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The dietary iron intake and iron status of female university students in Saudi Arabia

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RESEARCH

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ABSTRACT

Background
No prior research in Saudi Arabia has examined dietary iron intake and its association with iron status in young women.

Aims
This study therefore explored the iron intake, dietary iron sources and iron status of female Saudi university students in Tabuk, Saudi Arabia.

Methods
A cross-sectional study of dietary consumption and iron status used a sample of 200 apparently healthy female students (19–25 years old) on the university campus from February to June 2016.

Results
Covariance analyses showed that the prevalence of iron deficiency (ferritin <15ng/ml) and iron deficiency anaemia (ferritin <15ng/ml with haemoglobin <12g/dl) were 50.0 per cent and 12.5 per cent respectively. The three groups' (normal levels of iron; iron deficiency; and iron deficiency anaemia) mean iron intakes fell below recommendations, and the iron deficiency anaemia group's intake was lowest. Different food groups' proportional contributions to total iron intakes varied across the groups, with the iron deficiency anaemia group recording a lower mean consumption of meat-derived foods and a higher mean consumption of plant-derived foods than the other two groups. All three had lower Vitamin C consumption than recommended.

Conclusion
Women of childbearing age face a higher iron deficiency risk, so there is a need to encourage dietary routes for treating or avoiding iron deficiency by increasing iron intake (particularly heme iron) and iron absorption enhancers such as vitamin C, and decreasing consumption of iron absorption inhibitors, e.g., phytate.

Key Words
Iron status, iron intake, sources of iron, female students, Saudi Arabia

What this study adds:

1. What is known about this subject?
In Saudi Arabia, the most common form of micronutrient deficiency is iron deficiency. Different studies have reported an average prevalence of between 30 per cent and 56 per cent.

2. What new information is offered in this study?
The sample's mean iron intakes were below recommendations, and the iron deficiency anaemia group's intake of meat was lowest, with the highest plant-derived foods consumption.

3. What are the implications for research, policy, or practice?
The research builds understanding of female Saudi students'

iron intakes, and informs strategies to influence their iron intakes to prevent iron deficiency anaemia.

Background

Iron is a vital nutrient which plays a key role in numerous physiological processes, including the movement and storage of oxygen, the generation of oxidative energy, deoxyribonucleic acid (DNA) synthesis, and electron transport.[1-3] Although many healthcare advances have been made in recent years, iron deficiency remains a significant public health issue in developed and developing countries alike, with over 30 per cent of the global population affected.[4,5] Over the long term, an individual consuming less than the recommended amount of iron may be more likely to develop iron deficiency anaemia, a condition linked with further adverse health and lifestyle outcomes including an impaired capacity for work, a higher risk of infectious disease, higher risks of maternal and child mortality, lower birth weight and preterm delivery, and potential delays to infants' and young children's growth and development.[6-8] Hence, a reduced prevalence of iron deficiency anaemia and ultimately the prevention of this condition would have multifaceted positive effects on human health, development and quality of life generally, and should therefore be a high priority in monitoring and interventions with regard to the public.[3]

Iron deficiency can be developed at any stage of the human life cycle,[9] but some population subgroups face a particularly high risk of developing iron deficiency.[10] For example, women of childbearing age have a higher risk because of their body's high demand for iron during pregnancy and lactation, and also because of blood loss during menstruation.[11,12] Menstruation is one of the main causes of iron deficiency in women,[13,14] and an inverse relationship has been found to exist between a woman's menstrual flow and her serum ferritin levels.[13] More specifically, daily blood loss during menstruation can vary from around 4–10ml, an amount equivalent to an iron loss of between 2.5mg and 10mg/day,[15] and which means that women need higher daily iron intakes than men, but prior research has nevertheless found that women's iron intakes are usually lower than the recommended level of intake.[13] This means that a high frequency of anaemia among young women is unsurprising; for example, Al Hassan carried out recent research in the Saudi Arabian context with a sample of Saudi female university students, and found that they had a high prevalence of iron deficiency anaemia (64 per cent).[16] A sufficient level of dietary iron which also provides the necessary bioavailability to satisfy the body's demands is particularly vital during this time of life.[11]

Even though the causation of iron deficiency anaemia is complex, the condition usually appears when an individual's iron intake in their diet is lower than their physiological requirements;[11,17,18] therefore, people who have iron deficiency anaemia may not consume enough iron because their diet is either of poor quantity and/or quality, especially in developing countries.[11] Further, individuals' diets in developing countries generally lack adequate iron because of high food costs, restricted access to fresh and suitable foods, and an often limited understanding of nutrition.[19] Research focusing on dietary iron intake and iron providing food sources is of use to, physicians, health educators, dieticians, and policy makers as it helps to build a more comprehensive understanding of which foods drive the iron intakes of particular population groups so that suitable advice and strategies can be designed to improve the iron intakes of individuals at high risk of iron deficiency anemia.[20] With this in mind, and because to the best of the authors' knowledge no research has previously been published in the Saudi Arabian context which has assessed dietary iron intake and explored its effect on young women's iron status, the present study investigates the iron intakes, dietary iron sources and iron status of female Saudi Arabian university students in Tabuk, Saudi Arabia.

