Urban Egyptian Women Aged 19–30 Years Display Nutrition Transition-Like Dietary Patterns, with High Energy and Sodium Intakes, and Insufficient Iron, Vitamin D, and Folate Intakes

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Urban Egyptian Women Aged 19–30 Years Display Nutrition Transition-Like Dietary Patterns, with High Energy and Sodium Intakes, and Insufficient Iron, Vitamin D, and Folate Intakes

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ABSTRACT

Background: Recent changes in Egyptian dietary habits can be attributed to more urban and sedentary lifestyles and to alterations in the dietary and economic context. The mean BMI of Egyptian women is one of the highest worldwide, and 50% have iron deficiency.

Objective: The aim was to quantify food and nutrient intakes of urban Egyptian women and conduct a detailed analysis of micronutrients commonly consumed in inadequate amounts, such as iron, vitamin D, and folate.

Methods: Urban Egyptian women aged 19–30 y ($n = 130$) were recruited during 2016–2017. Energy needs were estimated using the Henry equation, assuming a low physical activity level (1.4). Dietary intakes and iron bioavailability were estimated from a 4-d food diary. Macronutrient intakes were compared with WHO/FAO population goals and micronutrient intakes with Egyptian recommendations. Iron needs were determined for each subject.

Results: The mean BMI (kg/m^2) was 27.9 ± 4.9. The mean total energy intake (TEI; 2389 ± 715 kcal/d) was significantly higher than needs (2135 ± 237 kcal/d; $P = 0.00018$). Total fat (33%TEI) and SFA (11%TEI) intakes were slightly higher than population goals (15–30%TEI and <10%TEI, respectively). Diets provided 18 ± 8 g/d of fiber, 98 ± 54 g/d of total sugars, and nearly twice the recommended sodium intake (intake: 2787 ± 1065 mg/d; recommendation: <1500 mg/d). Estimated dietary iron bioavailability was low (9.2% ± 1.6%), and 79% of women consumed less iron than the average requirement (17.5 ± 7 mg/d). Overall, 82% and 80% of women consumed less vitamin D and folate, respectively, than recommended.

Conclusions: Egyptian women aged 19–30 y have high intakes of energy and sodium, whereas iron, vitamin D, and folate intakes are insufficient, with only low concentrations of bioavailable iron. These results call for further investigation into measures that would improve this population's diet quality. *Curr Dev Nutr* 2020;4:nzz143.

Keywords: Egypt, women, diet, nutrition, malnutrition, transition, iron, bioavailability

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Supplemental Material 1 and Supplemental Tables 1–6 are available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/cdn/.

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Abbreviations used: EFSA, European Food Safety Authority; ICAN, Institute of cardiometabolism and nutrition; INRAE, Institut national de recherche pour l'agriculture, l'alimentation et l'environnement; INSERM, Institut national de la santé et de la recherche médicale; MRC, Medical Research Council; SEC, socioeconomic class; TEI, total energy intake; UMR PNCA: Unité mixte de recherche physiologie de la nutrition et du comportement alimentaire; USDA, United States department of agriculture.

Introduction

The mean BMI (in kg/m^2) of Egyptian women is among the highest in the world (30.6) (1), with an 88% prevalence of overweight and obesity in those women living in urban areas (2), which is greater than observed in men or children (2–4). Approximately 50% of Egyptian women aged 20–49 y have iron deficiency and 25% have iron-deficiency anemia (5). This coexistence of undernutrition along with overweight and obesity, known as the double burden of malnutrition (6), is also found in children (2). The situation in Egypt is not typical in that there is no clear gradient in anemia and overweight based on socioeconomic class (SEC). Anemia is almost as prevalent in the highest SEC as in the lowest (26% vs. 29%). The prevalence of overweight and obesity increases moderately with wealth (80% in the lowest SEC vs. 88% in the highest SEC) and strongly with age in women (52% of 15- to 19-y-old girls, 75% of 20- to 29-y-old women, and 93% of 40- to 49-y-old women are overweight or obese) (2).

The high prevalence of overweight and obesity in Egypt is thought to be related to high energy intake combined with low levels of physical activity (7), especially in women, due to sociocultural factors and safety concerns (8). Recent changes in the economic environment and dietary patterns (7, 9) mean that animal products, fruits, and vegetables are expensive foods that are now consumed in larger amounts by people of higher SECs (10). These nutrient-dense foods are therefore less accessible to lower SECs. Unrefined cereals, legumes, dark-green leafy vegetables, fruits, cheese, oils, and white and red meat have been described as the pillars of the traditional Egyptian food system (9). However, new lifestyles that are emerging as a result of urbanization and longer working hours have led to reduced consumption of traditional foods and greater intakes of fast food and sugar-sweetened beverages, more frequent snacking, and consumption of the main cooked meal later in the day (9, 10).

Repeated economic crises have also weakened this food-deficit country [Egypt is one of the largest food importers worldwide (11)], and the food subsidy system may have contributed to incentivizing the consumption of calorie-rich foods (e.g., subsidized oil, bread, and sugar) (3). Egyptians traditionally consume large quantities of broad beans and sweetened black tea (9), which contain phytates and iron-binding polyphenols, respectively, both of which decrease iron bioavailability (12). In individuals with obesity, iron absorption may be further impaired due to inflammation-induced hepcidin secretion, which leads to iron sequestration (13).

Improving young women's dietary intake has the potential to impact the health of both women and future infants (14–17). The objective of this study was to quantify food and nutrient intakes in 19- to 30-y-old Egyptian women living in urban areas and to examine specifically the intake of micronutrients commonly consumed in inadequate amounts, such as iron (2, 5), vitamin D (18, 19), and folate (20).

