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Dietary patterns among Afghan adults and their associations with overweight and obesity: a cross-sectional study in Kandahar, Afghanistan

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Abstract

Background Although obesity is on the rise in Afghanistan, to date no studies have investigated associations with diet and dietary patterns. Therefore, the present study aimed to assess the different dietary patterns consumed among Afghan adults living in Kandahar province and evaluate the correlations between those predominant dietary patterns and anthropometric measures.

Methods A cross-sectional study was conducted in Kandahar, Afghanistan, where data on sociodemographic characteristics, anthropometric measurements and diet were collected. A total of 711 men and women aged between 20 and 75 years were included in the final analysis. Dietary data were collected in 2018–2019 using a food frequency questionnaire and dietary patterns were identified by principal component analysis. Dietary pattern scores were then categorised into tertiles, where tertile 1 represented a lower adherence and tertile 3 the highest adherence to the pattern. Bonferroni adjusted *P* value of 0.004 was considered statistically significant.

Results Three dietary patterns were derived: a Western (WDP, rich in sweet beverages and refined grains), a Fruits and vegetables (FVDP), and a Traditional (TDP, rich in potatoes, fats and oil, and whole grains) dietary pattern. In this population, men had significantly higher adherence to WDP and TDP than women. Participants with higher socioeconomic status had significantly higher adherence to WDP and TDP and lower adherence to the FVDP. In linear regression models adjusted for potential confounders, BMI and waist and hip circumferences were positively correlated with WDP and FVDP and inversely correlated with the TDP, in particular among men and people with high SES, although none of these associations reached the Bonferroni-corrected threshold for statistical significance.

Conclusions Three distinct dietary patterns were identified among Afghan adults from Kandahar. Weak positive associations were found between the Western dietary pattern and general and central obesity. Associations of fruits and vegetables and traditional dietary patterns with obesity deserve further evaluation in a larger sample and with more detailed dietary intake assessment methods that also consider preparation methods and food processing.

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Keywords Afghanistan, Dietary patterns, Obesity, Principal component analysis

Background

According to the Global Nutrition Report, many countries face a double burden of malnutrition, where obesity and other diet-related non-communicable diseases prevail, together with undernutrition [1]. Although some progress is observed in controlling undernutrition and rates of stunting are decreasing, overweight and obesity rates are rapidly increasing and these countries have to manage the consequences of both sides of malnutrition [1]. Afghanistan is such a nation where the double burden of malnutrition exists, with some improvement in undernutrition coinciding with a gradual increase in obesity [2]. Beside possible dietary causes, changes in lifestyle and urbanization due to four-decades of conflicts in Afghanistan may contribute to the increasing rate of obesity, as out of an estimated 32.9 million population of the country, 24.4% of the population are located in the urban areas and these numbers are increasing [3]. Although obesity is increasing in rural areas of low-income countries, this risk factor is considered to be different in Afghanistan due to its conflicts which have caused a large-scale internal displacement and labour migration. On one hand, the population is migrating to urban areas and on the other hand, living conditions in rural areas are severely damaged, especially in Kandahar, a province in the southern zone of Afghanistan.

Obesity is a major health challenge that contributes to the increasing burden of non-communicable diseases (NCDs) which are the leading causes of mortality and morbidity worldwide [4–6]. The fundamental cause of obesity is considered to be energy imbalance due to high consumption and low expenditure of calories. An unhealthy diet rich in energy-dense foods and physical inactivity are major contributors to the obesity pandemic [7]. Globally, the composition of diet and patterns of physical activities are changing and these changes are considered to be major contributors toward the obesogenic environment, recognised by the rapid increase in obesity [8]. Among key changes in the diet are its structure and composition. Most of the diets have been sweetened remarkably and the consumption of edible oil has increased rapidly [9]. As a result, cheap and processed foods with high energy density are easily available. In addition to diet, physical activity patterns are also changing worldwide and includes marked reduction in the level of physical activity in many occupations as a result of mechanisation [9]. Since people consume their foods in combination rather than in isolation, a common method to study diet in relation to disease outcomes such as obesity, is to evaluate dietary patterns rather than individual foods or nutrients [10]. There are two major methods for the assessment of dietary patterns: a priori and *a posteriori* dietary pattern analyses [11]. *A posteriori* dietary pattern analyses allow data driven construction of patterns and is better suited for populations whose diet has not been previously studied and for whom pre-defined a priori patterns may not be appropriate. A common method to construct *a posteriori* dietary patterns is principal component analysis [12].

