Dietary Intake and Food Behaviours of Senegalese Adolescent Girls

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Abstract

Background: Malnutrition is a public health concern in low- and middle-income countries. In Senegal, 35% of adolescent girls are undernourished and 56% are anemic.

Methods: This study assessed dietary intake of adolescent girls aged 14-18 years in Dakar, Senegal. Specifically, the study 1) assessed their energy, fibre, macro- and micronutrient intakes, 2) described the types and the quality of the foods they consume, and 3) assessed some of their eating behaviours.

Dietary intake was measured using three non-consecutive 24-hour recalls from 136 adolescent girls attending two colleges. Energy and nutrient intakes were assessed and compared to recommendations. Foods were classified by food group and by whether they were healthy or unhealthy. Proportions of girls who ate breakfast as well as their daily intake (g) of fruits and vegetables were calculated.

Results: Sodium intake was high while fibre intake was low. On average, 40% of the adolescents' total energy intake came from fats. Mean intakes of zinc and calcium were higher in the weekend as compared to weekdays while the opposite was observed for sodium. Prevalence of inadequate intakes was above 80% for iron while almost 100% were at risk of calcium deficiency. Approximately 60% of the foods consumed were classified as healthy, however the majority of healthy foods came from grains.

Conclusions: Adolescent nutrition deserves attention given the poor quality of their dietary intake which may put them at risk of malnutrition and chronic diseases. These findings may be used to help improve programs targeting Senegalese adolescent girls' nutrition.

Background

In low- and middle-income countries (LMIC), malnutrition, including micronutrient deficiencies and overnutrition, is a public health concern (Development Initiatives 2018; World Health Organization (WHO) 2019). So far, efforts have been made to improve the dietary intake of children in LMIC, targeting primarily the first 1 000 days of life (UNICEF 2019). However, adolescence represents a second window of opportunity for nutrition interventions, as it is a period of rapid growth and psychosocial development which makes this group particularly vulnerable to malnutrition (UNICEF 2019). Given the central role of adolescent girls and women in LMIC societies and households as caregivers, as well as food and income suppliers, there is a need for interventions to focus specifically on improving adolescent girls' nutrition.

Globally, approximately 10% of children and adolescents are underweight and 20% are overweight or obese. In Sub-Saharan Africa, these proportions are at 7% and 10% respectively (UNICEF 2019). In Senegal, a Sub-Saharan African country, the prevalence of adolescent girls who are underweight (BMI < 18.5) is much higher, at 35%, while 7% are overweight or obese (BMI ≥ 25.0) (Agence nationale de la statistique et de la démographie (ANSD) & ICF International 2012). In addition to high rates of underweight, Senegal was ranked first out of 185 countries with the highest prevalence of anemia among women 15-49 years old (International Food Policy Research Institute 2016). In fact, 2018 data show that 57% of Senegalese adolescent girls were anemic (ANSD & ICF 2018). Iron deficiency and iron deficiency anemia are of great public health concern, especially among adolescent girls whose iron needs are high due to growth spurts and the onset of menstruation (UNICEF 2019). Consequences of iron deficiency and iron deficiency anaemia on children and adolescents have been well documented (Administrative Committee on Coordination (ACC) / Subcommittee on Nutrition (SCN) 2000) and include poor growth, poor academic performance and increased risk of infection (Dallman 1989). While iron deficiency has clearly shown to be problematic, other micronutrient deficiencies have also been reported, such as calcium, zinc and vitamin A (Fiorentino et al. 2013).

Worldwide, the diet of adolescent girls is usually inadequate to meet their nutritional needs (Keats et al. 2018). Results from a systematic review on diet and eating practices among adolescent girls living in LMIC showed that only 30% of them consumed fruits and 20% consumed vegetables on a daily basis (Keats et al. 2018). This same study reported that approximately 40% of adolescents consumed carbonated soft drinks at least once a day while 20% ate fast foods, and over two thirds of them ate salty, fried and /or sweet foods four to six times a week (Keats et al. 2018). Furthermore, results showed that 50% of adolescent girls did not consume three meals per day and 60% had lunch outside their home (Keats et al. 2018).

Despite numerous researchers and international organizations underlining the need to prioritize adolescent nutrition in LMIC (UNICEF 2019; Independent Accountability Panel for Every Woman, Every Child, Every Adolescent 2017; Black et al. 2013), so far, data on this population remain scarce. The United Nations Children's Fund (UNICEF 2019) has also reiterated the need to collect data on adolescents' diet to better understand their eating patterns, as this information is needed to help design appropriate and effective nutrition interventions.

Based on the UNICEF conceptual framework of the determinants of malnutrition (UNICEF 1990), this study aimed to describe the dietary intake and food behaviours of adolescent girls aged 14 to 18 years old attending two colleges of the Dakar region in Senegal. Specifically, this study investigates their energy, fibre, macro- and micronutrient intakes, describes the types and the quality of the foods they consume, and assesses some key eating behaviours. In addition, differences in dietary intakes between weekend days and weekdays were investigated given that adolescents spend a significant amount of their time at school during weekdays (Carducci et al. 2018), thus exposing them to a different food environment than that of their home.

