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Szkoła Główna Gospodarstwa Wiejskiego w Warszawie, Polska

ASSESSMENT OF CAFFEINE INTAKE FROM FOOD AND BEVERAGE SOURCES AMONG YOUNG WOMEN®

Ocena spożycia kofeiny z żywności i napojów w grupie młodych kobiet®

Key words: caffeine; caffeine intake, assessment, coffee, caffeine-containing products, women.

Caffeine is a purine-like alkaloid, a widely consumed psycho-stimulant, found in many plant species of which coffee beans, tea leaves, guarana, and cocoa beans are the most well-known. Furthermore, caffeine is an additive used in the food and beverage industry, it occurs in cola-type beverages and formulated caffeinated beverages or energy drinks, and in some dietary supplements. Due to the increasingly available offering of caffeine-containing products on the market, it is necessary to monitor the amount of caffeine consumed in the context of safety concerns for young women. The aim of this study were 1) to assess caffeine intake in relation to the dose considered by the EFSA as safe for adults in the general healthy population, and 2) to identify the main sources to caffeine intake among young women in Poland. The study was conducted from March to April 2021 in a group of 152 Polish young women aged 18 to 30 years (23.3±5.6). The study was carried out using the CAWI technique with the use of a 20-item food-frequency questionnaire to assess the frequency of consuming caffeine-containing products. The mean daily caffeine intake from all sources was 232 mg (95th percentile: 549 mg), which based on body weight (bw) was 2.88 mg/kg bw/day (P95: 7.62 mg/kg bw). The assessment of caffeine intake showed that in the studied group of women there is a risk of consuming excessive amounts of caffeine. In approx. 19% of women the dose of 5.7 mg/kg bw per day was exceeded, significantly more often in women aged 18-24 than in women aged 25-30 (23% vs 15%; p=0.036). In about 19% of women the daily intake was high (≥400 mg), in half of women (about 51%) it was moderate (200-400 mg), and in about 30% - it was low (<200 mg). Major contributors to caffeine intake were coffee (39%) and tea (34%), a smaller share included energy drinks and cola-type beverages and (12% and 9%, respectively). Approx. 20% of young women, whose caffeine consumption exceeded the safe level of caffeine intake, should limit the consumption of products which are the main sources of caffeine in their diet. In order to improve and shape the correct eating habits of young women, it is necessary to undertake educational activities aimed at the appropriate food choices of the assortment and the control over the amount of consumed caffeine-containing beverages.

Słowa kluczowe: kofeina, spożycie kofeiny, ocena, kawa, produkty zawierające kofeinę, kobiety.

Kofeina jest purynowym alkaloidem wywołującym określone efekty fizjologiczne, występującym w wielu gatunkach roślin, w tym w ziarnie kawy, liściach herbaty, guaranie i ziarnach kakaowca, także jest dodawana do napojów energetyzujących, napojów typu cola i jest składnikiem niektórych suplementów diety i środków farmaceutycznych. Ze względu na wzrastający trend rynkowej oferty produktów spożywczych zawierających kofeinę konieczne jest monitorowanie wielkości jej spożycia. Celem badania była ocena spożycia kofeiny w odniesieniu do dawki uznanej przez EFSA za bezpieczną dla ogólnej populacji oraz określenie produktów i napojów będących głównymi źródłami kofeiny w diecie młodych kobiet w Polsce. Badanie przeprowadzono od marca do kwietnia 2021 r. w grupie 152 młodych kobiet w wieku od 18 do 30 lat (23,3±5,6). Zastosowano technikę CAWI z wykorzystaniem 20-punktowego kwestionariusza częstotliwości spożycia produktów zawierających kofeinę. Wykazano, że średnie dzienne spożycie kofeiny wyniosło 232 mg (95-percentyl: 549 mg), co w przeliczeniu na masę ciała stanowiło 2,88 mg/kg mc. (P95: 7,62 mg/kg mc.). Stwierdzono, iż w badanej grupie młodych kobiet istnieje realne zagrożenie spożycia nadmiernej ilości kofeiny. U ok. 19 osób odnotowano przekroczenie dawki 5,7 mg/kg mc, istotnie częściej u kobiet w wieku 18-25 lat niż w wieku 25-30 lat (23% vs 15%; p=0,036). W przypadku ok. 19% osób spożycie kofeiny było duże (≥400 mg), u połowy osób (ok. 51%) na poziomie umiarkowanym (200-400 mg), a w przypadku ok. 30% - małe (<200 mg/dzień). Głównymi źródłami kofeiny w diecie młodych kobiet były kawa (39%) i herbata (34%), mniejszy udział stanowiły napoje energetyzujące (12%) oraz napoje typu cola (9%). Podsumowując, w przypadku ok. 20% badanych kobiet, u których stwierdzono przekroczenie bezpiecznej dawki, zalecane jest ograniczenie spożycia produktów będących głównymi źródłami kofeiny. Dla poprawy i kształtowania prawidłowych zwyczajów żywieniowych młodych kobiet konieczne są działania edukacyjne mające na celu zwrócenie uwagi na odpowiedni dobór asortymentu i ilości spożywanych napojów.