Although obesity is on the rise in Afghanistan, to date no studies have investigated dietary patterns among Afghan adults and its potential role in this increasing obesity burden in Afghanistan. In particular, no studies have applied dietary pattern analyses, specifically *a posteriori* defined patterns, in the Afghan population living in Kandahar province. Therefore, to address this knowledge gap, the objective of the present study was to determine predominant dietary patterns among adults living in Kandahar province using principal component analysis and evaluate their correlation with anthropometric measures in this population.

Methods

Participants and data collection

Kandahar province is located in the South of Afghanistan with a population of around 1.4 million, of whom 37.4% live in urban areas [3]. We used data from a population-based cross-sectional study which was conducted in the research centre of Kandahar University and has been described in details elsewhere [13]. In summary, a total of 729 male and female participants were recruited in the study using a convenient sampling method to recruit equal number of normal weight, overweight and obese participants. Pregnant women were excluded from the study. Data were collected on socio-demographic characteristics such as age, sex, occupation, marital status, residence, and income, smoking and snuffing, personal and familial health history, reproductive health, physical activity, anthropometric measurements and diet. All data were collected in an electronic questionnaire which was designed in Epi Info 7 (https://www.cdc.gov/epiinfo/) and administered by trained health staff. The study was approved by IARC's Ethics Committee, as well as Kandahar University's institutional review board (IRB). An informed consent was obtained from all the participants.

Socioeconomic status index was estimated using a reliable, valid and easy-to-calculate method, designed for developing countries and is explained in details elsewhere [14]. In short, this index has no sensitive questions and is based on an equation obtained from summing scores for variables such as education, occupation, residence, car ownership, and age. We used the short version of the international physical activity questionnaire (IPAQ) to measure physical activity levels during a usual week. This short version is recommended for monitoring physical activity at a national level [15].

Participants were asked whether they had a history of non-communicable chronic diseases such as hypertension, diabetes, dyslipidaemia, cancer or if they were using any regular medication for a medical condition. Interviewers also measured blood pressure of all the participants in a sitting position using ERKAMETER 3000 mercury sphygmomanometer (ERKA, Germany) at right hand supported at the heart level after resting for more than fifteen minutes. Participants also provided blood samples in a fasting state which were examined for blood lipid profiles and glucose levels.

Anthropometric measurements

All anthropometric measurements were performed by trained health staff. Body weight was measured with light clothing on to the nearest 0.1 kg and height was measured without shoes to the nearest 1 mm while the participant was standing to the wall. Body mass index (BMI) was calculated by dividing weight (in kilograms) by the square of height (in meters) and was categorised based on WHO's recommendations as normal weight, overweight and obese. Waist circumference (WC) was measured using a flexible measuring tape at the umbilicus level between the inferior margin of ribs and the anterior superior iliac crest. Hip circumference (HC) was measured at the maximum diameter of the gluteus muscle.

Dietary intake

A pre-tested semi-quantitative food frequency questionnaire (FFQ), developed for the Afghan population was used to collect dietary data. The questionnaire consisted of 141 commonly consumed food items and a photo album was used to improve accuracy of food portion size estimations. An interviewer asked the participants about their usual food consumption frequencies during the last year. The frequency categories in the FFQ included: Never, < 1 time per month, 1–3 times a month, once/week, 2–4 times/week, 5–6 times/week, once/day, 2–3 times/day, 4–5 times/day, and 6 times/day. The respondents were asked to report the frequency of intake of each food item based on their habitual intake over the last year. Daily dietary intakes were calculated by multiplying the portion size of food items by the frequency of consumption (converted in times per day), considering seasonal variation of the food items (number of months per year that foods are available). Daily total energy intake was calculated using FAO's food composition tables for the near East, and for the unavailable food items we used USDA's food composition Tables [16, 17].