Method

Study design and participants

This observational cross-sectional research was performed from February to June 2016 with a convenience sample of 200 apparently healthy female students of between 19 and 25-years-old, all of whom were enrolled in the science, education, or medicine colleges at the University of Tabuk, Saudi Arabia. Individuals who had received an eating disorder diagnosis; who were pregnant or breastfeeding; who were taking medication or nutritional supplements; and/or who were not enrolled as students at the university when recruitment took place were ineligible to participate in the study. All participants were given a full orientation which emphasized their right not to participate, and sent informed consent forms which they returned if they decided to participate.

Data collection

This study was performed on campus at the University of Tabuk, Saudi Arabia, with data collection taking place at various locations which were carefully chosen because of their general ease of access for students from the university's different colleges. A research team made up of a medical doctor, two nurses, a dietician and two laboratory technicians collected the dietary and anthropometric data and took the blood samples from the participants.

Dietary intake

A dietician trained for a week by the study's first author (Riyadh A. Alzaheb) carried out a 24-hour dietary recall survey with each participating student which involved gathering information on all the foods and beverages they had consumed during the preceding 24-hour period, so that their nutrient intake could be estimated from the resulting data. The recall survey form noted the types of foods or drinks consumed, such as the brand name or type of meat or vegetable, the times at which they were consumed, along with the sources of foods or beverages and any supplementary foodstuffs, such as butter or margarine spread on bread or toast, and/or sugar in tea or coffee. Familiar household items (such as bowls, cups and spoons), standard units (such as a slice of bread) and packaged food available to buy in stores (such as packets of crisps (chips), chocolate bars, and sunflower seeds) were used as approximations of portion sizes. Another series of questions was designed to remind the participants about foods which may otherwise be easy to forget, such as cookies, candy, ice cream and nuts. In each case, prior to the completion of the 24-hour dietary recall survey, the dietician asked the participant if they considered the previous 24-hour period to have been a typical day in terms of their diet. If the participant replied that they did not (because, for example, they had dined at a restaurant, or had attended a family gathering or party), then the dietician instead asked them to answer regarding what they had consumed on the day two days before the interview. After the recall completion, all the resulting data were reviewed by the first author (Riyadh A. Alzaheb), and if any omissions were found then the interviewer got back in touch with the student to request the missing information.

The data gathered using the 24-hour recall surveys were coded and entered into WISP (Tinuviel, Llanfechell, Anglesey, UK) by the study's first author (Riyadh A. Alzaheb) for analysis. WISP is a nutrition software program designed to analyse food intake data from 24-hour recalls, which can convert participants' reported food intakes into nutrient intake data. The WISP database includes over 6000 different food items and around 125 nutrients,[21] with food composition tables drawn from McCance and Widdowson's Food Composition Tables (6th ed.).[22] The nutritional composition dataset was also updated in this research with recipes for composite dishes, commercial food products (including newly-released foods), and up-to-date manufacturers' information relating to the foods that the study's participants reported having consumed in their 24-hour recalls.

Calculations were made for each participant's average daily intakes of energy, protein, carbohydrate, fat, dietary fibre, iron, calcium, and vitamin C. The main dietary iron sources were identified by classifying the foods the participants had consumed into the following six groups: Bread and cereals; Meat, poultry, fish, egg and meat alternatives; Milk and dairy products; Vegetables (fresh, processed and dishes); Fruits (fresh, dried and processed); and other products. Food items were also ranked by their contribution to the total iron intake (as percentages), and the highest-ranked food items in terms of contribution to daily iron intake were also listed.