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INTRODUCTION

Caffeine (1, 3, 7-trimethylxanthine) is a purine alkaloid found naturally in coffee infusions (filter coffee, espresso, instant coffee, and vending machines) and tea (loose leaves, bags, instant tea, and vending machines), which are widely consumed and constitute a part of everyday diet, as well as are consumed with products containing cocoa beans, extracts of guarana seeds. It is also consumed as a flavoring ingredient in a variety of beverages (e.g. energy drinks and cola-type drinks) [1, 7, 8, 31, 33]. Due to the broad market offer and availability, it is estimated that these processed products are consumed by population of all ages, including the majority of women [1, 5, 7, 10, 20, 27, 31]. As a result of the increased market offer, caffeine intake has increased in young women in many countries over the last decades [2, 8, 9, 10, 11, 16, 17, 18, 19, 20, 22, 27, 29, 32].

Caffeine induces many different physiological effects in health with a potentially positive impact on health when consumed in moderation and a negative impact at high dose, and the impact depends, among others, on the consumed dose, age, physiological condition and individual caffeine sensitivity and tolerance [1, 3, 4, 6, 7, 12, 21, 25, 33]. Short-term effects of caffeine on health are well known, including stimulation of the central nervous system with the effects on psychomotor and cognitive performance [1, 4, 13, 21, 31, 34, 35]. By stimulating the central nervous system, among others, it impacts the processes of sleep and wakefulness, it improves concentration and reduces the feeling of sleepiness. In case of higher doses, it can have a negative impact on sleep in a dose-dependent manner if consumed late in the day [3, 7, 21, 28]. Moreover, it stimulates the motor zone of the cerebral cortex, may cause psychomotor agitation, irritability, anxiety and fear, insomnia, as well as increased diuresis and intensified dyspeptic symptoms [4, 7, 13, 21, 24, 31, 34, 35]. Longer-term effects of caffeine consumption on health are more debated [6, 13]. A meta-analysis of randomized controlled study and umbrella review indicated that caffeine may increase systolic blood pressure after several weeks of moderate to high caffeine intake [6, 12, 25].

Some research results indicate that caffeine increases the concentration of cholesterol and homocysteine in the blood [15], and by increasing arterial wall stiffness, consequently causing hypertension, contributes to an increased risk of ischemic heart disease. In some individuals, it causes, among others, dilatation of coronary vessels and endothelial dysfunction, and it may lead to arrhythmias [4, 6, 12, 13, 15, 21, 33]. Recent studies have found associations between coffee consumption and the risk of developing cardiovascular diseases, and many have found that there **is no association** between coffee consumption and an increased risk of cardiovascular disease [6, 12, 15, 25]. Moreover, while some studies indicate that energy drinks have proaggregatory effects, which may be associated with an elevated risk of thrombosis, others indicate that coffee in fact reduces platelet activation, which may be beneficial for prophylaxis of thrombosis, and modify the progression of cardiovascular diseases [23]. On the other hand regular moderate caffeine consumption has beneficial effects for health such as a reduced risk of several types of cancer, as well as cardiovascular, metabolic conditions, and possibly decreases the risk of cognitive disorders [1, 12].