Methods

Study design and study population

The Research Ethics Committee of Ain Shams University, Faculty of Medicine, Cairo, Egypt, approved the study protocol. Dietary data from women aged 19–30 y ($n = 130$) were extracted from a descriptive, cross-sectional survey conducted between November 2016 and March 2017 in males and females (age range: 1–50 y; $n = 860$) living in 4 urban areas in Egypt (Greater Cairo, Alexandria, Delta, and Upper Egypt), representing SECs A to D in the urban population (21). A door-to-door random-sampling methodology with a screening questionnaire was used to reach quotas for age, gender, social class, and region in order to obtain a representative sample. Interviewers randomly selected households, and 1 individual per household (selected according to age and gender quotas) was invited to participate in the study and received the study documents in Arabic, including a consent form, an information sheet, a sociodemographic questionnaire, and a 4-d food diary. Participants self-reported their height and weight, yet there were challenges in collecting these data. Briefly, some respondents were unaware of their own weight and height and provided unrealistic estimates. Additionally, female respondents were sometimes reluctant to provide their weight (and height), especially when the interviewer was male. The research team tried to match female inetrviewers with female participants, but this was not always feasible. Missing or implausible values were corrected using an Akaike Information Criterion backwards elimination procedure [function "step" in R (22)] to identify a model with statistically significant predictors of height and weight values. The model that was retained included the variables "age," "gender," and "number of people in the household"; and a multiple imputation procedure was performed to impute missing height and weight values ("mice" package in R (23)), as detailed in **Supplemental Material 1**. The declared and imputed weight, height, and BMI values are presented in **Supplemental Table 1**.

A point system classified participants as belonging to 1 of 6 SECs (A, B, C1, C2, D, E). The point system was based on the job description of the main wage earner, the monthly household income, type of accommodation, possessions (washing machine, microwave, number of cars and value, etc.) and lifestyle (sports club membership, regular trips abroad). SEC A was the highest and class D was the lowest included in the sample. The diary was completed for 4 consecutive days, including, where possible, 1 weekend day, to better represent weekly dietary habits. The diary was completed on paper and covered the whole diet, including food and beverage intake at home and outside of the home, with detailed information on homemade recipes and dietary supplements. A photographic food atlas of portion sizes was used to estimate portion size based on pictures of typical dishes.

Quality-control checks related to food-intake data were routinely performed during data collection, and final data quality checks were done on the complete database. In addition to routine checks, 10% of data coded were cross-checked to identify and resolve discrepancies. Any issues regarding diary completeness, portion sizes, and energy and nutrient intakes were discussed among research team members to reach a consensus. Missing data, outliers, and out-of-range values were identified with energy and nutrient distributions. Among the 860 people surveyed, 144 were women aged 19–30 y, of whom 14 were excluded [due to having implausible daily energy intakes defined as being below the 5th or above the 95th percentiles (24)], leading to a study sample of 130 women, with 4 d of the diary completed (**Figure 1**).

Creation of a composite food-composition database

The 378 foods consumed by the subjects ($n = 130$) were classified into 15 main food groups and 52 subgroups, as detailed in **Supplemental Table 2**. This classification was based on the classification used in Optifood, a diet-modeling software program developed to design population-specific, food-based recommendations (25). Egyptian food-composition tables (26) were complemented with Turkish and Serbian food-composition tables (27, 28). The nutritional composition of foods such as lentils was adapted from the global food-composition table for pulses (29) and that of spices and some other foods was adapted from recently published Indian food-composition data (30). At the time of the study, the only fortification program in place in Egypt was salt iodization. As iodized salt use is very prevalent in the country [92.5% of households surveyed in a previous study used iodized salt (31)], all salt consumed was considered to be fortified with 15 ppm of iodine.

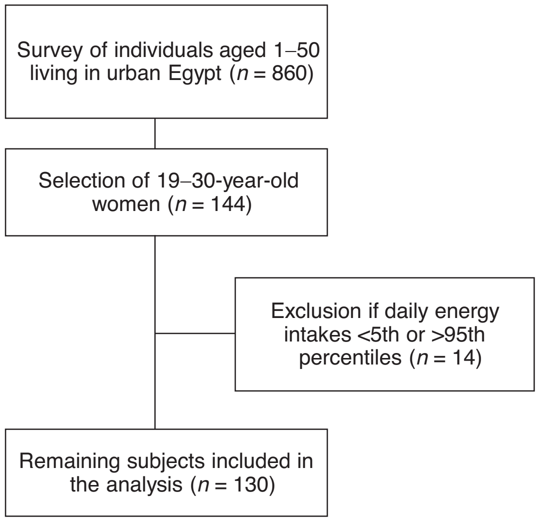

FIGURE 1 Subject selection for dietary analysis of 19- to 30-y-old Egyptian women living in urban areas.

Calculation of energy and nutrient intakes and comparison with needs and recommended intakes

Energy needs were calculated using equations for basal metabolic rate for 18- to 30-y-old women with individual reported or imputed body weight (32) and assuming a physical activity level of 1.4, corresponding to a sedentary lifestyle, for all women (33, 34). Total energy intakes (TEIs) were compared with energy needs for each woman. Nutrient intakes were calculated based on food and beverage intake only and did not include dietary supplements due to limited information on the types of supplements consumed and the low number of supplement users ($n = 8$, 6.2% of the study sample). Nutrient intakes were analyzed and compared with WHO/FAO population goals for macronutrients (35) and Egyptian recommendations for micronutrient intakes (36). For iron, mean intakes were compared with individual needs, as described in the following section.