Methods

Study site

This study was conducted in Dakar, the capital and largest city of Senegal, West Africa. Senegal has a tropical climate and two main seasons: the dry (October-June) and the rainy (July-September) seasons. Rice, millet, and corn and groundnut are the major food crops grown in this country (The Food and Agriculture Organization of the United Nations (FAO) 2019). This study site was chosen since approximately 20% of all Senegalese girls between 15 and 19 years old were living in the Dakar region in 2017 (ANSD 2018). Moreover, adolescents living in urban areas in LMIC are at high risk for the double burden of malnutrition due to the nutrition transition which brought significant shifts in dietary patterns and food consumption (Caleyachetty et al. 2018; World health organization 2017).

Theoretical framework

According to the UNICEF conceptual framework on the causes of malnutrition, dietary intake and health status are the immediate determinants of child nutritional status which in turn, depend on underlying determinants such as access to adequate food, access to health care (which include food behaviours) and to a healthy food environment (UNICEF 1990). This study focused primarily on dietary intake, as well as on food behaviours.

Study design and sample

This cross-sectional study used data which were collected over an eight-week period (January to February 2019) as part of a larger study that investigated psychosocial and environmental factors associated with the consumption of iron-rich foods among adolescents. The sample size for this larger study was estimated using the Gpower software (version 3.1.9.2, Fault, F., Universität Kiel, Germany), which considered a significance level (α) of 5%, a statistical power of 80% and a medium effect size of 15%. A non-response rate of 5% was considered for the calculation of the final sample size which was estimated at 134. Two colleges were purposively selected in the Greater Dakar Area of the Dakar district. This district has the largest population in the region and has the most secondary level schools (ANSD 2008). In each college, all adolescent girls aged 14-18 years old were eligible and invited to participate in the study. Written informed assent and consent were provided respectively by each girl and her parents prior to data collection. All methods were carried out in accordance with relevant guidelines and regulations.

Preparatory Work

Local research assistants (n = 17) were recruited and trained in the city of Dakar on data collection methods and tools over a 3-day period. Research assistants were considered for recruitment if they were fluent in Wolof (national language), available for the entire duration of the study and had previous experience in health research. This training was provided to ensure that the data collected through 24-hour food recalls and household questionnaires would be accurate and complete.

Data Collection

Food intake, eating behavioursand health status

Food intake and eating behaviours were assessed through three non-consecutive 24-hour recalls covering two different weekdays and one weekend day. A 24-hour recall is a valid assessment tool for estimating the relative intake of all foods consumed within a 24-hour period (Gibson 2005). Each recall was performed by a trained research assistant through an interview of approximately 30-45 minutes with each adolescent girl, in a quiet area in her college. Quantities of foods consumed were estimated using local utensils, bowls, plates and cups as well as plastic food models or actual foods, when possible. To estimate the nutritional value of home-cooked dishes, recipes were obtained from direct observation of three local women while they prepared these dishes. At least two recipes of each dish were cooked by each woman. All prepackaged foods listed in the adolescents' food recalls were purchased from street vendors near the colleges in order to record the nutritional content from the nutrition facts table.

Information obtained through the 24-hour recalls was also used to identify adolescents' eating behaviours. These included eating breakfast, having three meals daily and eating meals outside of the home.

Since certain illnesses, such as fever, diarrhea and dental caries can impact food intake, the current health status of each adolescent was recorded at the beginning of each 24-hour recall interview. Specifically, the adolescent was asked to report whether or not she was sick or had an illness that could impact her appetite or food intake on the day prior to the recall. Each adolescent was classified in good health if she reported not having an illness that impacted her dietary intake on each of the three days of the 24-hour recalls.

Household socioeconomic characteristics

Data on socio-demographic characteristics were collected using a standardized validated questionnaire that has been used during national surveys in the past decades (USAID 2020). The questionnaire was administered through an interview conducted with each adolescent girl's head of household and their spouse, when applicable. Information on the number of individuals in the household, housing conditions (e.g. presence of toilet or drinkable water), ownership of assets (e.g. television or air conditioning) and access to property (e.g. owner or tenant) were gathered.

Data analysis

Food intake

Data from the 24-hour recalls, including water intake, were entered in the Nutrific Software (version 1.1, 2018, Laval University, Quebec City, Canada) by the first author of this paper. Thereafter, data entered from each recall were reviewed by a trained dietitian with extensive experience in food intake data entry. Specific nutritional values from the nutrition facts tables of prepackaged foods purchased in the research area as well as data from West African Food Composition Table (Stadlmayr et al. 2012) were added to the Nutrific software database. The food composition of each recipe was entered directly in the software and the nutritional value for 100 g was calculated.

Each food consumed in this study was classified into one of the following 14 groups (Keats et al. 2018; FAO & FHI 360 2007) : 1) fruits, 2) vegetables, 3) grains, roots, tubers and plantains, 4) milk and dairy products, 5) meat and fish, 6) nuts and seeds, 7) eggs, 8) legumes, 9) condiments, 10) fried and salty foods (e.g. chips), 11) sweets (e.g. candy, ice cream, cookies), 12) fast food (e.g. burger, pizza, street foods), 13) sugary drinks, and 14) oils and fats. Mean daily quantities (in grams / g) of foods consumed per food group were calculated.