In this context, the European Food Safety Authority (EFSA) [8] and other authors [3, 4, 13, 21, 34] have set population recommendations for caffeine intake. For the general healthy population of adults, except children, adolescents and pregnant women, the dose of caffeine without adverse health effects is less than 400 mg per day (about 5.7 mg/kg bw per day). Caffeine-containing products are easily available on the market [1, 5, 7, 8, 10, 20, 27, 32], their excessive consumption may lead to exceeding the safe level, therefore it is reasonable to assess the consumption of caffeine from all sources.

The purpose of this study was to assess of caffeine intake in a group of Polish young women in relation to the dose considered by the EFSA as safe for adults in the general healthy population, and to identify the main sources to caffeine intake.

MATERIAL AND METHODS

Participants and data collection

The study group consisted of 152 Polish women aged 18–30 years old who correctly completed the consumption questionnaire using the Computer Assisted Web Interview (CAWI) method. A descriptive cross-sectional study was performed in March-April 2021.

Participants completed, online and in a voluntary and completely anonymous way, a survey designed using the Google Forms tool. For this study, pregnant or breastfeeding women were excluded. All women were informed of the purpose of the study. Consent to participate in the study was given by agreeing to complete the survey. The protocol was in accordance with the Declaration of Helsinki for research of involving human participants and was approved by the local Ethics Committee.

Quantitative data on the consumption of caffeine-containing products, as well as products that may be a source of caffeine, was collected using a self-reported 20-item food-frequency questionnaire, with the verification of consumption data by describing the size of the consumed portion of products and drinks. The frequency intake of common products containing caffeine was ascertained using questions with daily, weekly or monthly frequency options provided.

Calculation of daily caffeine intake

For each person, the average consumption of beverages prepared from ground roasted coffee beans, instant coffee extracts and other coffee-based beverages, tea (black, white and green), mate, as well as the consumption of coffee-flavored beverages (cola-based soft drinks, iced teas, formulated caffeinated beverages or energy drinks) and cocoa products (chocolate and chocolate-based confectionary and other cocoa products) was calculated. The use of caffeine-containing food supplements was also taken into account.

The source of data on the caffeine content in common caffeinated foods and beverages was the average caffeine concentrations determined in the Scientific Opinion published by EFSA on the safety of caffeine [8], and the caffeine level reported on the packaging labels, when present. The caffeine content in food supplements was adopted in accordance with the manufacturer's declaration.

Based on such data, for each person individually, the daily caffeine consumption (mg) was calculated and expressed as per kg body weight (mg/kg bw). The values of daily caffeine intake from food and beverages were compared with the dose considered by the EFSA [8] which does not give rise to safety concerns for the general healthy population, amounting up to 400 mg per day, which is approx. 5.7 mg/kg bw per day. Moreover, based on criteria used in other studies, daily caffeine intake was rated as low (<200 mg), moderate (200–400 mg) or high (> 400 mg) [3, 21].

Statistical Analysis

Statistical analysis of the obtained data was carried out using IBM SPSS Statistics 26.0 software. Descriptive analysis was used to report the frequencies and percentages of categorical variables, and the mean, standard deviation (\pm SD) and median (25, 75 and 95 percentiles) were reported for quantitative variables. The significance of differences for qualitative variables was assessed by the Pearson's chi-square test, and for quantitative variables by the Mann-Whitney U-test. All statistical tests stratified by age group. Statistical significance were accepted at a p-value below 0.05.

RESULTS

Characteristics of the study group

The age of women ranged between ages of 18 and 30 years, and the following age groups: 18–24 (n = 79); 25–30 (n = 73) amounted to 52% and 48% of the studied group, respectively. At the time of the research, the respondents were on average 23.3 ± 5.6 years old. Approximately 45% of people came from a large-city environment, approx. 1/3 from small-town and approx. 1/4 from rural areas. A significant proportion of the women (65%) had higher education. In the older group (aged 25–30) there was a significantly higher percentage of people with higher education compared to the younger age

group (aged 18–24), where those who completed secondary education or undergoing studies constituted the highest percentage.

