair of DNA molecules, cell proliferation, electron transport as part of energy production, immune function, and pathogen destruction, production of enzymes essential for the formation of new cells, amino acids, hormones, and neurotransmitters [3,4]. It is important to maintain adequate iron levels to support the body's diverse requirements. However, levels of iron in body tissues must be strictly regulated, as an excessive amount can lead to tissue damage due to free radicals formation [5,6]. Homeostasis of iron levels is primarily maintained by regulating gastrointestinal absorption in the duodenum and proximal jejunum. In contrast to most nutrients, iron excretion in the human organism is minimal and unregulated [7]. The main sources of dietary iron are foods such as meat, fish, egg yolks, beans, grains, dark green vegetables, and nuts. Heme iron is found dominantly in food of animal origin, especially meat products, while non-heme iron is present both in plant and animal foods. There is also ferritin iron which can be mainly found in liver and legumes [3]. Dietary iron is absorbed from the intestinal lumen by the divalent metal transporter 1 (DMT1), a transport protein of the enterocyte membrane responsible for iron absorption. This protein can only transport ferrous iron (Fe^{2+}), whereas the inorganic insoluble ferric form (Fe^{3+}) must be reduced before absorption. Heme iron, with the Fe^{2+} ion chelated into a complex with organic compounds, has a high bioavailability and is absorbed at a rate of approximately 25–30%. In contrast, the bioavailability of non-heme iron, which depends on various nutritional and physiological factors, is significantly lower and more variable, ranging from 2% to 20%. This disparity brings out the importance of understanding dietary sources and factors influencing iron absorption to effectively address potential deficiencies [8]. Many components of food can influence the bioavailability of iron, either enhancing or hindering its absorption. Iron-rich foods are often consumed as part of composite meals, which may include factors that promote iron absorption, such as ascorbic acid and muscle tissue. Additionally, certain prebiotics, probiotics, and symbiotics can also aid in the absorption of iron. Conversely, substances like phytic acid, tannins, polyphenols, peptides from partially digested proteins, or high levels of calcium can significantly reduce iron absorption. Inadequate dietary intake of bioavailable iron can lead to iron deficiency [9]. Iron deficiency is the most common nutritional cause of anemia, a condition characterized by a reduced number of red blood cells or hemoglobin concentration. Anemia particularly affects young children, women of reproductive age, and pregnant and postpartum women [3,10]. Anemia is a significant global public health issue. The World Health Organization (WHO) estimates that 40% of children aged 6–59 months, 37% of pregnant women, and 30% of women aged 15–49 years worldwide are anemic [9]. The most prominent symptoms of anemia are fatigue, weakness, and reduced ability to work. Additionally, behavioral disturbances and impaired performance on cognitive tasks can occur [11]. Iron deficiency can lead to changes in neurotransmitter balance and synaptogenesis, which can affect normal brain function [12]. Some studies indicate that insufficient iron intake may be linked to reduced intellectual and cognitive performance, particularly among female university students [11]. The student population is particularly vulnerable to iron deficiency due to the intense academic demands and increased mental activity associated with their studies [11]. Furthermore, adolescence often involves significant lifestyle changes, such as moving away from home for education, which can disrupt dietary habits. Research on the dietary patterns of adolescents shows a predominant trend towards imbalanced nutrition, characterized by excessive fast food consumption, irregular meal schedules, and a high prevalence of meal skipping, especially breakfast and school-provided lunches [13]. Female students are especially at risk for iron deficiency due to a combination of inadequate dietary iron intake and higher iron losses during menstruation [14,15]. The Recommended Dietary Allowance (RDA) for iron specifies the average nutritional intake necessary to meet the dietary requirements of specific population groups, based on age and gender [16]. According to these values, the recommended daily intake of iron is 18 mg for females aged 19 to 50 years and 8 mg for males in the same age group. To successfully meet the academic demands and goals during studies without compromising their health, it is essential for students to maintain their iron status within the mentioned reference values. Therefore, this study aimed to investigate the dietary patterns and iron intake from various dietary sources among pharmacy students to determine whether their daily iron intake meets the recommended requirements for maintaining optimal iron levels.