Each food and dish obtained from the recalls was also classified as healthy or unhealthy based on steps and criteria used by New Brunswick's Department of Education and Early Childhood Development Policy 711, which aims to create healthy food environments in schools (New Brunswick Department of Education and Early Childhood Development (NBDEECD) 2018) (Table 1). In step 1, each food was cross-referenced with the foods listed as "Higher Nutritional Value" or "Lower Nutritional Value" Foods. Foods were classified as healthy if they appeared in the "Higher Nutritional Value" list and classified as unhealthy if they appeared in the "Lower Nutritional Value" list. If the food was not listed, criteria enumerated in step 2 were used to classify it a healthy or not (Table 1). For dishes combining foods form different groups such as onion sauce, different types of sandwiches or local stews, the classification was based on the total amount of kilocalories consumed for each dish (Table 1). For example, if the total quantity eaten ranged between 100 and 199 kilocalories, the dish would have to contain less than 2 g of saturated fat and less than 400 mg of sodium to be considered as healthy. If the dish did not respect the above criteria, it was classified as unhealthy. Beverages classified as healthy were water, unsweetened milk and 100% pure fruit or vegetable juice (NBDEECD 2018).

For this study, micronutrients of interest included iron, calcium, zinc, and vitamins A and C given that intakes of these nutrients have been reported as potentially problematic in Senegal (ANSD 2018; Fiorentino et al. 2016; Balla & Chowdhury 2015; Fiorentino et al. 2013). In addition, intakes of kilocalories (kcal), fibre, fats and sodium were also assessed given that previous studies have reported suboptimal intakes among African adolescents (Keats et al. 2018; Fiorentino et al. 2013). The mean daily intake for energy and for each nutrient of interest was calculated for each adolescent using data from her three 24-hour recalls.

First, for all adolescents, data on dietary intakes obtained from the 24-hour recalls were adjusted for day-to-day variability (Institute of Medicine 2000a). Then, the estimated average requirement (EAR) cut-point method was used to determine the prevalence of insufficient intakes for zinc, calcium, vitamins A and C, as per international recommendations (International Zinc Consultative group (IZiNCG), 2019; WHO' FAO & United Nations University (UNU) 2004; Institute of Medicine of the National Academies 2000b). For fibre and sodium, proportions of adolescent girls whose intakes were below WHO`s recommendations of 25 g and the limit of 2 g per day respectively, were calculated (WHO & FAO 2003). To assess the probability of inadequate iron intake among adolescent girls, the probability approach (Carriquiry 1999; National Research Council 1986) was used considering a diet with 10% of iron bioavailability as recommended by the WHO / FAO / UNU (2004). Lastly, proportions of energy intake from each macronutrient (protein, fats and carbohydrates) were also calculated.

Eating behaviours

Proportions of adolescents who had breakfast and who ate three meals every day of the three days of data collection were calculated. The number per day of meals consumed outside of the home was also assessed. In this study, a meal consisted of a food from the group grains, roots, tubers and plantains (e.g. rice or bread), and of at least one food from another food group. Given the importance of vegetables and fruits in a healthy diet (WHO & FAO 2003), the mean daily total consumption of vegetables and fruits (g), as well as the mean daily intake of vegetables (g) and fruits (g) separately, were calculated. The proportion of adolescents consuming at least 400 g daily of vegetables and fruit (WHO & FAO 2003) was also assessed. Finally, the mean daily intake (g) of foods coming from each food group was calculated and compared to the EAT-Lancet reference diet, the first global benchmark diet susceptible of sustaining health and protecting the planet (Willett et al. 2019).

Statistical analyses

Normality of the distribution for continuous variables was examined by visual inspection of the probability plots and with the Kolmogorov-Smirnov test. Except for protein and fibre, all other nutrients were log transformed given that their distribution did not meet normality assumptions (Carriquiry 2003&1999; National Research Council 1986). Descriptive analyses were conducted to depict dietary intakes and paired t-tests were performed to assess differences in energy, nutrient and food intakes between weekdays and weekend days. Data were analyzed using the SPSS software (version 26, IBM Corporation, Armonk, NY, USA). For all analyses, a probability value of 0.05 was considered significant.

Results

The mean age of adolescents was 15 years old (± 1.2 years). Most of them (93%) were healthy at the time of the data collection. They were living in households with a mean size of 8 (± 3.7) individuals. Heads of households were mostly male (60%) and many had no formal education (41%).

The mean daily energy intake of adolescents was approximately 2 550 kcal (Table 2). Zinc (9 *vs* 7 mg, p = 0.019) and calcium (575 *vs* 488 mg, p = 0.006) intakes were higher on weekend days as compared to weekdays. In contrast, sodium intake was higher over the weekdays (p = 0.013). There was no difference between weekend days and weekdays in mean intakes of energy, protein, fats, carbohydrates, fibre, vitamins A and C as well as iron. Overall, the greatest proportion of energy came from carbohydrates, (48%), followed by fats (40%) and protein (12%). No differences were observed between weekend days and weekdays in proportions of energy from each macronutrient.