Statistical analysis

Eighteen participants were excluded from the database due to missing dietary data and anthropometric parameters, leaving 711 participants for inclusion in the final statistical analyses. To identify *a posteriori* dietary patterns, the principal component analysis (PCA) method was used. For this purpose, all food items were categorised into 31 food groups according to their nutritional contents, using the FoodEX2 classification system of the European Food Safety Authority (Table 1) [18]. PCA was performed with the varimax method of orthogonal rotation to facilitate interpretation of extracted factors. A Kaiser-Meyer-Olkin test of sampling adequacy was performed to assess whether the factor model as a whole was significant. A value of >0.6 was considered as an indicator of adequate sampling. Scree plots, eigenvalues and interpretability of factors were used to identify the three factors, which accounted for cumulative variation of 29.24% in food intake. These three factors appeared to represent the main dietary characteristics of the Afghan population living in Kandahar province, and the dietary patterns were named according to the food items showing high loadings. We used major food groups with factor loadings of ≥ 0.25 in naming the dietary patterns [19]. This threshold was chosen accounting for the overall range of loadings observed in our data (i.e., the ranking of foods in the pattern) and both the interpretability and differentiation of each pattern. For each dietary pattern, the factor score was calculated by summing intakes of food groups weighted by their factor loadings, and each participant received a factor score for each identified pattern. These dietary pattern scores were then categorised into tertiles for further analyses. Tertile 1, lower tertile of the distribution, represented a lower adherence, while tertile 3 (the upper tertile of the distribution) represented the highest adherence to the pattern. Initially, separate dietary patterns were derived for men and women, but as the patterns were similar for both sexes, the PCA was applied to the whole population. The mean (standard deviation) was used to describe continuous variables while the number and percentage were reported for categorical variables. Comparisons of continuous variables and categorical variables across BMI categories were analysed using one-way analysis of variance (ANOVA) tests and Chi-square tests, respectively. The associations between dietary patterns and anthropometric measures were evaluated using linear regression analyses adjusting for potential confounders including age (years), gender (men, women), total energy intake (kcal/day), socioeconomic status (low, medium, high), marital status (married, single, divorced/widow), educational classes (none, high school, higher education), and physical activity level (high, moderate, low). Multiple testing was addressed with the Bonferroni approach with a threshold of p value

Table 1 Food categories in which all foods and beverages from the KOR study FFQ were classified and used in the principal component analysis

No	Food Group	Items
1	Whole grains	Rice, popcorn, homemade and bakery bread
2	Refined grains	White bread, pasta, cake, cookies, donuts and biscuit
3	Bulb vegetables	Garlic and onion
4	Fruiting vegetables	Melon, watermelon, green chilies, capsicum, cucumber, eggplant, okra, pumpkin, ridged gourd, squash and tomato
5	Leafy vegetables and similar	Cabbage, lettuce, spinach, cauliflower, cress and leek
6	Root and tuber vegetables	Carrots, radish and turnip
7	Legumes	Chickpea, cowpea, kidney bean, lentil, mung bean, yellow peas and pea garden
8	Pome and Stone fruits	Apple, pear, apricot, peach and plum
9	Miscellaneous fruits	Banana, date, fig, guava whole, kiwi, mango, pomegranate, sapodilla, grapes, mulberry, lemon and sweet orange
10	Preserved fruits	Dried fig, dried mulberries and raisin
11	Nuts and seeds	Almond, cashew nut, pine nuts, pistachios, walnut, peanut, pumpkin seeds and sunflower seeds
12	Potato	Potato
13	Aromatic herbs	Coriander and mint
14	Fruit Juices	Sugarcane, apple, banana, lemon and mango juices
15	Meat	Chicken, mutton, kebab and beef
16	Fish and animal offal	Fish, kidney, liver and cow leg
17	Milk	Milk
18	Dairy products	Buttermilk, cheese, curd, cream and yogurt
19	Eggs	Egg
20	Cola Beverages	All carbonated beverages
21	Sweet beverages	Fruit juices, sherbet and energy drinks
22	Tea and coffee	Black tea, green tea and coffee
23	Sweets	Burfi, jaggery, jalebee, sheerpira, toffee, candy, chocolate, halva and jam
24	Dairy dessert and similar	Ice cream, gulab jamun, pudding and porridge
25	Soup	Soup
26	Sandwiches and pizza	Chicken burger, pizza, chicken roll and leek samoset
27	Snack	Potato chips, samoset and French fries
28	Condiments	Ketchup, vinegar, cardamom and ginger
29	Sugar and honey	Honey and sugar
30	Fats and oil	Animal oil, butter, plant oil and lard
31	Fiber	Ispaghula husk

0.05/12 = 0.004; considering the twelve tests analysed in this manuscript). Analyses were also stratified by gender, age and socio-economic status. Sensitivity analyses were performed excluding participants who recently changed their diet, lost weight, who had diabetes, hypertension or abnormal blood lipid levels. Statistical analyses were conducted using Stata version 14.1 (Stata Corp., College Station, TX, USA) and IBM SPSS Statistics version 25 (IBM Corporation, Armonk, NY, USA).