Anthropometric measurements

Body weight was measured to within 100g using medical weighing scales (Seca Ltd., Hamburg, Germany) while participants wore light clothing and no shoes. Height was measured using a portable height measure (Seca Ltd., Hamburg, Germany) to within 0·5cm, while the participant stood upright upon a flat surface without shoes, ensuring in each case that heels and occiputs were in contact with the stadiometer. Each participant's body mass index (BMI) was calculated using the formula: weight (kg) divided by height (m^2). The categories established by the World Health Organization (WHO) were then used to define the BMIs of participants as follows: underweight: <18·5; normal: 18·5–24·9; overweight, 25–29·9; obese, ≥30kg/m^2.[23]

Iron status

Blood analysis was employed to assess the iron status of all participants. A nurse from the research team took two fasting venous blood samples (one EDTA tube and one plain tube) from each participant between 1pm and 3pm on the day the anthropometric and dietary data were collected. The blood samples were immediately transferred to the laboratory in cool boxes. The haematological examinations carried out on the EDTA tube sample were haemoglobin (Hgb), haematocrit (Hct), mean corpuscular haemoglobin (MCH), mean corpuscular volume (MCV), and mean corpuscular haemoglobin concentration (MCHC), each performed via a Beckman coulter LH750 machine which was monitored and calibrated on a regular basis during the study period in accordance with quality assurance procedures. The remaining blood sample was left to clot, and was centrifuged (1,000g at room temperature for 10 minutes). The supernatant serum was then collected to carry out biochemical analyses, in which measurements of serum iron, ferritin and total iron capacity were each taken via a modular machine (Hitachi), which, was monitored and calibrated on a regular basis following standard quality assurance procedures. The study followed the

WHO's anaemia diagnosis criteria by classifying participants as normal in iron status (ferritin >15ng/ml), iron deficient without anaemia (ferritin <15ng/ml), or iron deficient with anaemia (ferritin <15ng/ml with haemoglobin <12g/dl).[24]

Statistical analyses

The research data were analysed using the SPSS for Windows program (version 23.0, SPSS, Chicago, Ill), with continuous variables expressed as mean and standard deviation (SD), and categorical variables expressed as percentages and frequencies. The Kolmogorov-Smirnov test was performed on all the variables to assess their normality; those found not to be normally distributed were logarithmically transformed before further analysis took place. Covariance analyses were used to draw comparisons between the dietary intakes of the three different iron status groups, which were statistically adjusted for energy intake to reduce the possible influence of misreporting in interpreting the results based on the participants' 24-hour recalls.[25] Differences were regarded as significant if $p<0.05$.

Results

A total of 200 Saudi female students studying at the University of Tabuk, with an average age of 21.8±1.6 years, agreed to participate in the present study (Table 1). The prevalence of iron deficiency and iron deficiency anaemia among the study population were 50.0 per cent and 12.5 per cent respectively.

Table 2 compares the daily intakes of macronutrients and of dietary fibre, iron, calcium and vitamin C across three groups of participants: those with normal iron levels; those with iron deficiency; and those with iron deficiency anaemia. No significant differences were found between the three iron status groups' mean intakes of energy, protein, total carbohydrate, or total fibre; however, the fat intake of the group with iron deficiency anaemia was observed to be significantly higher than that of the other two groups. Iron intake levels also substantially differed across the three groups, with the lowest intake recorded by the group with iron deficiency anaemia. In contrast, no significant differences were apparent between the three study groups regarding their calcium or vitamin C intakes. The normal iron group's mean iron intake was very close to the recommended level of 18mg/day at 17.8mg/day, compared to the group with iron deficiency (16.2mg/day) and the group with iron deficiency anaemia (14.6mg/day). Similarly, all three groups' mean calcium and vitamin C intakes were lower than the recommended levels.

Table 3 presents the main contributors to total iron intake. The bread and cereals food group was found to be the highest dietary contributor of iron for all three iron status groups, but its proportional contribution to individuals' daily iron intakes varied, from 32.8 per cent for normal iron status participants to 35.1 per cent for those with iron deficiency, and 38.3 per cent for participants with iron deficiency anaemia. After bread and cereals, the next most important dietary sources of iron both for those with normal iron status and for those with iron deficiency were the meat, poultry, fish, egg and meat alternatives group (23.8 per cent and 21.4 per cent), followed by the milk and dairy products group (17.4 per cent and 16.1 per cent); while for participants with iron deficiency anaemia, the next two most important dietary iron sources were the milk and dairy products group (19.7 per cent), and then the meat, poultry, fish, egg and meat alternatives group (15.3 per cent).