Proportions of adolescents for whom vitamin A and C intakes were below the EAR were 23% and 54% respectively, while 100%, 82% and 55% of them had intakes below the EAR for calcium, iron and zinc respectively (Table 2). Two thirds of adolescent girls had sodium intakes that were above the international recommendation and more than 95% had intakes below the recommendation for fibre.

On total, 727 g (SD ± 263) of healthy and 487 g (SD ± 286) of unhealthy foods were consumed by adolescents on a daily basis (Figure 1), which represent 60% and 40% of their total food intake respectively. There were no significant differences in mean intakes of total quantity of healthy or unhealthy foods between weekend days and weekdays. However, more healthy foods were consumed on weekend days, weekdays and all days/ overall (p = 0.000). Approximately 70% (504 g) of the total amount of healthy foods came from grain products (Table 3). White rice and white bread represented 37% and 10% of all grain products consumed, respectively (results not shown). Foods from the meat / poultry / fish and eggs food groups accounted for 14% (100 g) of total intake, fruits accounted for 7% (51 g), and vegetables accounted for 4% (32 g). Fast foods accounted for 31% (150 g) of the total amount of unhealthy foods consumed, followed by sweets at 29% (139 g) and sugary drinks at 27% (129 g). The mean daily consumption of plain water was 693 ml. There were no differences in food group intakes between weekend days and weekdays.

When compared to the EAT-Lancet reference for a healthy diet, descriptive analyses showed that the mean daily consumption of adolescent girls were larger than the reference values for grain products (504 *vs* 232 g, p = 0.000) and meat / poultry / fish (90 *vs* 71 g, p = 0.000). In contrast, consumption of legumes (20 *vs* 100 g, p = 0.000), milk and dairy products (20 *vs* 250 g, p = 0.000), eggs (10 *vs* 13 g, p = 0.007), and fruits and vegetables (83 *vs* 423 g, p = 0.000) was lower than the EAT-Lancet reference values.

Two-thirds of adolescents ate breakfast, 65% had three meals daily and 93% consumed at least one meal outside their home each day. Only 5% of them consumed more than 200g of fruits per day in average and none consumed more than 300g of vegetables.

Discussion

This is the first study to provide a comprehensive overview of the dietary intake of adolescent girls living in the Dakar region, Senegal. Despite the fact that healthy foods represented more than half of their total dietary intake, on average, their daily consumption of unhealthy foods was also high, and so were their intakes in fats and sodium. Differences in weekday and weekend dietary intakes were also noted. Specifically, mean intakes of calcium and zinc were higher on the weekend than on weekdays, while the opposite was observed for sodium. Our findings also show that while intakes of healthy foods were higher than that of unhealthy foods, fibre, iron and calcium intakes remained inadequate while intakes of other nutrients such as zinc and vitamins A and C appeared to be sufficient. Most of the healthy foods consumed by adolescent girls came from the grains, tubers, roots and plantains food group. They also consumed moderate amounts of foods from the meat / poultry / fish and egg groups but a small quantity of milk and dairy products. The daily consumption of fruits and vegetables was also below the WHO`s recommendation. Despite eating foods from a variety of food groups, the daily consumption of foods among adolescent girls did not generally meet the recommended EAT-Lancet reference for a healthy diet. Nevertheless, some positive behaviours were observed in the majority of adolescent girls such as drinking water, eating three meals a day and having breakfast.

Energy and nutrient intake

In our study, adolescents consumed an average of approximately 2 550 kcal per day, which is in line with the estimated energy requirements for girls in this age group, regardless of physical activity level. In fact, energy requirements for adolescents aged between 14-17 years old vary from 2 075 kcal (considering a low level of physical activity) to 2 875 kcal (high level of physical activity) (FAO 2001). In contrast, a study among children and adolescents (5-19 years old) conducted in 2010 in the Dakar region found that the mean daily energy intake was 1 400 kcal (Fiorentino et al. 2016). This difference of energy intake may be partially explained by the inclusion of both children and adolescents in Fiorentino et al.'s study. These differences may also reflect a change in food behaviours among adolescents due to the increase in the number of street food and fast food outlets in the Dakar region over the past decade (Marras, Salmivaara, Bendech & Seki 2017). However, our results are similar to Dapi et al.'s findings who reported a mean daily energy intake of 2 297 kcal among adolescent girls (n = 119) living in urban Cameroon (Marras, Salmivaara, Bendech & Seki 2017).