Calculation of iron bioavailability and needs

Iron needs for premenopausal women rely mainly on basal losses, menstrual losses, and iron bioavailability (12). Bioavailable iron needs were calculated by adding basal iron losses to menstrual iron losses. Basal iron losses are estimated to be 14 μg/kg of body weight per day (12, 37); when averaged over the entire 28-d menstrual cycle, this means that menstrual iron losses are ~0.56 mg/d (12). Therefore, women's iron needs were calculated as follows:

$$\begin{aligned} \text{Needs (bioavailable iron, mg/d)} &= \text{basal losses} + \text{menstrual losses (mg)} \\ &= [0.014 \times \text{body weight (kg)}] + 0.56 \end{aligned} \tag{1}$$

Iron bioavailability from diet was calculated based on intakes and bioavailability of both heme and nonheme iron from dietary intakes.

$$\begin{aligned} &\text{Resultant bioavailability from diet} \\ &= \frac{[\text{heme iron (mg)} \times 25\%] + [\text{nonheme iron (mg)} \times \text{nonheme iron bioavailability (\%)}]}{\text{iron intake (mg)}} \end{aligned} \tag{2}$$

Nonheme and heme iron intakes were estimated based on the content of heme and nonheme iron in each food subgroup (38, 39), as detailed in **Supplemental Table 3**. A bioavailability of 25% was assumed for heme iron intake (12, 40).

Equations from Armah et al. (41) were used to estimate nonheme iron bioavailability for each woman, as described below:

$$\begin{aligned} &\ln\ (\text{nonheme iron bioavailability})\ (\%) = 6.294 - 0.709 \ln\ (\text{SF}) \\ &+0.119 \ln\ (\text{C}) + 0.006 \ln\ (\text{MFP} + 0.1) - 0.055 \ln\ (\text{T} + 0.1) \\ &- 0.247 \ln\ (\text{P}) - 0.137 \ln\ (\text{Ca}) - 0.083 \ln\ (\text{NH}) \end{aligned} \tag{3}$$

where SF is serum ferritin (μg/L); C is vitamin C (mg); MFP is meat, fish, and poultry (g); T is black tea equivalents (number of cups); P is phytate (mg); Ca is calcium (mg); and NH is nonheme iron (mg). Serum ferritin was assumed to be 15 μg/L for all women, as approximately half of Egyptian women have a ferritin concentration <15 μg/L (5). Vitamin C, calcium, and meat-fish-poultry intakes were directly derived from the subjects' dietary data. As no information was available on phytate intake, a phytate intake of 1400 mg/d was assumed for all participants, which corresponds to a mixed diet with a high proportion of unrefined cereal grain products and legumes (42). Black tea equivalents were determined based on dietary data and using the approach described by Armah et al. (41) to convert the number of beverages consumed into black tea equivalents.

The total amount of iron needed could then be calculated as the bioavailable iron needs, divided by bioavailability, and a variation of 40% was assumed.

$$\begin{aligned} \text{Total amount of iron needed} &= \frac{\text{Needs (bioavailable iron, mg/d)}}{\text{Bioavailability}} \\ &\pm 40\% \end{aligned} \tag{4}$$

Statistical analysis

Data are presented as the means ± SDs for continuous variables and as percentages for categorical variables. As energy and iron needs were calculated individually, the differences between mean intake and needs were tested using Student's t tests. For all other micronutrients, the differences between mean and recommended intakes were tested using Welch's 2-sample t tests, as the series had unequal variances. When the recommended nutrient intake was expressed as a range, the value retained for comparison was the lower bound of the recommended range. A P-value cutoff of 0.05 was used for statistical significance. Bonferroni corrections for simultaneous analysis were applied to micronutrients, and the null hypothesis was rejected at a significance level of $0.05/20 = 0.0025$.

Micronutrient intakes were considered "critical" when the following 2 conditions were fulfilled: *1*) >50% of the sample had intakes less than the recommended amount (or needs, for iron) and *2*) the mean intake was significantly lower than the recommendation ($P < 0.0025$), except for sodium (which was considered critical if the intake was significantly higher than the recommendation; $P < 0.0025$).

TABLE 1 Demographic characteristics of the 19- to 30-y-old urban Egyptian women included in this study[1]

Variable	Values
Age, y	24.7 ± 3.7
Weight,[2] kg	73.9 ± 12.9
Height,[2] m	1.63 ± 0.12
BMI,[2] kg/m^2	27.9 ± 4.9
Geographical region, % of women	
Greater Cairo	43.1
Delta	26.2
Upper Egypt	16.9
Alexandria	13.8
Socioeconomic class, % of women	
A (highest)	2.3
B	14.6
C1	19.2
C2	51.5
D (lowest)	12.3

[1]Values are means ± SDs unless otherwise indicated; $n = 130$.
[2]Means were calculated after replacing missing or implausible height and weight values with imputed values.

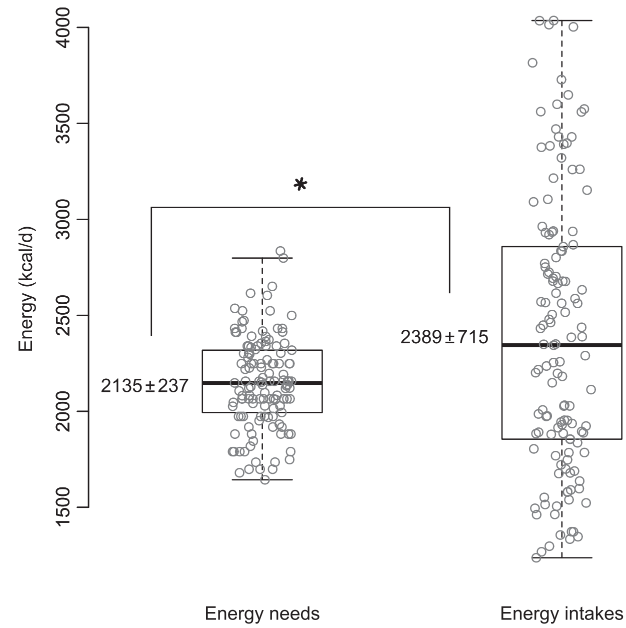

FIGURE 2 Energy needs and intakes of 19- to 30-y-old Egyptian women living in urban areas ($n = 130$). Each gray circle represents 1 woman. The mean ± SD values are presented on the left side of the boxplots. The asterisk in the center of the graph indicates that there was a significant difference in mean energy intake and needs, as determined by *t* test.