Discussion

The most widespread form of micronutrient deficiency in Saudi Arabia is iron deficiency, with different studies reporting an average prevalence of between 30 per cent and 56 per cent.[26] The prevalence of iron deficiency without anaemia found by this research in its convenience sample of female university students was 50.0 per cent, well within the prevalence ranges reported by prior studies in Saudi Arabia as well as research in other Middle Eastern countries.[27] This study also identified a lower overall prevalence of iron deficiency with anaemia among its student sample (12.5 per cent) than had previously been found by similar studies of iron status among female university students in Saudi Arabia (64.0 per cent),[16] Bangladesh (63.3 per cent),[28] India (44.0 per cent),[29] and the United Arab Emirates (23.2 per cent).[30] Although iron deficiency anaemia has many possible contributing factors among young women, inadequate iron intakes due to diets of insufficient quantity and/or quality are most likely to be key.[11,17,18] However, studies which have gathered Saudi female university students' iron intake data and examined its association with their iron status have been scarce to date. The present study therefore gathered and analysed this data and examined the association in order to assess how Saudi female students' iron statuses are influenced by their dietary iron intake.

This research observed generally inadequate dietary iron intakes among its study population of female students. The average iron intakes of each of the three iron-status groups (normal iron levels; iron deficiency; and iron deficiency anaemia) were each below the recommended 18mg/day.

Statistically significant variations were found between the total iron intakes of the three groups: the students in the iron deficiency anaemia group were found to have lower mean dietary iron intakes (14.6mg/day) than the other two groups (17.8mg/day for the normal group, and 16.2mg/day for the iron deficiency group). There is a lack of previous data on the dietary iron intakes of young women in Saudi Arabia. Similar studies in other countries have established that women's mean iron intakes are frequently inadequate and fall short of recommended levels.[13] For example, research examining the dietary intakes of healthy female Iranian university students found a mean daily iron intake of 13.0±5.0mg/day, a level which is 76 per cent less than recommended level (18mg).[31] Another research study in healthy Australian female university students calculated a mean daily iron intake of 11.2±3.8mg/day; importantly, only 3.7 per cent of the study's participants were found to consume the recommended amount of iron of 18mg/day.[15] Several prior studies have indicated that low iron intakes result in iron deficiency.[32-35] It is therefore important that young women are encouraged to consume foods which are naturally iron-rich because doing so will mean that they are less likely to develop iron deficiency anaemia.

A prior study found that the type of iron (heme versus non-heme) appears to be a more important determinant of iron status than total dietary intake.[17] The reason for this might be that the two different types of dietary iron differ in terms of their bioavailability: more specifically, heme is iron found in animal food sources including red meat, fish and chicken, while non-heme iron is consumed via plant-based foods including fruit, vegetables and grains. Human beings absorb between 25 and 35 per cent of heme iron[36], but only 2–15 per cent of non-heme iron[37], so as the previous research has confirmed, a direct correlation between an individual's total dietary iron intake and their biochemical iron status cannot be assumed.[38] The present research found the meat, poultry, fish, eggs and meat alternatives food group to be the second highest contributor to the study participants' total iron intake, contributing 23.4 per cent to the dietary iron intake of those with normal iron status and 21.4 per cent to the intake of those with iron deficiency; however, this food group was only the third highest contributor to total iron intake for participants with iron deficiency anaemia-, (15.3 per cent). Saudi Arabians generally consume low amounts of red meat and high amounts of plant-based foods, so the pattern found here is common.[39,40] Al-Sayes et al. showed this in their cross-sectional study, which found that a significant proportion of female Saudi university students who had normal iron levels had histories of infrequently (<2 servings/week) consuming red meat (55.5 per cent), but infrequent red meat consumption (<2 servings/week) was the case for 67.1 per cent of iron deficient participants and for 75.3 per cent of those with iron deficiency anemia.[39] Several research studies recently conducted in the Saudi Arabian context have found that female participants who only infrequently consumed red meat (<2 servings/week) faced a higher risk of developing iron deficiency and iron deficiency anemia.[39-41] Similarly, a systematic review of studies of young women living in industrialized countries which had explored the dietary determinants of iron deficiency found that most research had established a positive association between young female participants' iron status and their intakes of meat or heme iron.[17] It therefore appears that dietary changes which result in the consumption of higher amounts of animal-derived foods would be a relatively straightforward intervention to reduce the risk of iron deficiency anaemia among this population group.