MATERIAL AND METHODS

This study was carried out at the Department of Bromatology, University of Belgrade - Faculty of Pharmacy. The study involved 70 students from the Faculty of Pharmacy, including all five studying years, with age ranging from 18 to 30 years. They all were asked to fulfill previously validated IRON Intake Calculation–Food Frequency Questionnaire (IRONIC-FFQ) [17]. Participation in this study was voluntary. The students were chosen by random selection. Each questionnaire had its identification number, from 1 to 70. All questionnaires were distributed, fully completed, and entered into a statistical analysis. The data has been collected in the 2023/2024 school year during autumn semester.

A structured questionnaire was used to assess eating habits and estimate the average intake of iron-rich food products. Iron intake was calculated by summing the contributions of individual food items based on their iron content, as provided in standard food composition tables [18]. Reported weekly consumption frequencies for each food item were converted into daily intake values by dividing the total weekly intake by seven. This method allowed a more accurate estimation of daily iron intake that reflects typical dietary habits.

Additionally, the iron intake was calculated for selected groups of food products including meat products, fish, eggs, dairy products, cereals, fruits, legumes, vegetables, potatoes, fat, nuts, cocoa, and chocolate products. Also, iron derived from animal food products and iron from plant-based food was determined. The calculation of heme and non-heme iron intake was performed based on the assumption that 40% of the total iron from animal-based food products is in the form of heme iron, while the remaining 60% is non-heme iron. For plant-based food products, 100% of the iron content was considered non-heme iron [18].

The total iron intake, heme iron intake, non-heme iron intake, and iron intake from the selected groups of food products were compared between sub-groups stratified by gender, age, year of study, and usage of iron supplementation. Also, correlation between measured values of iron intake and lifestyle habits was explored. Calculated total iron intake was finally compared with the RDA set by the Institute of Medicine [16]. Body mass index (BMI) was calculated using the Quetelet equation (weight (kg)/height^2 (m^2)) based on self-reported height and weight and classified using the WHO system of BMI classification [19]. Usage of iron supplementation was assessed according to self-reported statements about use of oral iron supplementation or medication, including usage of multivitamins or single- or multi-mineral or any other kind of iron-containing supplements.

All analyses were conducted using IBM SPSS v23.0 statistical software. Analysis of variance was conducted using ANOVA followed by Bonferroni post hoc test to compare sub-groups. All results were presented as average values with standard deviation. Correlation was calculated using the Pearson correlation coefficient. The level of statistical significance between variables was defined based on criterion $p \leq 0.05$ [20].

RESULTS

Table 1 shows the basic information on gender, age, year of study, and BMI distribution in the group of students. As expected, females were in the majority (81.4%) in the studied group. Age range was divided into three sub-groups; the youngest group involved participants from 18 to 22 years old, the middle from 23 to 26, and the oldest group included students from 27 to 30 years old. All three age sub-groups were represented in similar numbers; most of them were students in the final year of study (61.4%). Dividing body mass by height squared revealed that most students (84.2%) had a BMI within the normal range (18.5-25). Table 1 also presents the lifestyle habits of the studied group of students, including smoking, alcohol consumption, physical activity, and iron supplementation. The majority of students (67%) reported engaging in some form of physical activity, while a significant proportion were non-smokers (91.4%). Alcohol consumption was predominantly low, with 75.7% of students consuming alcoholic beverages less than once per week. Iron supplementation was reported by only 18.6% of the students.

Table 1. Demographic and lifestyle characteristics of participants.