Results

The main characteristics of the study sample are shown in Table 2. The mean age at recruitment was 37.4 years, with 42.5% female participants, 92% urban participants. Socioeconomic status was evenly distributed across the population but obese participants were more often of low socioeconomic status. In addition, compared to normal weight participants, obese participants were on average older, less physically active, more often women, living in urban areas, married. Obese women were more often parous and postmenopausal than normal weight women. Out of 302 female participants, only 8% ($n = 25$) of the study population were nulliparous and 92% ($n = 277$) had given birth to children. In addition, out of 283 participants who had given birth to children, around 8% ($n = 22$) of the mothers had not breastfed their children, and 92% ($n = 261$) of them had breastfed their children. As expected, overweight and obese participants also more often experienced co-morbidities such as diabetes, hypertension and dyslipidaemia.

As shown in Table 3, three dietary patterns were derived by PCA explaining 29.24% of the variation in the diet. The Kaiser-Meyer-Olkin index had a value of 0.818 showing that the sampling was adequate for this analysis. Based on Bartlett's test of sphericity ($p < 0.001$) we rejected the null hypothesis that the correlation matrix was an identity matrix. The first dietary pattern which was characterised by high factor loadings from cola

Table 2 Baseline characteristics of the total study population and according to body Mass Index (BMI)