The levels of iron absorption inhibitors and enhancers in a diet should also be considered in estimating an individual's iron status because they encourage or restrict iron absorption, mostly of non-heme iron.[42] The most prominent non-heme iron absorption enhancers are vitamin C and unidentified factors present in meat, while the most common non-heme iron absorption inhibitors are calcium, phenolic compounds present in tea and coffee, and phytates in high fibre foods.[42] The present research has found that the bread and cereals food group accounted for the highest proportion of dietary iron for participants with all three iron statuses, but its share of individuals' daily intakes of iron was variable. Middle Eastern populations consume high amounts of small grain cereals,[43] and this is potentially problematic for their diets because phytates are present in cereal-based foodstuffs, making it likely that Middle Eastern consumers will have low absorption of non-heme iron.[3] Various prior studies have performed comparisons of women following omnivore and vegetarian diets in terms of their iron status and have established that the serum ferritin concentrations of vegetarians are lower than those of omnivores.[15] Moving on to focus on the other inhibitors of non-heme iron absorption, and to calcium in particular, no significant difference was found between the three study groups with regard to their calcium intake. Indeed, calcium's significance as an inhibitor remains debatable.[44] Several prior research studies examining samples of young women have identified negative associations between their iron status and intakes of calcium[45,46] or dairy products.[45,47] However, other studies have not found any association to exist between iron status and calcium[48-50] or iron status and the intake of dairy products or milk.[51-53] However, concerning enhancers of iron absorption, dietary non-heme iron from plant-based foods can be absorbed more effectively by dietary vitamin C. In this research, each of the three study groups recorded dietary intakes which fell short of the recommended amount of vitamin C. In the past, several research papers have found that low intakes of vitamin C-rich foods could be associated with a fourfold increased risk of developing iron deficiency anemia.[41,49,54] This means that a potentially effective strategy to prevent iron deficiency would be to boost non-heme iron bioavailability by lowering individuals' intakes of iron inhibitors (phytates) and raising their intakes of iron absorption enhancers (such as vitamin C).

The present research has some inherent limitations. Firstly, the size of its sample of participants, although prior studies examining this aspect of health in similar populations used roughly similar sample sizes.[28-30,41] Secondly, the students who formed the sample did so as volunteers, so they could possibly be regarded as unrepresentative of Saudi Arabia's overall female student population. Thirdly, the research used serum ferritin a marker of iron status, but an individual's ferritin level may be skewed if they are suffering from acute or chronic inflammation because ferritin also acts as an acute phase reactant. Fourthly, this research aimed to assess young women's dietary iron intake and to investigate its effect on their iron status. As such, other factors which are known to affect anaemia such as socio-demographic status, ethnicity, gynaecological/obstetric history and anti-cancer medication, were not examined as they were deemed to lie outside the scope of the research. Fifthly, the reporting of an individual's dietary intake on one single day may not truly represent a usual day for that person. The present research minimized this possible limitation by asking for confirmation from all its participants that the previous day's dietary intake was typical in their lives. If the participant replied that it was not a usual day, they were instead invited to report their dietary intake on the day two days prior to the interview day. Sixthly, when individuals recount their dietary intakes, they can be vulnerable to mis-reporting; possibly leading them to misrepresent their actual intakes.[25] The present research deployed an adjustment method to minimize the potential effect of misreporting on the results and interpretation arising from the 24-hour recall data. Finally, the WISP database's food composition tables are derived from McCance and Widdowson's Food Composition Tables (6th ed.),[22] but the latter lacks fully detailed data on the nutrients contained in the most popular foodstuffs and beverages in Saudi Arabia. The research therefore used WISP's features to give new codes to foods which were found to be absent from the database, so that the nutritional composition dataset was updated to include the contents of composite dishes, commercial food products (including foods which were new to the market), and the latest manufacturers' information on the foods and drinks consumed by the participating female students.

Conclusion

The iron deficiency prevalence in this research's sample of healthy Saudi female students was 50.0 per cent, and 12.5 per cent of participants had iron deficiency anaemia. The mean iron intakes of all three iron-status groups (i.e., normal levels of iron; iron deficiency; and iron deficiency anaemia) fell below the recommended iron intake, and the iron deficiency anaemia group recorded the lowest intake. The research also explored the proportional dietary iron sources of all three iron status groups, finding that the iron deficiency anaemia group had a lower mean intake of meat-based foods (rich in heme iron) and a higher mean intake of plant-based foods (rich in non-heme iron, with a high inhibitory effect on non-heme iron absorption) than the other two groups. Consumption of vitamin C (an enhancer of non-heme iron absorption) was lower than recommended for all three groups. Therefore, a nutritional intervention strategy which aims both to improve dietary iron intake and raise it to an adequate level by encouraging a greater intake of iron-rich foods (particularly heme iron), and to change consumption habits to boost intakes of dietary enhancers and remove inhibitors of iron absorption, would help in reducing young Saudi women's high risk of anaemia. Further research on the effectiveness of dietary interventions targeting young women's iron status is also required.