Results

Population characteristics

The mean age of the women was 24.7 ± 3.7 y. Most of the participants were from Greater Cairo (43.1%), and the majority were lower middle class (51.5% of the women were from SEC C2) (**Table 1**). The mean reported weight was 72.2 ± 13.4 kg and the mean reported BMI was 27.6 ± 5.3 ($n = 80$; Supplemental Table 1). After replacing the missing and implausible values with imputed values (38%; $n = 50$; Supplemental Table 1), the mean weight for the 130 women was 73.9 ± 12.9 kg, and the mean BMI was 27.9 ± 4.9 (Table 1).

Energy and nutrient intakes

The mean daily total energy intake (2389 ± 715 kcal) was significantly higher (on average, 254 kcal higher; $P = 0.00018$) than daily energy needs (2135 ± 237 kcal) (**Figure 2**).

The mean total fat (89 ± 32 g/d; 33.4%TEI) and SFA (30 ± 13 g/d; 11.2%TEI) intakes were slightly higher than those specified by the WHO's population goals (15–30%TEI and <10%TEI, respectively) (**Figure 3**). Protein intake (87 ± 28 g/d; 14.6%TEI) was within the recommended range (10–15%TEI), and carbohydrate intake (307 ± 96 g/d; 51.4%TEI) was slightly below the recommended range (55–75%TEI). Approximately one-third of carbohydrates came from total sugars (98 ± 54 g/d; 16%TEI), whereas the WHO recommends a free-sugar intake of <5–10%TEI (43). Fiber intake was 18 ± 8 g/d, which is below the daily recommended intake of 25 g/d.

Mean iron, potassium, vitamin D, and folate intakes were below recommendations (**Table 2**). On average, women had intakes of 13.8 ± 4.6 mg iron/d, whereas their daily needs were 17.5 ± 7 mg iron/d, with 78.5% of women with inadequate intakes (iron bioavailability and needs will be discussed in detail in the following section). More than four-fifths of women consumed less vitamin D (82.3% of subjects had an intake of <5 μg/d), folate (80% of women had an intake of <400 μg/d), and potassium (82.3% had an intake of <4.7 g/d) than the recommended levels. Sodium intake (2787 ± 1065 mg/d) was nearly twice the recommended level, with 93.1% of participants consuming >1500 mg/d and 88% of women consuming >2300 mg/d [which is the upper limit set by the US Institute of Medicine for healthy individuals (44); data not shown]. Mean intakes were within or above recommendations for calcium, copper, iodine, magnesium, phosphorous, zinc, vitamin A, vitamin E, niacin, pantothenic acid, riboflavin, thiamin, and vitamins B-12, B-6, and C.

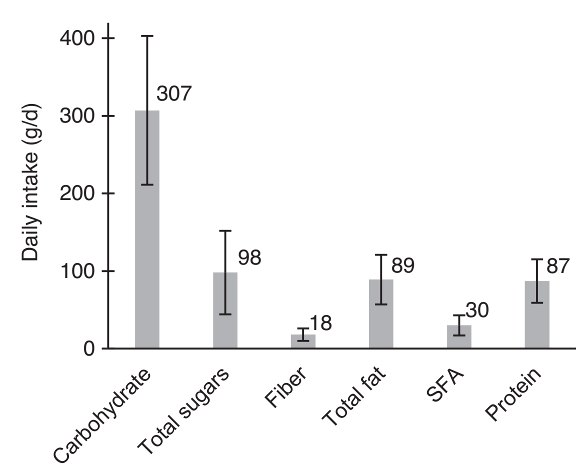

FIGURE 3 Mean daily macronutrient intake in 19- to 30-y-old urban Egyptian women ($n = 130$). Error bars displayed on the figure are standard deviations.

TABLE 2 Mean daily micronutrient intakes in 19- to 30-y-old urban Egyptian women compared with recommended intakes[1]

Micronutrient	Mean ± SD intake	Recommended intake[2]	Mean of the differences[3] (95% CI)	P[4]	Percent of women with inadequate intake[5]
Critical micronutrients[6]					
Iron, mg	13.8 ± 4.6	17.5 ± 7[7]	− 3.7 (−4.7, −2.8)	*	78.5
Potassium, g	3.4 ± 1.2	>4.7	− 1.3 (−1.5, −1.0)	*	82.3
Sodium, mg	2787 ± 1065	<1500	1287 (1102, 1472)	*	93.1
Folate, mg	308 ± 130	>400	− 92 (−115, −69)	*	80.0
Vitamin D, μg	3.27 ± 3.53	5–10	− 1.73 (−2.34, −1.12)	*	82.3
Other micronutrients					
Calcium, mg	1001 ± 392	>1000	1 (−67, 70)	0.9658	56.9
Copper, mg	1.56 ± 0.63	>0.9	0.66 (0.55, 0.76)	*	11.5
Iodine, μg	211 ± 98	>150	61 (43, 78)	*	27.7
Magnesium, mg	458 ± 148	220–310	238 (212, 264)	*	3.1
Phosphorus, mg	1406 ± 438	>700	706 (630, 782)	*	1.5
Zinc, mg	10.98 ± 3.56	7.2–9	3.78 (3.16, 4.39)	*	13.8
Vitamin A, μg retinol equivalent	851 ± 1279	500–700	351 (129, 573)	*	63.1
Vitamin E, μg	11.89 ± 6.36	7.5–15	4.39 (3.28, 5.49)	*	25.4
Niacin, mg niacin equivalent	21.3 ± 10.8	14–16	7.3 (5.4, 9.2)	*	23.8
Pantothenic acid, mg	8.46 ± 18.14	>5	3.46 (0.31, 6.61)	0.0315	68.5
Riboflavin, mg	1.55 ± 0.59	>1.1	0.45 (0.34, 0.55)	*	23.1
Thiamin, mg	1.25 ± 0.43	>1.1	0.15 (0.08, 0.23)	*	41.5
Vitamin B-12, μg	6.02 ± 5.61	>2.4	3.62 (2.65, 4.59)	*	21.5
Vitamin B-6, mg	1.45 ± 0.61	>1.3	0.15 (0.04, 0.25)	0.0072	52.3
Vitamin C, mg	152 ± 94	45–75	107 (91, 123)	*	6.2