Participants		Female (n=57)	Male (n=13)
Age, *n* (%)	18-22	18 (25,7%)	4 (5.7%)
	23-26	18 (25,7%)	5 (7.1%)
	27-30	21 (30%)	4 (5.7%)
Year of study, *n* (%)	1	8 (11.4%)	0 (0%)
	2	2 (2.8%)	0 (0%)
	3	2 (2.8%)	1 (1.4%)
	4	11 (15.7)	3 (4.3%)
	5	34 (48.6%)	9 (12.9%)
BMI, *n* (%)	Underweight <18.5	2 (2.8%)	0 (0%)
	Normal (18.5-24.9)	49 (70%)	10 (14.3%)
	Overweight (25-29.9)	6 (8.6%)	3 (4.3%)
Physical activity, *n* (%)	No training	19 (27.3%)	4 (5.7%)
	2-3 trainings weekly	29 (41.4%)	8 (11.4%)
	>3 trainings weekly	9 (12.8%)	1 (1.4%)
Smoking status, *n* (%)	Smoker	4 (5.7%)	2 (2.8%)
	Non-smoker	53 (75.7%)	11 (15.7%)
Alcohol consumption, *n* (%)	Never	23 (32.9%)	5 (7.1%)
	Occasionally (<once weekly)	22 (31.4%)	3 (4.3%)
	Once weekly	9 (12.8%)	4 (5.7%)
	Frequently (>once weekly)	3 (4.3%)	1 (1.4%)
Iron supplementation, *n* (%)	Yes	10 (14.3%)	3 (4.3%)
	No	47 (67.1%)	10 (14.3%)

The total daily iron intake, the intake of different forms of iron (heme and non-heme), and iron from animal and plant foods in both genders are shown in **Table 2**. It was stated that there were no differences in total iron intake ($p = 0.306$), heme iron ($p = 0.843$), non-heme iron ($p = 0.211$), animal iron ($p = 0.846$), and plant iron

Table 2. Daily iron intake by form and nutritional source across gender sub-groups.

		Female	Male	*p* value
Intake of different forms of iron (mg/day)	Total iron	16.2±8.7 (100%)	13.6±6.3 (100%)	0.306
	Heme iron	2.3±1.7 (14%)	2.6±1.4 (16%)	0.843
	Non-heme iron	13.9±7.7 (86%)	11.4±5.1 (84%)	0.211
	Animal iron	5.7±4.3 (35%)	6.4±3.5 (47%)	0.846
	Plant iron	10.5±6.9 (65%)	7.2±3.7 (53%)	0.235
Different sources of iron (mg/day)	Meat products	4.7±4.1 (28.7%)	4.6±3.4 (33.7%)	0.950
	Fish	0.3±0.3 (2%)	0.3±0.2 (2.2%)	0.799
	Eggs	0.7±0.5 (4.2%)	0.5±0.1 (3.9%)	0.265
	Dairy products	0.3±0.1 (1.8%)	0.2±0.1 (1.8%)	0.439
	Cereals	2.8±2.7 (17.2%)	1.0±1.0 (7.7%)	0.027
	Fruits	0.7±0.6 (4.6%)	0.9±0.7 (7.0%)	0.297
	Legumes	3.2±3.2 (19.7%)	2.9±1.8 (21.2%)	0.736
	Vegetables	0.8±0.5 (5%)	0.5±0.2 (4.0%)	0.066
	Potatoes	0.3±0.2 (1.7%)	0.3±0.2 (2.1%)	0.870
	Fat	0.10±0.09 (0.6%)	0.05±0.04 (0.4%)	0.035
	Nuts	1.4±1.5 (8.7%)	1.6±2.1 (11.6%)	0.749
	Cocoa	0.4±0.4 (2.1%)	0.3±0.3 (2.0%)	0.599
	Chocolate	0.6±0.5 (3.4%)	0.3±0.2 (2.3%)	0.098

Statistically significant difference ($p \leq 0.05$).

intake ($p = 0.235$) between male and female gender. Furthermore, the intake of iron from meat, fish, eggs, dairy products, fruits, legumes, vegetables, potatoes, nuts, and cocoa products did not differ significantly between the gender sub-groups. However, daily iron intake from cereals ($p = 0.027$) and fats ($p = 0.035$) was significantly higher among females.

Table 3. Daily iron intake by form and nutritional source across age sub-groups.