References

1. Abbaspour N, Hurrell R, Kelishadi R. Review on iron and its importance for human health. J Res Med Sci. 2014;19(2):164–174.
2. Huybrechts I, Lin Y, De KW, et al. Intake and dietary sources of haem and non-haem iron in Flemish preschoolers. Eur J Clin Nutr. 2012;66(7):806–812.
3. Pynaert I, Matthys C, Bellemans M, et al. Iron intake and dietary sources of iron in Flemish adolescents. Eur J Clin Nutr. 2005;59(7):826–834.
4. Jackson J, Williams R, McEvoy M, et al. Is higher consumption of animal flesh foods associated with better iron status among adults in developed countries? A systematic review. Nutrients. 2016 Feb 16;8(2):89.
5. Miller JL. Iron deficiency anaemia: A common and curable disease. Cold Spring Harb Perspect Med. 2013 Jul 1;3(7).

6. Geissler C, Singh M. Review: Iron, meat and health. Nutrients. 2011;3(3):283–316.
7. Murray-Kolb LE. Iron status and neuropsychological consequences in women of reproductive age: What do we know and where are we headed? J Nutr. 2011;141(4):747S-755S.
8. FAO WHO. Vitamin and Mineral Requirements in Human Nutrition. World Health Organisation and Food and Agricultural Organisation of the United Nations: Rome, 2004.
9. Kefiyalew F, Zemene E, Asres Y, et al. Anemia among pregnant women in Southeast Ethiopia: prevalence, severity and associated risk factors. BMC Res Notes. 2014 Nov 3;7:771.
10. Pynaert I, Delanghe J, Temmerman M, et al. Iron intake in relation to diet and iron status of young adult women. Annals of Nutrition and Metabolism. Ann Nutr Metab. 2007;51(2):172–81.
11. De Andrade Cairo RC, Rodriques Silva L, Carneiro Bustani N, et al. Iron deficiency anemia in adolescents; a literature review. Nutr Hosp. 2014 Jun 1;29(6):1240–9.
12. Fayet-Moore F, Petocz P, Samman S. Micronutrient Status in Female University Students: Iron, Zinc, Copper, Selenium, Vitamin B12 and Folate. Nutrients. 2014;6(11):5103–5116.
13. Israeli E, Merkel D, Constantini N, et al. Iron deficiency and the role of nutrition among female military recruits. Med Sci Sports Exerc. 2008;40:S685–S690.
14. Chandyo RK, Henjum S, Ulak M, et al. The prevalence of anaemia and iron deficiency is more common in breastfed infants than their mothers in Bhaktapur, Nepal. Eur J Clin Nutr. 2016 Apr;70(4):456–62.
15. Leonard AJ, Chalmers KA, Collins CE, et al. The effect of nutrition knowledge and dietary iron intake on iron status in young women. Appetite. 2014;81:225–231.
16. Al Hassan NN. The prevalence of iron deficiency anemia in a Saudi University female students. J Microsc Ultrastruct. 2015;3:25–28.
17. Beck KL, Conlon CA, Kruger R, et al. Dietary determinants of and possible solutions to iron deficiency for young women living in industrialized countries: a review. Nutrients, Nutrients. 2014 Sep 19;6(9):3747–76.
18. Ma AG, Chen XC, Zheng MC, et al. Iron status and dietary intake of Chinese pregnant women with anaemia in the third trimester. Asia Pac J Clin Nutr. 2002;11:171–175.
19. Ball K, Mishra GD, Thane CW, et al. How well do Australian women comply with dietary guidelines. Public Health Nutr. 2004;7(3):443–52.
20. Fox MK, Reidy K, Novak T, et al. Sources of energy and nutrients in the diets of infants and toddlers. J Am Diet Assoc. 2006;106:S28–S42.
21. Tinuviel Software: WISP User's Manual. Version 3.0. Intake, Recipe and Menu Nutritional Analysis System. Warrington, UK; 2003.
22. Food Standards Agency: McCance and Widdowson's The Composition of Foods. sixth summaryth edition. Cambridge: Royal Society of Chemistry; 2002.
23. World Health Organization (2000) Obesity: Preventing and Managing the Global Epidemic. Report of a WHO Consultation on Obesity. Technical Report Series no. 894. Geneva: WHO.
24. WHO/UNICEF/UNU (2001). Iron deficiency anemia: Assessment, prevention and control a guide for programme managers. Geneva, World Health Organization, (Document WHO/NHD/01.3).
25. Vandevijvere S, Michels N, Verstraete S, et al. Intake and dietary sources of haem and non-haem iron among European adolescents and their association with iron status and different lifestyle and socioeconomic factors. Eur J Clin Nutr. 2013;67(7):765–772.
26. Verster A, Pols J. Anaemia in the mediterranean region. East Mediterr Health J. 1995;1:64–79.
27. Musaiger AO. Iron deficiency anaemia among children and pregnant women in the Arab Gulf countries: the need for action. Nutr Health. 2002;16(3):161–71.
28. Shill KB, Karmakar P, Kibria MG, et al. Prevalence of iron-deficiency anaemia among university students in Noakhali region, Bangladesh. J Health Popul Nutr. 2014 Mar 32(1):103–10.
29. Bano R, Ahmad N, Sharma BC, et al. Nutrition- al anemia in the medical students. Indian Med Gaz. 2012;1:16–8.
30. Sultan AH. Anemia among female college students attending the University of Sharjah, UAE: prevalence and classification. J Egypt Public Health Assoc. 2007;82:261–71.
31. Azadbakht L, Esmaillzadeh A. Macro and Micro-Nutrients Intake, Food Groups Consumption and Dietary Habits among Female Students in Isfahan University of Medical Sciences. Iran Red Crescent Med J. 2012;14(4):204–209.
32. Alaofe H, Zee J, Turgeon OH. Dietary iron and iron deficiency anemia among adolescent girls from Benin. Rev Epidemiol Sante Publique. 2007;55(3):187–96.
33. Deegan H, Bates HM, McCargar LJ. Assessment of iron status in adolescents: dietary, biochemical and lifestyle determinants. J Adolesc Health. 2005;37(1):75.
34. Pon LW, Noor-Aini MY, Ong FB, et al.Diet, nutritional knowledge and health status of urban middle-aged Malaysian women. Asia Pac J Clin Nutr. 2006;15(3):388–99.
35. Ma A, Chen X, Zheng M, et al. Iron status and dietary intake of Chinese pregnant women with anaemia in the third trimester. Asia Pac J Clin Nutr. 2002;11(3):171–5.