[1] $n = 130$. *$P < 0.0025$ (cutoff used for rejecting null hypothesis after Bonferroni correction).
[2] Based on nutrient intakes recommended by the Egypt Health Ministry and the WHO (36).
[3] The mean of differences was calculated as the mean intake minus the recommended intake, using the lower bound of the range when recommendations were expressed as ranges (magnesium; zinc; vitamins A, D, and E; niacin; and vitamin C). A positive difference indicates that mean intakes are above recommendations; a negative difference indicates that mean intakes are below recommendations.
[4] The P values shown are for Welch's 2-sample t tests comparing the intake of and requirement for all nutrients except iron, for which a Student's t test was performed to compare the intake and requirement. When recommended nutrient intakes were expressed as ranges, the lower bound of the range was used as comparison with mean intakes in statistical tests.
[5] For sodium, intakes above the recommendation are labeled as being inadequate. For all other nutrients presented, intakes below the recommendation (or below the lower bound of the range) are considered inadequate.
[6] Nutrients were identified as "critical" when >50% of women had intakes less than the recommendation and the mean intake was significantly lower than the recommendation ($P < 0.0025$ after Bonferroni correction), except for sodium (which was defined as critical given that >50% of women had intakes higher than the recommended amount and the mean intake was significantly higher than the recommendation).
[7] Individual iron requirements for each woman were calculated based on body weight and assuming menstrual losses of 0.56 mg/d (12). A variation in iron requirements of 40% was assumed.

Calculation of iron bioavailability, intakes, and needs

Dietary iron was consumed predominantly in nonheme form (**Table 3**; 12.6 ± 4.3 mg/d of nonheme iron out of the 13.8 ± 4.6 mg iron consumed daily). Given that nonheme iron has a bioavailability of 7.8% ± 0.7%, and assuming a bioavailability of 25% for heme iron (12), the total iron bioavailability was 9.2% ± 1.6%, with the variability coming from diet composition (as serum ferritin was assumed to be 15 μg/L for all women). Dietary intake provided, on average, 1.3 ± 0.5 mg/d of bioavailable iron, whereas the needs were 1.6 ± 0.2 mg/d (**Figure 4**).

Energy and nutrient sources according to food consumption

Table 4 summarizes the contribution of the various food groups to energy, total sugars, protein, total fat, SFA, iron, potassium, sodium, folate, and vitamin D intakes. **Supplemental Tables 4–6** detail the food groups and subgroups that provided all other nutrients.

The 3 food groups with the greatest contribution to mean total daily energy intake were bakery products (351 ± 230 kcal); meat, fish, and eggs (351 ± 199 kcal); and dairy products (290 ± 185 kcal). The 3 food subgroups with the highest contribution to daily total energy intake were refined grain products (e.g., rice, pasta, noodles, couscous) (265 ± 144 kcal), bread (258 ± 167 kcal), and sandwiches (182 ± 248 kcal) (Supplemental Table 4).

Added sugars (25.8 ± 19.2 g) and beverages (21.9 ± 24.5 g) accounted for most of the total sugar intake. Meat, fish, and eggs (29.7 ± 18.5 g); dairy products (16.9 ± 11.5 g); and bakery products (9.5 ± 5.9 g) were the 3 main sources of protein. Total fat was obtained primarily from meat, fish, and eggs (20.1 ± 12.7 g); dairy products (19.6 ± 13.9 g); and composites (mixed food groups) (8.6 ± 9.2 g). At the subgroup level, the main sources of SFAs were white cheese (7.8 ± 7.9 g), milk (2.8 ± 2.8 g), and sandwiches (2.2 ± 3.3 g) (Supplemental Table 4).

Iron was obtained primarily from meat, fish, and eggs (3.16 ± 2.06 mg) and bakery products (2.52 ± 1.90 mg). At the subgroup level (Supplemental Table 5), the primary iron sources were bread (1.97 ± 1.72 mg) and legumes (1.01 ± 1.12 mg), both of which contain only nonheme iron, as well as sandwiches (1.27 ± 2.24 mg),

TABLE 3 Parameters for estimating nonheme iron absorption, iron intake, and iron bioavailability in 19- to 30-y-old urban Egyptian women[1]

	Values
Parameters for nonheme iron absorption calculation[2]	
Serum ferritin, μg/L	15
Vitamin C, mg/d	152 ± 94
Meat, fish, and poultry, g/d	158 ± 105
Black tea equivalents, number of cups/d	1.4 ± 1.0
Phytate, mg/d	1400
Calcium, mg/d	1001 ± 392
Iron intake,[3] mg/d	
Nonheme	12.6 ± 4.3
Heme	1.2 ± 1.3
Total	13.8 ± 4.6
Iron bioavailability, %	
Nonheme[2]	7.8 ± 0.7
Heme[4]	25
Resultant bioavailability from the diet[5]	9.2 ± 1.6