		18-22 (n=22)	23-26 (n=23)	27-30 (n=25)	*p* value
Intake of different forms of iron (mg/day)	Total iron	16.4±7.6	14.1±7.7	16.3±9.6	0.521
	Heme iron	2.6±1.8	2.1±1.7	2.1±1.5	0.532
	Non-heme iron	13.8±6.3	12.0±6.1	14.5±9.1	0.432
	Animal iron	6.5±4.5	5.2±4.3	5.2±3.8	0.533
	Plant iron	9.7±5.0	8.6±4.0	11.1±8.9	0.396
Different sources of iron (mg/day)	Meat products	5.5±4.2	4.3±4.0	4.1±3.7	0.448
	Fish	0.3±0.3	0.3±0.3	0.3±0.3	0.844
	Eggs	0.6±0.4	0.6±0.4	0.7±0.5	0.500
	Dairy products	0.3±0.1	0.3±0.1	0.3±0.1	0.902
	Cereals	2.1±2.8	2.0±1.3	3.2±3.2	0.222
	Fruits	0.9±0.7	0.8±0.6	0.7±0.5	0.286
	Legumes	3.3±1.8	2.7±2.1	3.4±4.3	0.752
	Vegetables	0.7±0.4	0.6±0.4	1.0±0.7	0.071
	Potatoes	0.3±0.2	0.2±0.1	0.3±0.2	0.567
	Fat	0.1±0.1	0.1±0.1	0.1±0.1	0.234
	Nuts	1.3±1.5	1.4±1.6	1.6±1.6	0.773
	Cocoa	0.4±0.4	0.2±0.2	0.4±0.5	0.157
	Chocolate	0.5±0.6	0.5±0.4	0.6±0.5	0.784

Statistically significant difference ($p \leq 0.05$).

Table 3 shows the distribution of daily iron intake, considering both total iron and different forms of iron from selected dietary sources across all three age sub-groups. Apparently, iron intake is similar across all age stages.

However, when daily iron intake was compared considering different years of study there were some notable differences. Results showed significant differences according to the year of the study in heme iron intake ($p = 0.023$) and animal-origin iron ($p = 0.023$). Also, iron intake from fruit had reached statistically significant difference ($p = 0.004$). The post hoc analysis revealed a significant difference in the intake of heme iron ($p = 0.050$) and iron of animal origin ($p = 0.050$) between the 1st and 2nd years of study, whereby higher intake was observed among 2nd-year students. Iron from fruit sources was significantly higher in 2nd year compared to 1st year ($p = 0.011$) and the 5th year of the studies ($p = 0.042$).

Table 4. Daily iron intake by form and nutritional source across the year of study sub-groups.

		1st year of study	2nd year of study	3rd year of study	4th year of study	5th year of study	*p* value
Intake of different forms of iron (mg/day)	Total iron	12.7±7.0	23.9±0.1	19.5±6.1	17.3±8.8	15.1±8.6	0.371
	Heme iron	1.5±0.3*	5.1±0.4*	3.4±3.1	2.7±2.1	2.0±1.4	0.023
	Non-heme iron	11.2±6.9	18.8±0.3	16.1±3.1	14.6±7.0	13.1±7.9	0.782
	Animal iron	3.7±0.8*	12.8±1.1*	8.5±7.7	6.8±5.3	5.0±3.6	0.023
	Plant iron	8.7±6.8	10.8±1.0	10.8±1.8	10.2±4.7	9.8±6.4	0.981
Different sources of iron (mg/day)	Meat products	3.0±0.6	11.3±1.6	7.5±6.9	5.8±4.9	4.1±3.4	0.060
	Fish	0.3±0.3	0.3±0.1	0.4±0.3	0.3±0.3	0.3±0.3	0.987
	Eggs	0.4±0.4	1.1±0.4	0.6±0.5	0.7±0.4	0.7±0.4	0.263
	Dairy products	0.3±0.1	0.3±0.1	0.1±0.1	0.3±0.1	0.3±0.2	0.575
	Cereals	3.9±4.4	0.2±0.2	1.6±2.6	2.1±1.6	2.5±2.6	0.321
	Fruits	0.4±0.2*	1.9±0.4*†	1.4±0.7	1.0±0.7	0.7±0.6†	0.004
	Legumes	1.6±0.4	5.8±1.4	3.6±1.5	3.3±2.0	3.2±3.5	0.418
	Vegetables	0.6±0.4	1.1 ±0.2	0.6±0.3	0.7±0.3	0.8±0.6	0.654
	Potatoes	0.3±0.2	0.4±0.1	0.3±0.1	0.3±0.2	0.3±0.2	0.836
	Fat	0.16±0.17	0.11±0.08	0.08±0.07	0.08±0.05	0.08±0.07	0.176
	Nuts	0.8±0.9	0.4±0.6	2.6±2.0	1.9±1.6	1.4±1.6	0.330
	Cocoa	0.3±0.3	0.4±0.2	0.3±0.3	0.4±0.3	0.3±0.4	0.989
	Chocolate	0.5±0.5	0.3±0.0	0.4±0.2	0.5±0.6	0.5±0.5	0.952