36. Hurrell R, Egli I. Iron bioavailability and dietary reference values. Am. J. Clin. Nutr. 2010;91(5):1461S–1467S.
37. Hunt JR, Roughead ZK. Nonheme-iron absorption, fecal ferritin excretion, and blood indexes of iron status in women consuming controlled lactoovovegetarian diets for 8 wk. Am. J. Clin. Nutr. 1999;69(5):944–52.
38. Tetens I, Bendtsen K, Henriksen M, et al. The impact of a meat- versus a vegetable-based diet on iron status in women of childbearing age with small iron stores. Eur J Nutr. 2007;46:439–445.
39. Al-Sayes F, Gari M, Qusti S, et al. Prevalence of iron deficiency and iron deficiency anemia among females at university stage. J Med Lab Diagn. 2011;2:5–11.
40. Alquaiz AM, Gad Mohamed A, Khoja TA, et al. Prevalence of anemia and associated factors in child bearing age women in Riyadh, Saudi Arabia. J Nutr Metab. 2013; 636585–10.
41. Al-Quaiz JM. Iron deficiency anemia. A study of risk factors. Saudi Med J. 2001;22(6):490–496.
42. Patterson A, Blumfeild M. Iron Deficiency and Its Prevention in the Australian Context: A systematic Review of the Literature; Meat & Livestock Australia: Newcastle, Australia, 2009.
43. Aboul-Ata AE, Mazyad H, El-Attar AK, et al. Diagnosis and control of cereal viruses in the Middle East. Adv Virus Res. 2011;81:33–61.
44. Gibson S. Iron intake and iron status of preschool children: Associations with breakfast cereals, vitamin C and meat. Public Health Nutr. 1999;2(4):521–8.
45. Galan P, Yoon HC, Preziosi P, et al. Determining factors in the iron status of adult women in the SU.VI.MAX study. Eur J Clin Nutr. 1998;52(6):383–8.
46. Rangan AM, Aitkin I, Blight GD, et al. Factors affecting iron status in 15–30 year old female students. Asia Pac J Clin Nutr. 1997;6(4):291–5.
47. Galan P, Hercberg S, Soustre Y, et al. Factors affecting iron stores in French female students. Hum Nutr Clin Nutr. 1985;39(4):279–87.
48. Asakura K, Sasaki S, Murakami K, et al. Iron intake does not significantly correlate with iron deficiency among young Japanese women: A cross-sectional study. Public Health Nutr. 2009;12(9):1373–83.
49. Cade JE, Moreton JA, O'Hara B, et al. Diet and genetic factors associated with iron status in middle-aged women. Am J Clin Nutr. 2005;82(4):813–20.
50. Leonard AJ, Chalmers KA, Collins CE, et al. The effect of nutrition knowledge and dietary iron intake on iron status in young women. Appetite 2014;81:225–231.
51. Pynaert I, de Bacquer D, Matthys C, et al. Determinants of ferritin and soluble transferrin receptors as iron status parameters in young adult women. Public Health Nutr. 2009;12(10):1775–82.
52. Blanco-Rojo R, Toxqui L, Lopez-Parra AM, et al. Influence of diet, menstruation and genetic factors on iron status: A cross-sectional study in Spanish women of childbearing age. Int J Mol Sci. 2014 Mar 6;15(3):4077–87.
53. Rigas AS, Sorensen CJ, Pedersen OB, et al. Predictors of iron levels in 14,737 Danish blood donors: Results from the Danish Blood Donor Study. Transfusion. 2014;54(3 Pt 2):789–96.
54. Cook J, Reddy M. Effect of ascorbic acid intake on nonheme- iron absorption from a complete diet. Am J Clin Nutr. 2001;73(1):93–8.