[1]Values are means ± SDs; n = 130. For serum ferritin, phytate intake, and heme iron bioavailability, the same values were assumed for all participants, so there is no SD.
[2]Nonheme iron absorption (assumed to be equal to bioavailability) was estimated using equations from Armah et al. (41).
[3]Intakes were calculated from the 4-d food diary of 19- to 30-y-old Egyptian women and from the proportion of heme and nonheme iron contained in animal-derived foods [Supplemental Table 3; (38, 39)].
[4]Heme iron absorption was assumed to be 25% (12).
[5]Resultant iron bioavailability from the diet was based on heme and nonheme iron intake and bioavailability.

which can contain some animal ingredients. The top 3 sources contributing to potassium intake were meat, fish, and eggs (482 ± 304 mg); potatoes (456 ± 525 mg); and vegetables (447 ± 474 mg). Dairy products (660 ± 539 mg/d; white cheese notably, with 464 ± 482 mg/d; Supplemental Table 5) and meat, fish, and eggs (424 ± 311 mg/d) were the foods that contributed most to sodium intake.

The top 3 sources of folate in the diet of Egyptian women were vegetables (54.0 ± 60.4 μg); legumes, nuts, and seeds (51.8 ± 51.4 μg); and meat, fish, and eggs (39.0 ± 35.2 μg). Nearly all vitamin D intake came from the meat, fish, and eggs group (2.65 ± 3.49 μg), with boneless fish (1.84 ± 3.39 μg), eggs (0.50 ± 0.65 μg), and poultry (0.22 ± 0.28 μg) being the main sources (Supplemental Table 6).

Discussion

A high prevalence of overweight was found in this group of 19- to 30-y-old women from urban areas of Egypt (mean BMI: 27.9 ± 4.9). This is consistent with data from the WHO reporting a mean BMI of 30.6 for Egyptian women (1) and with data from the national Demographic and Health Survey, which reported that 20- to 29-y-old Egyptian women had a mean BMI of 28.2 (2). A low level of physical activity was assumed for calculating energy needs, as previously reported in Egyptians (34, 45), which could be due to cultural and religious barriers or women's safety concerns (8, 34, 46). The food habits of these women were typical of a population undergoing nutrition transition, facing the double burden of malnutrition. Their daily energy intakes were, on average, 254 kcal greater than their needs, which can be a sufficient caloric surplus contributing to an increase in the prevalence of overweight and obesity in the long term. The dietary data revealed unbalanced nutrient intakes, with a high intake of total sugars, SFAs, and sodium and an insufficient intake of vitamin D, folate, potassium, and iron. Data available in previous studies using biochemical measures show consistency with the insufficient intakes of iron (2, 5), vitamin D (18, 19), and folates (20) estimated in our study.

Most women (78.5%) had insufficient iron intakes, and this is consistent with the high prevalence of iron deficiency (50%) and iron-deficiency anemia (25%) in Egyptian women (5). This may be related to the relatively low consumption of heme iron–rich animal products, combined with the daily consumption of black tea and high-phytate food items such as bread, which decreases the bioavailability of nonheme iron (13.8 ± 4.6 mg/d of total iron intake, 1.2 ± 1.3 mg/d of heme iron, and nonheme iron absorbed at a rate of 7.8% ± 0.7%). Given the low number of subjects reportedly taking dietary supplements (n = 8; 6.2%), the insufficient iron intakes could be problematic at the population level, particularly for women of childbearing age. Several assumptions were made when calculating iron bioavailability. Phytate intakes were set at 1400 mg/d for all participants, based on the high consumption of legumes and bread (74 and 97 g/d, respectively). Serum ferritin, which was set at 15 μg/L based on national Egyptian data (5), is the main factor affecting nonheme iron bioavailability (41). Indeed, when iron stores are low (low ferritin concentration), less of the hormone hepcidin is released by the liver, which promotes dietary iron absorption in the gut and iron recycling in the body (47). The results from this study suggest that encouraging careful selection of heme iron–rich animal food sources, the inclusion of vitamin C–rich fruit such as citrus fruit in the diet, and decreased consumption of tea and coffee could improve both iron intake and bioavailability. Future studies warrant concurrent assessment of iron status and dietary intake in this population.

Total fats (33.4%TEI) were consumed in slight excess compared with WHO population goals (15–30%TEI), but complied with European Food Safety Authority (EFSA) and the US Institute of Medicine recommendations [20–35%TEI (48, 49)]. SFAs (11.2%TEI) were consumed in higher amounts than recommended [<10%TEI according to WHO, "as low as possible" according to EFSA (49) and US (48) recommendations], mainly due to the high consumption of white cheese (notably feta cheese, which is high in sodium and SFAs and is widely consumed in Egypt).

Approximately one-third of carbohydrate came from total sugars. Ideally, the contribution of total sugars to carbohydrate intake should be reduced, as the 2 main sources of sugars were table sugar and sugar-sweetened beverages, and the WHO recommends that only 5–10%TEI should come from free sugars (43).

In total, 93% of the women had intakes of sodium in excess of recommendations: on average, twice the recommended amount of sodium intake was consumed (2787 ± 1065 mg/d instead of 1500 mg/d) and 88% of women consumed ≥2300 mg/d. Since high sodium intake increases the risk of high blood pressure, stroke, fatal stroke, and fatal coronary heart disease, the WHO strongly recommends reducing sodium intake to <2000 mg/d (50), and the US Institute of Medicine uses an upper limit of 2300 mg/d of sodium for healthy individuals without hypertension (44). High intakes of sodium (2500–2700 mg/d) have already been highlighted in adolescents (12–18 y old) with and without hypertension from the city of Sohag (51). Reducing cheese consumption or