**statistically significant differences ($p \le 0.05$) according to Bonferroni post hoc test between 1st and 2nd year of study, † statistically significant differences ($p \le 0.05$) according to Bonferroni post hoc test between 2nd and 5th year of study.*

The study also examined iron supplementation among students. Comparing total and dietary iron intake across food groups revealed no significant differences between those who used supplements and those who did not (**Table 5**).

When evaluating daily iron intake in relation to the RDA, a notable gender difference is observed. Among females, only 33.3% had a daily iron intake exceeding the RDA of 18 mg/day, despite a relatively higher number of individuals with moderately elevated iron intake (**Figure 1**). In contrast, 69.3% of males reported iron intake levels above the RDA of 8 mg/day (**Figure 2**).

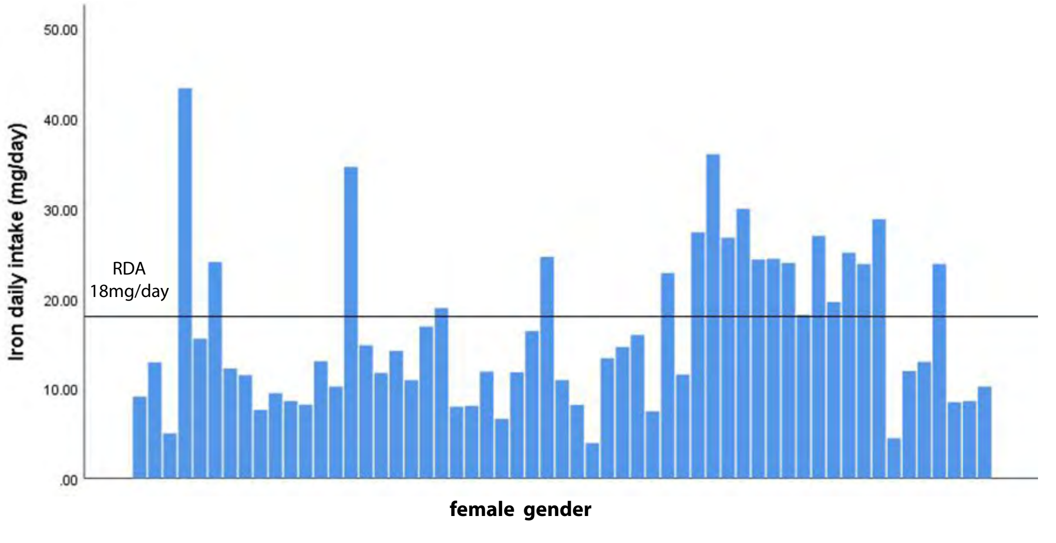

Figure 1. Daily iron intake in female responders compared to the recommended dietary allowance (RDA).

Table 5. Daily iron intake by form and dietary sources across iron supplementation sub-groups.

		Iron supple-mentation	Without iron supplementa-tion	*p* value
Intake of different forms of iron (mg/day)	Total iron	14.1±5.4	16.1±8.9	0.444
	Heme iron	1.7±1.4	2.4±1.7	0.160
	Non-heme iron	12.5±4.5	13.7±7.9	0.569
	Animal iron	4.1±3.5	6.0±4.3	0.160
	Plant iron	9.7±3.7	9.7±6.9	0.925
Different sources of iron (mg/day)	Meat products	3.1±3.3	5.0±4.0	0.134
	Fish	0.3±0.2	0.3±0.3	0.611
	Eggs	0.7±0.5	0.6±0.4	0.681
	Dairy products	0.3±0.1	0.3±0.1	0.579
	Cereals	2.9±2.8	2.4±2.6	0.484
	Fruits	0.8±0.6	0.8±0.6	0.989
	Legumes	2.7±1.7	3.2±3.2	0.560
	Vegetables	0.8±0.4	0.8±0.5	0.797
	Potatoes	0.2±0.2	0.3±0.2	0.146
	Fat	0.1±0.1	0.1±0.1	0.363
	Nuts	1.5±1.1	1.4±1.7	0.812
	Cocoa	0.2±0.3	0.4±0.4	0.115
	Chocolate	0.5±0.5	0.5±0.5	0.666

Statistically significant difference (p ≤ 0.05).