Daily caffeine intake

Table 1 presents the daily intake of caffeine in the entire studied group of women and in individual age groups. Overall, the caffeine consumption for all women was 232 (\pm 108) mg/day with a P95 estimated at 549 mg/day. Mean caffeine intake was significantly higher in the group aged 25–30 years than in under 25 years, with 257 (\pm 113) and 230 (\pm 108) mg/day and 95th percentile of 475 and 426 mg/day, respectively. However, when converted to mg/kg of body weight, women aged 18–24 years reported statistically significantly higher caffeine consumption than women aged 25–30 (3.57 vs. 2.34 mg/kg bw/day; $p=0.028$). The intake at the 95th percentile level was 426 mg/day and 7.62 mg/kg bw/day. On average, it was about 2.88 (\pm 1.84) mg/kg bw/day with fluctuations in the range from 0.3 to almost 9 mg/kg bw/day.

Assessment of daily caffeine intake

Figure 1 describes the daily caffeine intake per kg of body weight, relative to the safe dose determined by the EFSA [5]. In this regard, the Figure also highlights that 15% and 23% of the Polish women consumed more than 400 mg/day or 5.7 mg/kg per day of caffeine, respectively. In both age groups, there were people whose caffeine intake was greater than 400 mg/day, which was higher than the dose considered safe for adults. This situation concerned 15% and 23% of the studied age groups, respectively. Overall, the percentage of participants with caffeine consumption >400 mg/day was significantly higher among women aged 20–30 (approx. 23%) than among women in the older age group (approx. 14%). In the case of approx. half of the women (49%) caffeine consumption was moderate (200–400 mg/day), and in the case of approx. 28% of the respondents it was low (<200 mg/day).

Table 1. Caffeine intake (mg/ day or mg/kg/day) in young women

Tabela 1. Spożycia kofeiny (mg/dzień lub mg/kg mc/dzień) w grupie młodych kobiet

□	Total N=152		18–24 years n=79		25–30 years n=73	
	mg/d	mg/kg mc/d	mg/d	mg/kg mc/d	mg/d	mg/kg mc/d
Mean \pm SD	232 \pm 108	2.88 \pm 1.84	230 \pm 108	2.34 \pm 1.79*	257 \pm 113	3.57 \pm 1.85*
Min-max	17.8 – 642	0.31 – 8.81	17.8 – 496	0.30 – 8.32	26.5 – 652	0.42 – 8.81
Percentiles						
25	112	2.01	104	1.82	118	2.31
50	234	2.49	226	2.35	143	2.87
75	278	4.41	232	4.01	291	4.87
95	551	7.62	426	7.56	475	7.94

* Means differed significantly at $p \leq 0.05$; Mann-Whitney U test

* Średnie różnią się istotnie statystycznie przy $p \leq 0,05$; test U Manna-Whitneya