Variables[1]	Normal Weight	Overweight	Obese	Total	*P* value[2]
	257 (36%)	**233 (33%)**	**221 (31%)**	**711**	
Socio-demographic characteristics					
Age (years)	31.5 (12.7)	40.6 (14.2)	40.9 (12.4)	37.4 (13.8)	< 0.001
Urban, number (%)	230 (89)	215 (92)	211 (95)	656 (92)	0.051
Marital Status, number (%)					< 0.001
Married	151 (59)	183 (78)	186 (84)	520 (73)	
Single	96 (37)	34 (15)	18 (8)	148 (21)	
Widow/Separated	10 (4)	16 (7)	17 (8)	43 (6)	
Socioeconomic status, number (%)					< 0.001
Low	62 (24)	72 (31)	104 (47)	238 (34)	
Medium	79 (31)	89 (38)	68 (31)	236 (33)	
High	116 (45)	72 (31)	49 (22)	237 (33)	
Women, number (%)	78 (30)	89 (38)	135 (61)	302 (42.5)	< 0.001
Women's reproductive history					
Premenopausal women [3], number (%)	54 (69)	56 (63)	72 (53)	182 (60)	0.061
Age at menarche (years)[3], mean (SD)	12.8 (1.2)	12.9 (1.5)	12.9 (1.3)	12.9 (1.3)	0.687
Nulliparous[3], number (%)	15 (19)	6 (7)	4 (3)	25 (8)	< 0.001
Multiparous[3], number (%)	63 (81)	83 (93)	131 (97)	277 (92)	
Breast feeding[3], number (%)	61 (78)	75 (84)	125 (93)	261 (86)	0.01
Age at menopause (years)[3], mean (SD)	47.5 (5.9)	47.4 (5.5)	46.5 (4.4)	47.0 (5.0)	0.633
Contraceptive use duration (years)[3], mean (SD)	4.6 (4.4)	4.3 (3.3)	6.5 (5.4)	5.4 (4.7)	0.023
Lifestyle factors					
Total energy intake (kcal/day), mean (SD)	3758 (1172)	3967 (1355)	3950 (1683)	3886 (1408)	0.187
Weekly Physical Activity (METs), mean (SD)	1900 (1847)	1790 (2086)	1300 (1424)	1677 (1829)	0.001
Daily Sitting Time (Hours), mean (SD)	10.5 (3.2)	10.1 (3.2)	10.6 (3.1)	10.4 (3.2)	0.232
Daily Sleeping Time (Hours), mean (SD)	7.7 (1.3)	7.4 (1.4)	8.1 (1.7)	7.7 (1.5)	< 0.001
Smoking status, number (%)					0.002
Never Smoker	212 (83)	168 (72)	181 (82)	561 (79)	
Former Smoker	19 (7)	43 (19)	27 (12)	89 (12)	
Current Smoker	26 (10)	22 (9)	13 (6)	61 (9)	
Snuffing status, number (%)					0.003
Never	213 (83)	179 (77)	199 (90)	591 (83)	
Former	8 (3)	5 (2)	2 (1)	15 (2)	
Current	36 (14)	49 (21)	20 (9)	105 (15)	
Anthropometric measurements					
Weight (kg), mean (SD)	60.3 (8.2)	74.9 (8.7)	90.0 (13.9)	74.3 (16.0)	< 0.001
Height (cm), mean (SD)	166.4 (9.1)	165.5 (9.4)	161.2 (10.0)	164.5 (9.7)	< 0.001
Body Mass Index (kg/m^2), mean (SD)	21.7 (1.9)	27.3 (1.5)	34.6 (4.2)	27.5 (5.9)	< 0.001
Sitting Height (cm), mean (SD), missing = 1	86.0 (6.0)	86.0 (5.9)	83.7 (5.9)	85.3 (6.0)	< 0.001
Waist circumference (cm), mean (SD)	80.5 (7.9)	96.8 (6.9)	110.7 (9.6)	95.2 (14.9)	< 0.001
Hip circumference (cm), mean (SD)	92.3 (5.3)	102.7 (5.0)	115.7 (9.3)	103.0 (11.7)	< 0.001
Waist to Hip ratio (WHR), mean (SD)	0.87 (0.07)	0.94 (0.07)	0.96 (0.07)	0.92 (0.08)	< 0.001
Self-reported weight changes during last year					
Self-reported weight gain during last year, number (%)	71 (28)	91 (39)	101 (46)	263 (37)	< 0.001
Self-reported weight loss during last year, number (%)	94 (37)	81 (35)	57 (26)	232 (33)	0.030
Weight Loss (intentionally), number (%)	17 (7)	40 (17)	37 (17)	94 (13)	< 0.001
Change in Diet (last year), number (%)	18 (7)	73 (31)	93 (42)	184 (26)	< 0.001
Eating Less Food for Weight Loss	8 (3)	55 (24)	68 (31)	131 (18)	< 0.001
Eating Less Fat for Weight Loss	7 (3)	50 (21)	62 (28)	119 (17)	< 0.001
Exercise for Weight Loss	12 (5)	47 (20)	34 (15)	93 (13)	< 0.001
Skipping Meals for Weight Loss	1 (0.5)	16 (7)	44 (20)	61 (9)	< 0.001
Medical history					
Hypertension, number (%)	38 (15)	97 (42)	124 (56)	259 (36)	< 0.001

Table 2 (continued)

Variables[1]	Normal Weight 257 (36%)	Overweight 233 (33%)	Obese 221 (31%)	Total 711	*P* value[2]
Diabetes Mellitus, number (%)	33 (13)	46 (20)	39 (18)	118 (17)	0.107
Dyslipidaemia, number (%)	70 (27)	113 (48)	120 (54)	303 (43)	< 0.001

[1] Number of missing values is 0 unless otherwise specified; [2] Chi-square test or ANOVA; [3] For women only; Continuous variables are shown with mean and standard deviation; Categorical variables are shown with number and percentage

Table 3 Dietary patterns and their food groups factor loadings derived by principal component analysis in an Afghan population[a]

Food Groups	Western	Fruits and vegetables	Traditional
Cola beverages	0.2600	-	-
Refined Grains	0.2766	-	-
Sugar and honey	0.2799	-	-
Dairy dessert and similar	0.2827	-	-
Fruit juices	0.2861	-	-
Milk	0.2915	-	-
Sweet beverages	0.2945	-	-
Sandwiches and pizza	0.2999	-	-
Fruiting vegetables	-	0.3094	-
Pome and stone fruits	-	0.312	-
Aromatic herbs	-	0.3442	-
Root and tuber vegetables	-	0.4305	-
Leafy vegetables and similar	-	0.4543	-
Tea and coffee	-	-	0.2677
Legumes	-	-	0.3065
Potato	-	-	0.3470
Fats and oil	-	-	0.3475
Whole Grains	-	-	0.4340
Eigenvalues	**5.51**	**1.9**	**1.65**
% of explained variance	**12.96**	**8.61**	**7.67**
% of accumulated explained variance	**12.96**	**21.57**	**29.24**