In terms of macronutrient intakes, the most concerning finding was that adolescents in our study consumed, on average, 110 g of fats per day. These findings are well above those of Keats et al. (2018) who reported that the mean daily intake of fats was 36 g among adolescent girls aged 15-19 years living in Africa, and also, slightly higher than the 70-75 g daily intakes reported by Dapi et al. (2011) and Napier & Hlambelo (2014) among adolescent girls in urban Cameroon and South Africa respectively. In addition, about 40% of the total daily calories consumed by adolescents in our study came from fats, a proportion slightly higher than the 30% reported by Fiorentino et al. (2016) and Dapi et al. (2011) as well as the 34% observed in Napier et al.`s study (Napier & Hlambelo 2014). This high intake in fats may be related to our finding that 78% of girls reported eating fast foods daily, with a mean intake of 150 g per day, as these tend to contain high quantities of fats. Overall, these findings are worrisome as an excessive intake of fats, particularly saturated fats (which are commonly found in fast foods), increases adolescents' risk of becoming overweight or obese and of developing chronic diseases in adulthood, such as cardiovascular diseases (Anand et al. 2015).

On average, adolescents in our study had an intake of only 15 g of fibre per day, which is well below the recommended daily intake of 25 g (WHO & FAO 2003). It is also well below the 30 g previously observed among adolescent girls in urban Cameroon (Dapi et al. 2011) although similar to the intake (17 g) reported by Napier & Hlambelo (2014) in South Africa. In fact, 98% of adolescents had insufficient intakes of fibre, which is slightly higher than the proportion (88%) reported by Fiorentino et al. (2016). Our findings may be partially explained by the low intake of vegetables and fruits. Similarly to others (UNICEF 2019; Keats et al. 2018), only 46% of adolescent girls consumed fruits and vegetables every day. Therefore, promoting vegetables and fruit is important, not only to provide essential micronutrients to their diet, but also to increase their intake in fibre.

As previously mentioned, iron deficiency in LMIC has been well documented, and our findings add to this body of literature. In our study, the average daily iron intake was 10 mg, which is well below the recommended daily nutrient intake of 30 mg for a diet with 10% of bioavailable iron (WHO, FAO & UNU 2004). Among our sample, 82% of the adolescent girls were at risk of inadequate iron intakes, as compared to Fiorentino et al.'s study which reported that 55% of children and adolescents had insufficient iron intakes. Among adolescent girls, Dapi et al. (2011) estimated that approximately 50% of them had iron intakes that were below the EAR. In our study, the high proportion of adolescent girls who were at risk of inadequate iron intakes may be attributed to the moderate consumption of iron-rich foods from the meat / poultry / fish and eggs groups. In fact, the mean daily average intake of foods from these two groups combined was only 100 g. It is worth noting that there were large variations in intakes of these foods. For example, only 14% of adolescent girls reported having consumed eggs over the 3-day period while 50% reported eating, on average, more than 90g of meat / poultry / fish during the same period. Our findings may also be partially explained by the iron bioavailability reference used in this study. Specifically, to estimate the prevalence of insufficient iron intake, a diet with 10% of iron bioavailability was considered as the reference in our study, as recommended by WHO / FAO / UNU (2004). However, adolescents in our study may have had a diet that more closely resembled that of a western diet with a 15% of iron bioavailability given the mean intake of iron-rich foods was around 100 g. In fact, when considering such diet, 50% of adolescent girls would have an insufficient iron intake. This proportion would be similar to that of Fiorentino et al. (2016) who used 18% of iron bioavailability as a reference to estimate the proportion of insufficient iron intake among urban Senegalese school-aged children and adolescents. Nevertheless, it is likely that adolescents are at risk for iron deficiency and iron deficiency anemia which are both the leading causes of adolescent disability-adjusted life years among girls aged 10–19 (UNICEF 2019).

Compared to Fiorentino et al. (2016) who found that 79% of children and adolescents (10-17 years old) had insufficient intakes of vitamin A, this proportion was only 23% in our study. While lower than Fiorentino et al.'s (2016) findings, this proportion is in line with Dapi et al. who found that only 18% of adolescent girls in urban Cameroon had insufficient intakes of vitamin A (Dapi et al. 2011). Despite a limited consumption of vegetables (which are rich sources of vitamin A), our finding was not surprising considering the frequent use of vegetable oil, which contains 200 ug RE of vitamin A / 100g, which is used for cooking local dishes. Moreover, oil fortification with vitamin A has become mandatory at the end of 2009 (Government of Senegal 2009), a few months before the study conducted by Fiorentio et al. was undertaken. This may also explain the difference between their results and ours. Additionally, in our study, some (n = 8) adolescents benefited from dishes prepared with red palm oil which is an excellent source of vitamin A. In fact, the mean daily consumption of oils and fats in our group was 57 g (± 92 g) which provides an intake of approximately 114 ug RE. The significant consumption of fortified oils by adolescents may also have contributed to the high energy intake from fats.

Results from our study showed that 54% of adolescents had inadequate intakes of vitamin C, as compared to 53% in Fiorentino et al.'s study and to 35% in Dapi et al.'s study. As with fibre, this finding is most likely due to the low consumption of fruits and vegetables, which are the main sources of vitamin C.

Zinc intakes appeared to be adequate to meet adolescent requirements. While rich food sources of zinc such as meat and fish are often also rich sources of iron, our study found that 55% of adolescents had a zinc intake that was below international recommendations, as compared to 24% for iron. Therefore, it is likely that other food sources of zinc contributed to adolescents' intake, such as grains products (which includes millet), legumes (such as "niebe") and dairy products.