Source: Own study

Źródło: Opracowanie własne

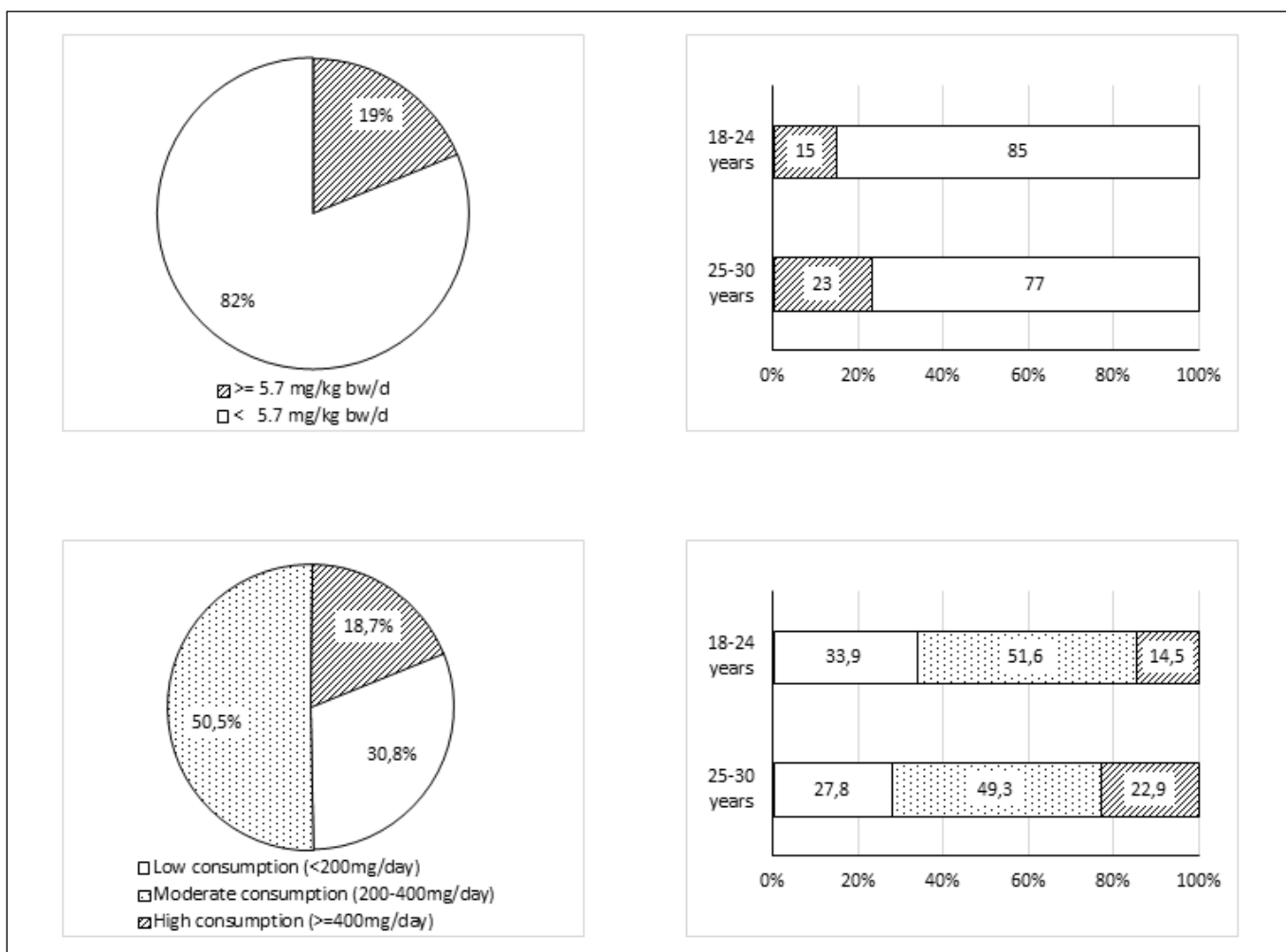


Fig. 1. Assessment of daily caffeine intake in young women.

Rys. 1. Ocena spożycia kofeiny w grupie młodych kobiet.

Values are expressed as means and represent the percentage (%) of the studied group of women exceeding the recommendation of 400 mg (or 5.7 mg/kg bw per day).

Wartości przedstawiono jako średni odsetek (%) badanej grupy kobiet przekraczających zalecenie 400 mg (lub 5,7 mg/kg mc na dobę).

Source: Own study

Źródło: Opracowanie własne

Main sources of daily caffeine intake

Figure 2 shows the main food group sources of caffeine and the contribution of each caffeine source to the total caffeine intake. Two significant main sources of caffeine in the diet of the women participating in the study in both age groups are coffee – 39% of the total intake, with a greater share of coffee beans (in the group aged 25–30) and tea – 34% of overall intake, with a significant predominance of black tea in both age groups.

The youngest age group differed from the rest with a higher share of consumption of other beverages (Fig. 2). The share of energy drinks and cola type drinks was significantly higher among women aged 18–25 than among women aged 25–30, 23% and 19%, respectively. Other products were of little significance in this respect. With regard to dietary intake of caffeine products, approx. 95% of the respondents consumed black tea and approx. 55% consumed green tea. Similarly, many people drank coffee, i.e. 75% – infusion of roasted (ground) coffee, and 58% of respondents - instant coffee. There were 63% and 52% of women drinking cola-type soft

drinks and energy drinks, respectively. Cola-type beverages, energy drinks and instant coffee were more common among younger women, and ground coffee infusions among the older age group of women.