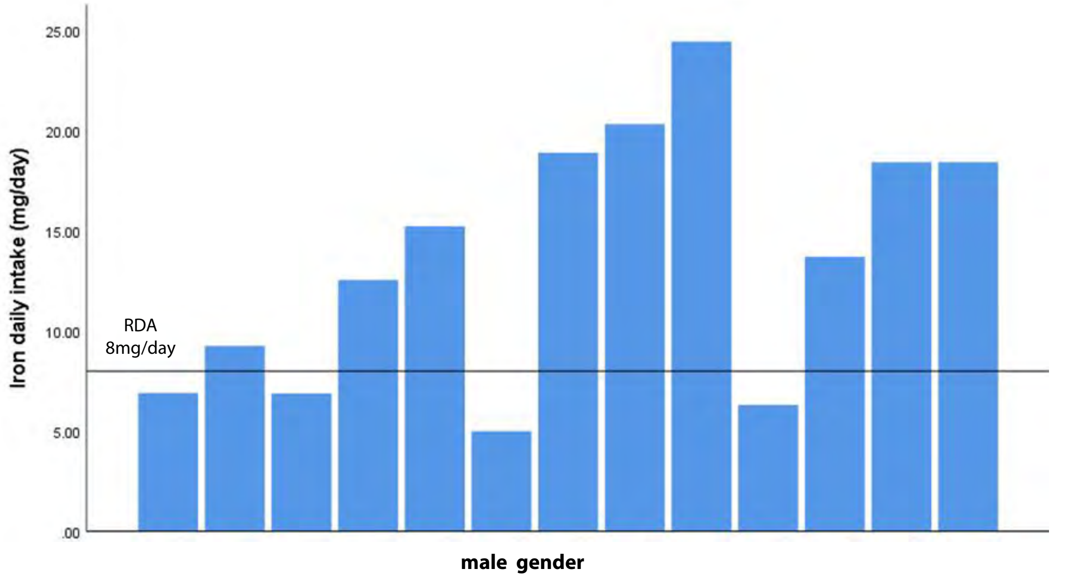

Figure 2. Daily iron intake in male responders compared to the recommended dietary allowance (RDA).

DISCUSSION

The period of adolescence and young adulthood are often marked by intense phases, especially during academic endeavors. This period is characterized by high levels of physical and mental activity throughout the day. A diet that is insufficient in vegetables, fruits, dairy products, and meat may result in inadequate intake of essential vitamins and minerals, including iron [21-23].

The majority of students who participated in our study were female (81.4%), likely because the examined group consisted of pharmacy students, where females represent the predominant portion of the student population. This survey included students from all five years of study, with around 60% of participants being in their final year. It can be assumed that they have acquired some basic knowledge about healthy dietary and lifestyle habits. Most of the participants had a normal BMI (84.2%) and practiced some kind of physical activity 2 to 3 times per week (52.8%). Regarding alcohol consumption and smoking status as important parameters of an unhealthy lifestyle, the students declared negatively, with 91.4% of non-smokers, 40% never drinking alcohol and 35.7% drinking alcohol occasionally, less than once a week. These results suggest that the observed group of participants generally has good lifestyle habits.

No significant difference was observed between genders in total iron intake and the different forms of iron, which contrasts with most studies that report lower dietary iron intake in women [24, 25]. In our study, women had slightly higher total iron intake and these results are in accordance with study with a similar population in which iron intake, adjusted by energy intake, was similarly distributed after adjusting for energy intake [25]. However, if we compare obtained values of iron intake with the RDA values, we can notice that although men have a slightly lower total iron intake (13.6 mg/day) they meet their daily nutrient requirement (8 mg/day), in contrast to women whose total iron intake (16.2 mg/day) does not meet the RDA (18 mg/day).