Similarly to iron, calcium intake was problematic as almost all adolescent girls had an insufficient intake; a similar finding to that of Fiorentio et al. (2016) and Dapi et al. (2011). The low consumption of milk and dairy products may explain this finding which has also been reported in South Africa by Napier & Hlambelo (2014). Yet, this situation is of concern as it may jeopardize adolescent growth and increase the risk of osteoporosis later on in their life.

The mean sodium intake on weekend days as well as weekdays was well above the 2 g limit recommended by WHO & FAO (2003). In fact, two thirds of adolescents had intakes that exceeded this threshold. Similar to fat intake, the high sodium intake may be attributed to the consumption of fast foods and some condiments. In addition, 93% of adolescents were having at least one a meal outside their home, which was usually lunch during the school days. This may partially explain the higher intake during weekdays. This meal most often consisted of a sandwich prepared with white bread (the French baguette) and onion sauce (prepared with bouillon cubes which contain large amounts of sodium), to which meat, green peas, French fries or canned mackerel were added, among other ingredients.

This excessive and chronic intake of foods and dishes rich in sodium is particularly worrisome given the increased risk of hypertension later in life (Ha 2014).

Eating behaviours

Despite there being differences in zinc, calcium and sodium intakes between weekend days and weekdays, no differences were observed for food groups. It is possible that the slight increases (although not significant) in consumption of cereal, milk and dairy products, and condiments were enough to impact these intakes, thus leading to statistically significant differences for those nutrients but not for food groups.

Our findings showed that grains, roots, tubers and plantains were the main food group consumed by adolescent girls, and that rice was the most consumed food in this group. This finding is not surprising as rice is the staple food in Senegal. It was not uncommon for large quantities of white cooked rice (up to 750 g per meal) and white bread (up to 100 g of the "French baguette") to be eaten either at lunch and / or dinner, daily. Given the large quantities of grain-based dishes consumed, these foods contributed a significant amount of calories to the adolescents' diet. It is worth noting that both rice and plain white bread were both categorized as healthy foods in our study. Therefore, it is very likely that these foods contributed to our finding that adolescent girls consumed more healthy than unhealthy foods. This said, using fibre content as an additional criterion to classify foods may have provided a better picture of the quality of healthy foods that were consumed.

Recent UNICEF data (UNICEF 2019) revealed that worldwide, 42% adolescents in LMIC consumed carbonated soft drinks at least once a day. Consumption of sugary drinks was also common in our study; 25% of adolescents interviewed reported consuming sugary drinks daily. High consumption of sugary drinks has been identified as problematic, not only because of the high content in sugar but also because of the possibility of them replacing more healthy beverages such as water and milk. In fact, only 2% of adolescents in our study consumed milk and dairy products daily, which is similar to findings from Keats et al.`s review (2018) that showed that only 6% of African adolescents consumed milk and dairy products daily. This said, plain water was still the drink of choice among adolescents in our study.

It is important to note that our study did find that adolescents were engaging in some healthy behaviours, such as having breakfast and eating three meals a day, and drinking plain water. Moreover, while most were having breakfast and eating three meals a day, these were often times taken outside the home. Therefore, it is possible that these meals were of lower nutritional quality (Ndiaye et al. 2016).

Lastly, the dietary pattern of adolescent girls participating in our study was very different than that of the EAT-Lancet reference for a healthy diet. For example, their diet was high in refined grains and processed foods including sweets. Adolescent girls should be encouraged to adopt the EAT-reference for a healthy diet as it could help prevent malnutrition and chronic diseases while also preventing environmental degradation and human death (Willett et al. 2019).

Strengths And Limitations

Our study has several strengths. First, this is the first study to describe, in a comprehensive manner, the energy, nutrient and food intake of adolescent girls living in a LMIC as well as differences in their dietary intakes between weekend days and weekdays. It also provides valuable information on the quality of adolescents' diet as well as their food behaviours. Our study is also the first to attempt to classify healthy and unhealthy food intake of adolescents in LMIC. The use of three separate 24-hour recalls is another strength of this study, as this method provides more accurate information on food and nutrient intakes than a food frequency questionnaire targeting the whole diet and may be less impacted by potential memory bias (Gibson 2005). Moreover, purchasing samples of all foods that were bought by adolescents ensured that information on the quantity and nutritional content of these foods was adequately assessed. Finally, as compared to previous studies that have used mainly Institute of Medicine reference values for nutrient intakes for healthy American and Canadian populations, in the present study and with the exception of vitamin C, international reference values from the WHO, FAO and UNU were used to more accurately represent the African context.

Our study also had limitations which need to be acknowledged. First, our sampling was purposive and thus, our results cannot be generalized to other populations. Second, since food intake data were obtained at one time point only, it is possible that adolescents' dietary intakes would be different at some other point in the year, given potential seasonal variations in food availability. Third, it is possible that adolescent girls may have misreported their food intake (Ochola & Masibo 2014). However, we used repeated measurements of dietary intake to mitigate this potential bias.