DISCUSSION

The quantitative consumption of coffee, tea and other products was the basis for estimating caffeine intake with the daily food ration of the women participating in the study in various age groups. Coffee is one of the most consumed beverages worldwide. [1, 7, 8, 20, 27, 32], also in Poland [5, 33]. The assessed diet was characterized by different levels of caffeine, i.e. in the range from 17.8 to 642 mg/day, which was 0.31 to 8.81 mg/bw (the median was 234 mg/day and 2.49 mg/kg bw/day, respectively). The obtained results were within the range of data obtained by other authors [9, 10, 16, 18, 19, 28, 29, 30].

When analysing caffeine consumption in particular age groups, the highest intake was recorded among women aged

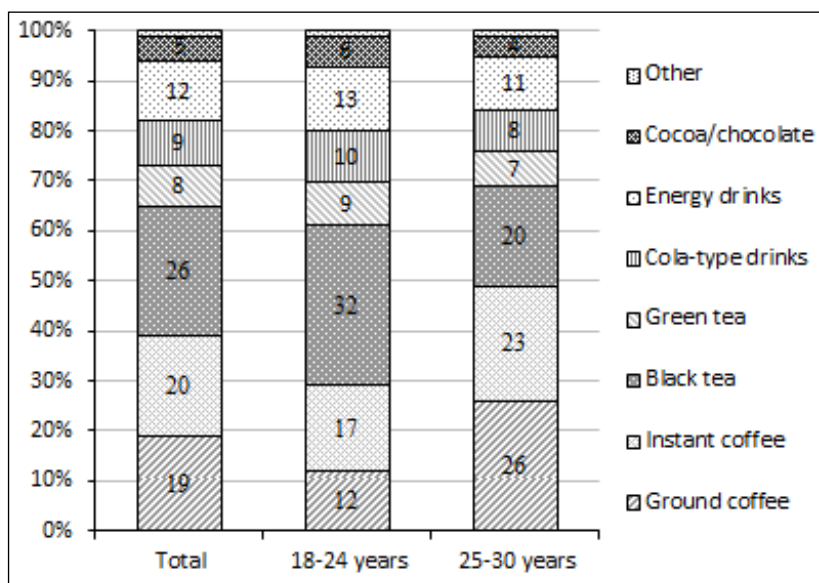


Fig. 2. Main food sources of daily caffeine intake in young women.

Rys. 2. Główne źródła kofeiny w diecie młodych kobiet.

Values are expressed as means and represent the percentage (%) of caffeine contribution in of each food group with respect to total daily caffeine intake.

Wartości przedstawiono jako średni odsetek (%) poszczególnych grup produktów w odniesieniu do całkowitego dziennego spożycia kofeiny w grupie młodych kobiet.

Source: Own study

Źródło: Opracowanie własne

25–30 (257 mg/day), and lower among the respondents aged 18–24 (230 mg/day). The evaluation of caffeine consumption showed that for 19% of women there is a real risk of consuming excessive amounts of caffeine above the dose of 5.7 mg/kg of body weight considered safe [5]. In addition, the consumption of caffeine was assessed at the level of the 95th percentile, which was 549 mg/day (7.41 mg/kg bw), which also indicates that the daily dose of caffeine safe for adults was exceeded, i.e. 400 mg/day and 5.7 mg/kg bw/day [8, 34, 21]. In such circumstances, one should strive to significantly reduce the consumption of products that contain significant amounts of caffeine. The presented situation seems to be concerning, as high caffeine consumption may cause side effects [4, 7, 13, 31, 34, 35], incl. psychomotor agitation, irritability, restlessness and anxiety, an increase in blood pressure and arrhythmias. Sleep disturbances or insomnia may also occur. The potential harmful effects may depend not only on the consumed dose, but also on individual sensitivity as well as the limited and lower ability to metabolize caffeine in the liver due to the insufficient amount and activity of the cytochrome P450 isoenzyme, i.e. CYP1A2. The risk of adverse health effects increases in particularly sensitive individuals, i.e. those with slow caffeine metabolism [1, 7, 8]. The EFSA considers up to 400 mg/day of habitual caffeine consumption to be safe for adults, and recommends that pregnant or breastfeeding women restrict their caffeine intake to less than 200 mg/day [8].