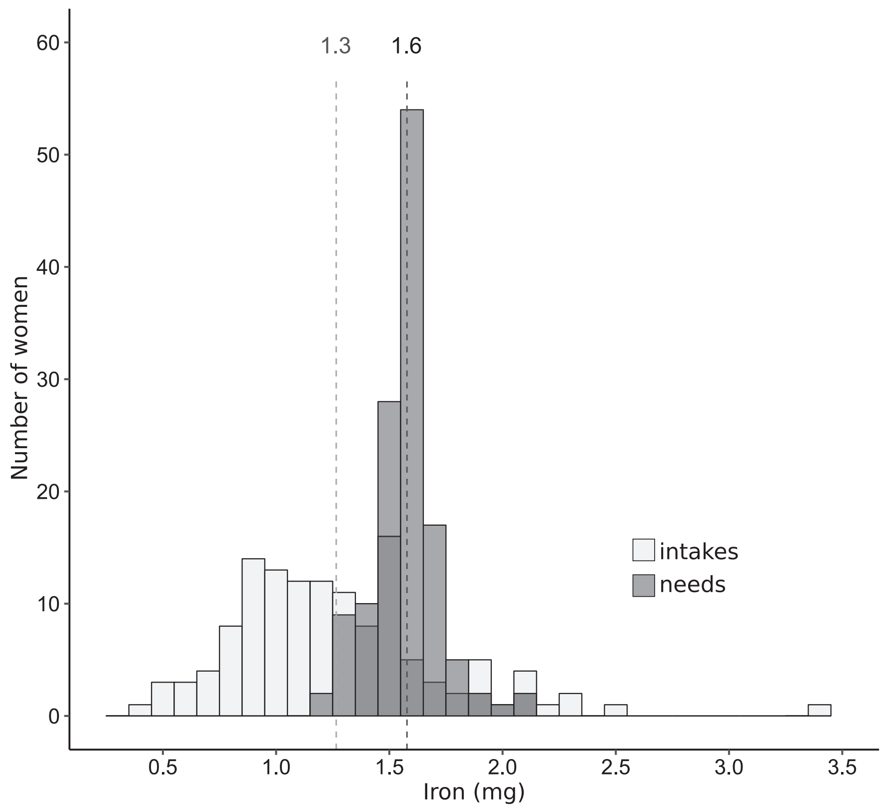

FIGURE 4 Bioavailable iron intake (light gray) and iron losses (dark gray) in 19- to 30-y-old urban Egyptian women (n = 130). The light-gray dashed line represents the mean intake, and the dark-gray dashed line represents the mean losses.

refraining from adding salt at the table or during cooking could help reduce sodium intake. In contrast, potassium intake was below recommendations for 82% of the women, with an average intake of 3.4 ± 1.2 g/d. It is important to note that the Egyptian recommendation for potassium intake (>4.7 g/d) is higher than the EFSA's definition of an adequate intake (3.5 g/d), and that EFSA states that a potassium intake >3.5 g/d tends to decrease the risk of stroke (52).

Vitamin D intakes were below the recommended amount for 82% of the women, which is concerning as most Egyptian women wear veils (53), so vitamin D synthesis from sun exposure is limited. Vitamin D deficiency has previously been identified as a problem in Egyptian mothers (19) and healthy Egyptian females (18) and is often related to limited sun exposure, low fish consumption, a low level of education, and a high BMI (19). Increased vitamin D intake could be encouraged by promoting direct supplementation, the introduction of vitamin D–fortified products, or the selection of appropriate vitamin D–rich foods, such as fish. Young Egyptian women could be encouraged to consume larger portion sizes and/or consume fish more frequently, with suitable advice around healthy preparation, to help increase their vitamin D intake.

Overall, 80% of the women surveyed had an insufficient folate intake. In contrast, a previous study using blood measures suggested that folate intake was less of concern, as only 14.7% of women of reproductive age (20–49 y old) had folate deficiency (serum concentrations <10 nmol/L) (20). In the current study, the main sources of folate were vegetables (especially green leafy vegetables such as spinach or the plant *molokheya*), legumes (with a large consumption of broad beans, consumed as the traditional Egyptian dish *fuul*), and animal products. The Egyptian government launched an initiative in 2008 to increase iron and folate intake by fortifying the national (in Egyptian *baladi*) bread flour with iron and folate (54), but regrettably, the program has now ended. Tailored dietary recommendations that include good sources of folate would help women consume an adequate intake.

The main limitation of our study is linked to the self-reported nature of height and weight values collected in the study. Energy needs were estimated based on self-reported weights, where more than one-third of values were missing or implausible. In order to address this issue, we imputed missing and implausible values based on demographic data on 19- to 50-y-old men and women, and values were similar. Yet, calculated energy needs are only approximations obtained from the data available. The issues that we faced collecting self-reported height and weight highlight the importance of overcoming barriers (such as cultural or practical) in taking direct body measurements. The small sample size of our study population (n = 130) is another limitation, and further research on dietary practices of Egyptian women at the national level could investigate the magnitude of the nutritional imbalances. Additionally, as in any dietary survey, subjects may have misreported or changed their dietary intakes during the days of survey, and the results may not be representative of their habitual dietary intakes. Biochemical indicators of

TABLE 4 Contribution of each food group to energy, total sugars, protein, total fat, SFA, iron, potassium, sodium, folate, and vitamin D intakes in 19- to 30-y-old urban Egyptian women[1]