Conclusions

Our results show that adolescent nutrition deserves more attention given the poor quality of their intakes which may put them at risk of malnutrition and of developing obesity or other chronic diseases later in life. Our findings provide key information on the quality of the dietary intake and food behaviours of adolescent girls that could be used to design or improve existing nutrition programs and inform future strategies on behaviour change.

Declarations

Ethics approval and consent to participate

This study was approved by the National Committee on Health Research in Dakar, Senegal (# 0000106) as well as by the Ethic committee on human research of the Université de Moncton in Moncton, New Brunswick, Canada (# 2018-214). Written informed assent and consent were provided respectively by each participant and her parents.

Consent for publication

The article has not been previously published elsewhere. The manuscript is not under consideration for publication in another journal and will not be submitted elsewhere until the editorial process is completed. All authors consent to the publication of the manuscript.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Competing interests

The Author(s) declare(s) that there is no conflict of interest.

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Authors' contributions

M.G.J., S.W., A.N.N., I.G., and S.B. contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

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Tables

Table 1. Steps and criteria to classify foods as healthy or unhealthy *

Food group	Step 1: Food lists		Step 2: Nutrient criteria for healthy foods		
	Foods with a higher nutritional value	**Foods with a lower nutritional value**	**Saturated fat**	**Sodium**	**Sugar**
Fruits	Fresh fruit, frozen fruit, canned fruit (packed in juice or light syrup) Apple sauce and other fruit sauces (100% fruit, no added sugar) 100% fruit juice	Fruit drinks not containing juice 100% pure Fruit cups in gelatin Canned fruit with thick syrup Tart filling prepared Processed fruit snacks (e.g. fruit jelly candies, etc.)	≤ 2 g / serving	≤ 150 mg	None added
Vegetables	Fresh vegetables, frozen vegetables, canned vegetables, 100% vegetable juice	Vegetables in batter Fried vegetables Fries - frozen, processed potatoes & potato chips	≤ 2 g / serving	≤ 150 mg	None added
Grain products	Whole grain flour, enriched white flour, wheat, oat, corn, barley, bulgur, couscous Whole grain bread products – bread, bagel, pita, English muffin, buns, naan, pizza crust Whole grain rice, wild rice, rice Whole grain or enriched pasta	Pastries, croissants, pies Instant noodles/pasta Pre-seasoned & instant rice Canned rice, canned pasta Doughnuts	≤ 2 g / serving	≤ 250 mg	≤ 9 g
Milk & dairy products	Milk (2% MF or less) Hard cheese Cottage cheese Plain yogurt Pudding mix prepared with milk	Commercially prepared milkshake Ice cream Processes cheese slices and spreads	≤ 3 g / serving	≤ 180 mg	≤ 26 g (≤ 20 g for milk substitutes)
Meat, fish & eggs & legumes	Chicken, turkey Beef, lean or extra lean ground meat Eggs Fish, seafood &canned fish Legumes (beans, peas, lentils) Tofu, nut butter	Fried meat, fish, chicken Commercially battered and/or breaded meat, fish, chicken Pepperoni, salami	≤ 4 g / serving	≤ 500 mg	Not applicable
Nuts & Seeds	Nuts and seeds	-	Not applicable	None added	None added
Condiments	Ketchup, mustard, relish and pickles, mayonnaise, salad dressings, soy sauce, sour cream, hot sauce, cream cheese	-	1 tablespoon	1 teaspoon	-
Dishes (reference amount per kcal) **100-199**	Entrées made with higher nutritional value ingredients		≤ 2 g	≤ 400 mg	-

200-299	≤ 3 g	≤ 500 mg
300-399	≤ 4 g	≤ 500 mg
≥ 400	≤ 5 g	≤ 700 mg

* New Brunswick's Department of Education and Early Childhood Development, 2018

Table 2. Mean (± SD) energy and nutrient intake on weekdays (N = 272) and weekend days (N = 136) and % of the population under the Estimated Average Requirements (EAR) or international recommendations

Nutrients	**Mean ± SD**		**% < EAR / Recommandations†**
	Weekdays	Weekend days	
Energy (kcalories)	2540 ± 940	2560 ± 1082	ND‡
Protein (g)	97.8 ± 45.9	102.9 ± 53.6	ND
Fats (g)	119.3 ± 78.4	112.9 ± 87.4	ND
Carbohydrates (g)	296.6 ± 93.1	307.9 ± 111.9	ND
Fibre (g)	15.8 ± 5.8	14.8 ± 7.6	98.5
Iron (mg)	10.0 ± 3.7	9.4 ±5.2	82.7
Zinc (mg)	7.2 ± 3.3*	8.6 ± 5.8	55.1
Calcium (mg)	488.0 ± 239.3*	574.8 ± 277.8	99.3
Vitamin A (ug RE)	996.8 ± 1071.7	1066.7 ± 1410.4	22.8
Sodium (g)	2.33 ± 0.83*	2.09 ± 0.86	39.7
Vitamin C (mg)	84.6 ± 222.1	58.9 ± 63.4	54.4