Regarding the distribution of iron forms in the diet, we observed a slightly higher intake of heme and animal-based iron in men. On the other hand, women had significantly higher iron intake from cereals (p = 0.027) and fat (p = 0.035) with remark that fat contribution was very small, 0.6% of total daily iron intake. Correlation analyses have revealed some interesting information about dietary patterns. There was positive correlation between BMI and total iron (r = 0.228, p = 0.050), heme and animal iron intake (r = 0.464, p < 0.001, for both values), and fruit consumption (r = 0.482, p = 0.001). Physical activity was positively correlated with heme and animal iron intake (r = 0.298, p = 0.012, for both values), as well as meat (r = 0.312, p = 0.009) and fat (r = 0.240, p = 0.046) consumption. These results indicate that higher BMI, associated with increased calorie intake, leads to greater bioavailable iron intake. Physical activity is often associated with higher protein consumption, i.e. a higher proportion of meat, egg, and fish products in the daily diet [26], which was confirmed by our findings. Correlation between different dietary sources showed that iron consumption from meat products is positively correlated with iron from fish (r = 0.387, p = 0.001), dairy products (r = 0.332, p = 0.005), potatoes (r = 0.362, p = 0.002), cocoa (r = 0.424, p = 0.044) and fruit (r = 0.704, p = 0.001). While iron from cereals were positively correlated with fish (r = 0.411, p = 0.001), legumes (r = 0.372, p = 0.002), vegetables (r = 0.520, p < 0.001), nuts (r = 0.413, p = 0.001) and cocoa (r = 0.446, p = 0.001) iron consumption. These results can give us indication of some dietary patterns in the student population. Since females demonstrated a significantly higher intake of iron from cereals (p = 0.027), it can be inferred that plant-based foods are more commonly consumed by women, whereas men may have a stronger preference for foods of animal origin. For both genders, the primary sources of iron were meat products, legumes, and nuts, consistent with findings from previous studies [25]. But cereals were very significant source of iron for women likewise it was noted in other studies with groups of adolescents that the primary source of iron was cereals [27]. It is important to highlight that plant-based food is the main source of non-heme iron. Bioavailability of this iron form is influenced by many dietary factors [28]. Plant-based food contains many inhibitors of iron absorption like phytic acid, polyphenols, calcium, and fibers so we cannot assume effectiveness of iron resorption from these food products [29]. Therefore, besides providing appropriate amount of iron it is important to consider its bioavailability [30].

Among pharmacy students, no significant differences in daily iron consumption were observed across age sub-groups. Iron intake from vegetables was nearly significantly higher in the oldest age group (27–30 years, p = 0.071), possibly reflecting changes in dietary habits due to greater awareness of healthy nutrition. Elsewise, analysis of iron intake according to sub-groups from different years of the studies showed higher heme (p = 0.023) and animal-origin iron (p = 0.023) intake, as well as fruit (p = 0.004) iron consumption in the group of students on 2nd year of the study.

Food-based approaches to increase iron intake through the careful selection of food products and dietary diversification are important and sustainable strategies to prevent iron deficiency in the general population. However, in situations where iron deficiency is most prevalent, additional iron intake is often provided through dietary supplements, particularly for vulnerable groups [31,32]. Many studies found that iron supplementation can have a beneficial effect on cognitive function. More *et al.* [33] in their study observed that both anemic and non-anemic groups of adolescent females with iron deficiency had lower scores on tests of concentration, attention, and visual memory and iron supplementation improved their scores in these cognitive tests. A meta-analysis by Falkingham *et al.* [34] found evident effects of iron supplementation on cognitive abilities, based on 14 randomized controlled trials. Regardless of participants' initial iron levels, iron supplementation was found to improve attention and concentration (standardized mean difference 0.59; 95% CI: 0.29 to 0.90) in studied groups of children and adolescents. The systematic review by Samson *et al.* [35], which analyzed the results of 50 studies (26 cross-sectional and 24 iron intervention studies), suggested that iron levels may be linked to academic performance. It also highlighted those improvements in academic performance, concentration, and attention can be achieved through appropriate iron supplementation. We investigated iron supplementation among pharmacy students and found that only 18.6% reported using dietary supplements containing iron. Additionally, when we analyzed iron intake from various dietary sources based on whether or not students used dietary supplements containing iron, we found no differences between the subgroups. Some studies have shown that women using iron supplementation tend to have a healthier lifestyle and greater nutrition awareness, resulting in higher iron intake [36]. However, this was not confirmed in our study.