	Energy, kcal	Total sugars, g	Protein, g	Total fat, g	SFAs, g	Iron, mg	Potassium, mg	Sodium, mg	Folate, µg	Vitamin D, µg
Grains and grain products	273 ± 146	0.8 ± 0.8	7.0 ± 4.2	3.6 ± 2.3	1.4 ± 0.9	0.82 ± 0.67	159 ± 109	132 ± 98	19.3 ± 22.2	0.06 ± 0.06
Bakery products	351 ± 230	12.1 ± 16.8	9.5 ± 5.9	4.3 ± 5.3	1.4 ± 2.2	2.52 ± 1.90	249 ± 159	361 ± 224	3.6 ± 5.4	0.04 ± 0.10
Potatoes	164 ± 189	0.9 ± 1.4	2.2 ± 2.5	7.1 ± 8.2	1.9 ± 2.3	0.58 ± 0.67	456 ± 525	45 ± 72	23.2 ± 26.7	0.00 ± 0.02
Legumes, nuts, and seeds	130 ± 114	0.3 ± 0.3	6.0 ± 5.6	7.0 ± 7.3	0.9 ± 1.1	1.70 ± 1.57	245 ± 230	124 ± 111	51.8 ± 51.4	0.00 ± 0.00
Dairy products	290 ± 185	9.9 ± 8.0	16.9 ± 11.5	19.6 ± 13.9	13.2 ± 9.3	0.35 ± 0.34	321 ± 228	660 ± 539	27.5 ± 17.8	0.37 ± 0.25
Meat, fish, and eggs	351 ± 199	1.0 ± 1.1	29.7 ± 18.5	20.1 ± 12.7	6.2 ± 4.6	3.16 ± 2.06	482 ± 304	424 ± 311	39.0 ± 35.2	2.65 ± 3.49
Fruits	91 ± 98	15.4 ± 17.0	1.3 ± 1.4	0.3 ± 0.4	0.0 ± 0.1	0.70 ± 0.76	364 ± 395	3 ± 3	24.8 ± 27.2	0.00 ± 0.00
Vegetables	71 ± 94	3.9 ± 5.7	2.2 ± 2.4	2.9 ± 7.3	0.4 ± 0.8	0.78 ± 0.71	447 ± 474	125 ± 152	54.0 ± 60.4	0.04 ± 0.13
Added fats	55 ± 107	0.0 ± 0.0	0.0 ± 0.0	6.2 ± 12.0	0.6 ± 1.2	0.01 ± 0.01	0 ± 0	0 ± 1	0.0 ± 0.0	0.00 ± 0.02
Added sugars	106 ± 79	25.8 ± 19.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.20 ± 0.44	29 ± 107	2 ± 7	0.0 ± 0.0	0.00 ± 0.00
Sweetened snack foods (candy and chocolate)	22 ± 48	2.0 ± 4.5	0.2 ± 0.6	1.2 ± 2.6	0.5 ± 1.2	0.08 ± 0.20	13 ± 29	2 ± 7	0.3 ± 0.6	0.01 ± 0.02
Beverages (nondairy)	109 ± 116	21.9 ± 24.5	0.8 ± 0.8	0.3 ± 0.8	0.1 ± 0.2	0.66 ± 1.09	194 ± 179	130 ± 72	32.1 ± 43.1	0.00 ± 0.00
Miscellaneous[2]	20 ± 83	2.1 ± 11.6	0.3 ± 1.1	0.3 ± 1.1	0.1 ± 0.5	0.16 ± 0.51	43 ± 194	264 ± 605	1.9 ± 7.5	0.00 ± 0.02
Composites (mixed food groups)[3]	241 ± 262	1.8 ± 2.1	9.3 ± 10.6	8.6 ± 9.2	2.5 ± 3.3	1.74 ± 2.38	268 ± 287	337 ± 382	24.7 ± 30.2	0.09 ± 0.18
Savory snacks	115 ± 138	0.2 ± 0.6	1.5 ± 1.8	7.0 ± 8.6	0.4 ± 0.9	0.35 ± 0.42	176 ± 234	178 ± 218	5.9 ± 7.2	0.00 ± 0.02

[1] Values are means ± SDs; $n = 130$.
[2] The "Miscellaneous" group includes condiments, herbs, spices, sauces, salad dressing, jam, spreads, and sweeteners.
[3] The "Composites (mixed food groups)" group includes main dishes, sandwiches, soups, and vegetarian dishes that were composed of ingredients from several food groups.

nutrients (e.g., serum ferritin, plasma folate, 25-hydroxyvitamin D) were not measured in this study, but these would have facilitated understanding of the validity of the results. Several assumptions on parameters impacting iron bioavailability were made based on the literature [phytate intakes (42), serum ferritin concentrations (5), menstrual losses (12)], whereas other parameters were not taken into account [e.g., contraception method (55), inflammation (13), parasite infection (12), genetic disease such as β-thalassemia (56, 57)], as data related to these factors were unfortunately not collected in our study. It would have been interesting to compare iron intakes with blood analyses (e.g., serum ferritin, hemoglobin, C-reactive protein) to better understand the root causes of anemia in our population.

The results from this study indicate that 19- to 30-y-old women living in urban Egypt have nutrition transition–like dietary patterns, with notably high energy, SFA, total sugar, and sodium intakes and insufficient iron, vitamin D, and folate intakes. In addition to the nutrient-poor and energy-rich diets reported here, the high prevalence of overweight and obesity in this population poses a greater risk for nutritional deficiencies (13) and related chronic diseases (58). Strategies are needed to increase both iron absorption and intake and to improve overall diet quality. To date, no country-specific, food-based dietary guidelines exist for Egypt (59), while traditional Egyptian foods include a range of very nutritious foods that are high in dietary fiber and low in saturated fat (60), such as legumes (broad beans, chickpeas, etc.), liver, green leafy vegetables, herbs, fruits, dates, and bread (9). The greater availability and consumption of fast foods (9) and subsidized foods (bread, oil, and sugar), which are high in calories, may have played a role in the increasing prevalence of obesity (3), suggesting that it could be helpful to fortify healthier (less caloric, more nutrient-dense) foods. Follow-up work should focus on developing food-based dietary guidelines that include local foods and investigating the potential public health benefits associated with food fortification. Improving the dietary habits of Egyptian women has the potential to improve the health of women, children, and future generations (14–17).

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