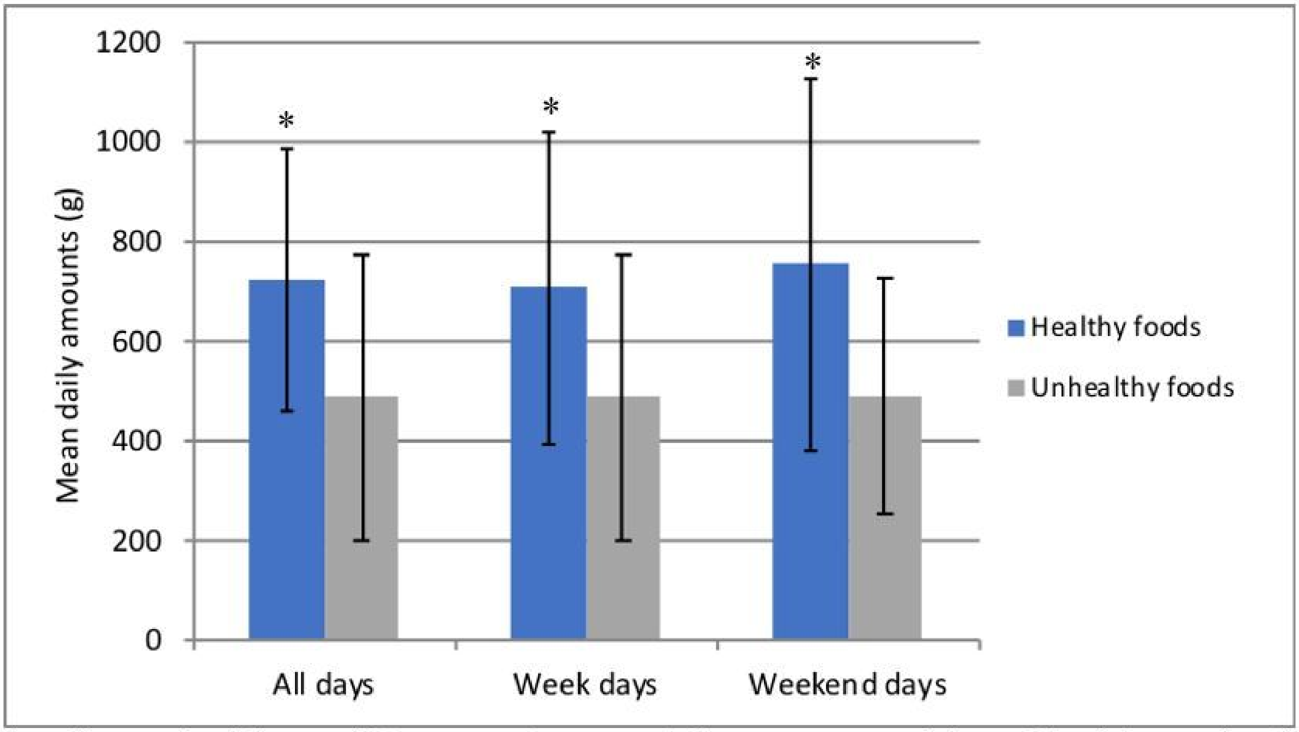
* Indicate a significant difference ($p < 0.05$) of means between weekdays and weekend days.

‡ As body weight was not recorded, proportions of adolescent girls below EAR / recommendations for energy and protein were not determined (ND) neither for fats and carbohydrates.

Table 3. Mean ± SD daily amounts (g) of food consumed by adolescent girls overall and during weekdays and weekend days by food group (N = 136)

	Mean ± SD (g / day)		
Food groups	Overall	Weekdays	Weekend days
Grains, roots, tubers & plantains	504 ± 212	492 ± 239	533 ± 311
Fast foods	150 ± 90	150 ± 100	150 ± 145
Sweets	139 ± 115	144 ± 134	128 ± 162
Sugary drinks	129 ± 126	125 ± 142	136 ± 175
Meat, poultry & fish	90 ± 48	90 ± 56	90 ± 91
Oil & fats	57 ± 57	56 ± 69	58 ± 94
Fruits	51 ± 77	49 ± 89	52 ± 91
Vegetables	32 ± 44	32 ± 57	31 ± 64
Legumes	20 ± 38	22 ± 55	16 ± 39
Milk & dairy products	20 ± 31	17 ± 34	25 ± 59
Eggs	10 ± 15	9 ± 18	10 ± 23
Fried & salty foods	8 ± 17	7 ± 14	11 ± 46
Condiments	4 ± 17	5 ± 25	2 ± 6
Water (ml)	693 ± 312	677 ± 330	724 ± 456
All foods (except water)	1213 ± 359	1197 ± 433	1243 ± 458

Figures



*Indicate significant differences ($p < 0.05$) between quantities of healthy and unhealthy foods consumed all days as well as over weekdays and weekend days.

Figure 1

Mean daily amounts (g ± SD) of healthy and unhealthy food consumed by adolescent girls overall as well as during weekdays and weekend days (N = 136)