A limitation of this study was the small number of participants, as well as the absence of biochemical blood analysis for iron status parameters and a history of anemia among the participants. Additionally, this cross-sectional survey included students who were randomly selected without considering their year of study, which led to a predominance of final-year students among the respondents, thereby compromising the balance across different study years. Addressing these issues in future research would strengthen the validity and applicability of the findings.

Further education on iron-rich dietary sources and effective dietary combinations is necessary for the student population, particularly in light of the growing global trend toward plant-based diets. Proper knowledge in this area is crucial. Additionally, iron supplementation should be considered, especially for individuals already diagnosed with iron deficiency.

CONCLUSION

Overall, the results of this study confirm the generally known fact that the female students involved in the study, aged between 18 and 30, do not meet their daily iron requirements through their diet. They are at risk of developing iron deficiency over the years, especially during the period when demands are higher, including the academic study period. Also, the higher intake of iron from cereals with questionable and certainly lower absorption in the female population is another fact that reveals the risk of inadequate bioavailable iron intake. Further studies considering iron consumption with a larger number of subjects, including students from different faculties combined with information about their iron status parameters could provide some very interesting and valuable information needed for general recommendations about iron consumption to meet students' daily dietary requirements.

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Procena dijetarnog unosa hemskog i nehemskog gvožđa u populaciji studenata farmacije

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Kratak sadržaj

Nedostatak gvožđa je jedan od najčešćih nutritivnih deficita širom sveta i vodeći je uzrok anemije. Studenti, pre svega ženskog pola, su posebno podložni razvoju anemije usled loših navika u ishrani, neredovnih obroka praćenih vrlo intenzivnim rasporedom obaveza u toku dana. Nizak nivo gvožđa može negativno da utiče na intelektualne i kognitivne sposobnosti studenata, ali i da ugrozi njihovo sveukupno zdravlje. Stoga, jako je važno zadovoljiti dnevne potrebe za gvožđem, prvenstveno putem ishrane. Zbog nedostatka informacija o životnim stilovima studenata u Srbiji, studija je osmišljena da ispita varijacije u unosu gvožđa među studentima sa fokusom na razlike u polu i godini studija. Sedamdeset studenata Farmaceutskog fakulteta Univerziteta u Beogradu učestvovalo je u ovoj studiji preseka popunjavanjem elektronskog strukturisanog upitnika. Većina učesnika bila je: ženskog pola (81,4%), studenti završne godine (61,5%), nepušači (91,4%) i fizički aktivni 2 do 3 puta nedeljno (52,8%). Rezultati su ukazali da je prosečan ukupan unos gvožđa za studentkinje bio 16,2±8,7 mg/dan, što je ispod preporučenog dnevnog unosa od 18 mg/dan. Samo 33,3% studentkinja je svoje dnevne potrebe za gvožđem zadovoljavalo hranom. Nasuprot tome, 69,3% učenika muškog pola ispunilo je svoje dnevne potrebe od 8 mg/dan iz hrane, sa prosečnim ukupnim unosom gvožđa od 13,6±6,3 mg/dan. Pored toga, studentikinje su konzumirale znatno više gvožđa poreklom iz žitarica (p = 0.027) i masti (p = 0.035), koji sadrže nehemski oblik gvožđa sa manjom bioraspoloživošću. Dobijeni rezultati naglašavaju važnost edukacije studenata o različitim oblicima gvožđa u hrani i faktorima koji utiču na njegovu apsorpciju. Adekvatno znanje u ovoj oblasti može osnažiti studente da usvoje zdravije navike u ishrani i uz pravi izbor hrane efikasno zadovolje svoje potrebe za unosom gvožđa.

Ključne reči: *gvožđe; studenti; deficit; ishrana; dijetarni izvori gvožđa.*