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PEER REVIEW

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

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Ethical approval was granted for the research by the Committee of Research Ethics at the University of Tabuk (HAP-07-TU-001).

Table 1: Key characteristics of the study population of female students (n=200)

Characteristic	Values
Age in years (Mean±SD)	21.8±1.6
Marital status (n, %)	
Single	87 (43.5)
Married	113 (56.5)
Monthly household income (n,%)	
< 5000 SR	39 (19.5)
5000 – 15,000 SR	131 (65.5)
> 15,000 SR	30 (15.0)
Body mass index (BMI) (n, %)	
Underweight (<18 kg/m2)	29 (14.5)
Normal (18-24.9 kg/m2)	73 (36.5)
Overweight (≥25-<30 kg/m2)	64 (32.0)
Obese (≥30 kg/m2)	34 (17.0)
N, number of participants in group; SD, standard deviation; SR, Saudi Riyal (≈0.35 Australian dollars).	

Table 2: Intakes of nutrients among the study population according to their iron status (n=200)

	DRI	Iron status						p-value
		Normal *(n = 75, 37.5%)*		Iron deficiency *(n = 100, 50.0%)*		Iron deficiency anemia *(n = 25, 12.5%)*		
		Mean±SD	Adequacy (%)	Mean±SD	Adequacy (%)	Mean±SD	Adequacy (%)	
Energy (kcal)	-	2139±234	-	2086±247	-	2153±327	-	.280
Protein (g)	-	71.2±16.2	-	66.5±12.7	-	69.7±13.7	-	.097
Carbohydrate (g)	-	312.4±53.4	-	296.3±45.5	-	291.6±54.7	-	.061
Total fat (g)	-	82.8±16.2	-	78.1±12.5	-	86.0±18.4	-	0.02
Dietary fiber (g)	-	13.2±3.7	-	12.9±4.1	-	14.0±5.3	-	.530
Iron (mg)	18	17.8±2.2	99	16.2±1.4	90	14.6±2.3	81	.000
Calcium (mg)	1000	930±106	93	935±90	94	932±116	93	.983
Vitamin C (mg)	75	63.9±17.9	85	61.2±19.9	81	60.4±20.2	80	.583

DRI, Dietary Reference Intake values; N, number of participants in group; SD, standard deviation.

Table 3: Dietary sources of iron among the study population according to their iron status (n=200)

Iron status		
Normal *(n = 75, 37.5%)*		
Rank	**Food group**	**% of Total**
1	Bread and cereals	32.8
2	Meat, poultry, fish, egg and meat alternatives	23.8
3	Milk and dairy products	17.4
4	Vegetables (fresh, processed and dishes)	14.3
5	Fruits (fresh, dried and processed)	7.2
6	Other products*	4.5
Iron deficiency *(n = 100, 50.0%)*		
Rank	**Food group**	**% of Total**
1	Bread and cereals	35.1
2	Meat, poultry, fish, egg and meat alternatives	21.4
3	Milk and dairy products	16.1
4	Vegetables (fresh, processed and dishes)	11.7
5	Fruits (fresh, dried and processed)	8.2
6	Other products*	7.5
Iron deficiency anemia *(n = 25, 12.5%)*		
Rank	**Food group**	**% of Total**
1	Bread and cereals	38.3
2	Milk and dairy products	19.7
3	Meat, poultry, fish, egg and meat alternatives	15.3
4	Vegetables (fresh, processed and dishes)	12.8
5	Fruits (fresh, dried and processed)	7.5
6	Other products*	6.4
*This rank denotes foods or food components which did not fit into the other categories. Examples include desserts, cakes, quiches, pizzas, other miscellaneous foods, and beverages.		