The assessment of caffeine consumption, paying attention to young women as a group at risk of higher intake, has been the subject of many national [2, 11, 19, 22] and foreign [3, 9, 10, 17, 27, 28, 32] studies. The estimated caffeine consumption in women in this study was similar to the results of other national studies [19] and the observed trends in caffeine

consumption in other European countries [9, 16, 18, 24, 28, 29, 30]. Caffeine consumption reported in U.S. studies [10, 17, 20] was at a slightly lower level and was dependent on the nutritional habits of women, associated with a significant share of soft drinks. Particularly in terms of women's nutrition, it should be emphasized that the excessive use of stimulants is also indicated among many risk factors for osteoporosis. The adverse effect of caffeine may result from the higher consumption of soft drinks containing caffeine at the expense of consumption of dairy drinks, which constitute a good source of calcium. When calcium intake is sufficient, caffeine does not reduce bone mass [13, 21]. Given the popularity and prevalence of energy drinks, caffeine intake could reasonably be expected to increase quickly among young women. In studies of pregnant women, the substantial majority finding from observational studies and meta-analyses is that maternal caffeine consumption is associated with negative pregnancy outcomes, and pregnant women and women contemplating pregnancy are advised to avoid caffeine [14].

Determining the share of particular groups of products played an important role in the estimation of caffeine intake in the studied group of women. The main sources of caffeine in the daily food rations of the women participating in the study included tea, then coffee and flavoured carbonated drinks, including cola type drinks and energy drinks. Observations on the frequent consumption of carbonated drinks containing caffeine by younger age groups are also confirmed by other national studies [2, 11, 19, 22]. It should be emphasized that both European [16, 18, 27, 29, 30] and U.S. [10, 17, 20, 26] studies indicate that coffee, tea and flavoured soft drinks are the most significant sources of caffeine, and the greatest potential for reducing the amount of caffeine intake can be achieved by limiting coffee consumption (in adults) and consumption of energy drinks and cola type drinks (in younger population groups). In addition, the dietary sources of caffeine shift over the lifespan: adult women primarily consume coffee and tea, whereas adolescents and young women consume caffeinated beverages and chocolate (cacao), which contain much lower amounts of caffeine [7, 16, 27, 32].

Taking into account the dynamically developing market of energy drinks and sugar-rich beverages, many studies have found that their consumption is widespread [7, 11, 15, 16, 18, 19, 22, 26] and has been recognized as a significant factor of adverse health effects [3, 8, 21, 24, 26, 28, 31, 34, 35]. The amounts of caffeine consumed by women in these studies may facilitate the formulation of proposals for changes in diet, leading to a reduction in its consumption from the main sources and greater control of the level of caffeine consumption within a daily diet, considering the increasing consumption trend of healthy beverages.

CONCLUSIONS

Caffeine-containing products are easily available on the market, and the selection is large and constantly growing. Approx. 20% of the young women participating in the study, who were found to exceed the maximum intake of 400 mg/day recommended by EFSA, should limit the consumption of caffeine-containing products (coffee and tea), as well as flavoured caffeine-containing beverages (cola-type drinks, energy drinks) preferred especially by the younger age group.

In order to improve and shape the correct eating habits of young women, it is necessary to undertake educational activities aimed at the appropriate food choices of the assortment and the control over the amount of consumed caffeine-containing beverages.

PODSUMOWANIE

Produkty zawierające kofeinę są łatwo dostępne na rynku, a ich oferta jest duża i stale rosnąca. W przypadku ok. 20% badanych młodych kobiet, u których stwierdzono przekroczenie zalecanego przez EFSA maksymalnego spożycia do 400 mg/dzień (5,7 mg/kg mc/dzień) należy ograniczyć spożywanie produktów będących źródłami kofeiny (kawy i herbaty), a także preferowanych szczególnie przez młodszą grupę wiekową aromatyzowanych napojów bezalkoholowych (napoje typu cola, napoje energetyzujące).

W celu poprawy i kształtowania prawidłowych nawyków żywieniowych w badanej grupie młodych kobiet konieczne jest podejmowanie działań edukacyjnych mających na celu odpowiedni dobór asortymentu produktów i napojów oraz kontrolę ilości spożywanych napojów zawierających kofeinę.

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