[a] Absolute values < 0.25 are not presented.

beverages, refined grains, sugar and honey, dairy dessert, fruit juices, milk, sweet beverages, and sandwiches and pizza was labelled as the "Western Dietary Pattern (WDP)". The second dietary pattern, characterised by fruiting vegetables, pome and stone fruits, aromatic herbs, root and tuber vegetables, and leafy vegetables was labelled as the "Fruits and vegetables Dietary Pattern (FVDP)". The third dietary pattern which was labelled as the "Traditional Dietary Pattern (TDP)" was characterised by high factor loadings for tea and coffee, legumes, potatoes, fats and oil, and whole grains.

The general characteristics according to the tertiles of each dietary pattern score are summarised in Table 4. Compared to participants with low adherence, participants with a high adherence to the WDP were on average younger (33.6 vs. 42.2 years) and taller (166.6 vs. 161.3 cm) than those with low adherence to this pattern. They were also more often men, single, and of high economic status. Women with high adherence to the Western dietary pattern were more often premenopausal women, nulliparous, and had less often breastfed their children. Participants with a higher adherence to the FVDP were on average older (39.3 vs. 37.6 years), were more often married, and were more often former smokers compared to those with low adherence to this pattern. Similar adherence to this pattern was observed for men and women. Although not significant, there was an increasing trend in the number of women adhering more to the FVDP dietary pattern. Participants with a high adherence to the TDP were on average younger (33.2 vs. 43.8 years) and taller (167.0 vs. 161.5 cm) than those with low adherence to this pattern. They were also more often men, single, and of high economic status. Women with high adherence to the TDP were less often menopaused. No significant associations were seen between any dietary pattern and physical activity levels.

Table 5 describes multivariate-adjusted linear regression analysis of *a posteriori* dietary patterns in relation to anthropometric measures. The WDP was positively associated with BMI, WC and HC with beta estimates per 1 standard deviation (SD) increase in the dietary pattern score of 0.05 (-0.01;0.10), 0.04 (-0.01;0.09) and 0.08 (0.02;0.13), respectively. The FVDP was positively associated with BMI, WC and HC with beta estimates of 0.04 (-0.01;0.09), 0.05 (0.01;0.10) and 0.06 (0.01; 0.10). The TDP was negatively associated with BMI, WC and HC with beta estimates of -0.07 (-0.14; 0.01), -0.05 (-0.12;0.03) and −0.07 (-0.15;0.00), respectively. None of these associations reached the Bonferroni corrected threshold of statistical significance ($P = 0.004$). WHR did not seem to be strongly associated with any dietary pattern.

The positive associations observed between anthropometric measures and the WDP seemed to be restricted to men and participants with high socioeconomic level (Fig. 1) while among women, an inverse association was observed between WHR and the WDP. Inverse associations between BMI, WC and HC and the TDP were observed among men while a positive association was observed between WHR and the TDP among women. Regarding stratification by age, a positive association between WC and the FVDP was observed among older

Table 4 Selected characteristics across tertiles of dietary patterns among adults of Afghan population participating in KOR

Variables	Western Dietary Pattern				Fruits and vegetables Dietary Pattern				Traditional Dietary Pattern			
	Tertile 1	Tertile 2	Tertile 3	*P* value[1]	Tertile 1	Tertile 2	Tertile 3	*P* value[1]	Tertile 1	Tertile 2	Tertile 3	*P* value[1]
Age (years), mean (SD)	42.2 (13.4)	36.4 (13.7)	33.6 (13.0)	**< 0.001**	35.4 (13.8)	37.6 (14.2)	39.3 (13.2)	**0.008**	43.8 (14.9)	35.2 (12.5)	33.2 (11.5)	**< 0.001**
Women, number (%)	146 (62)	77 (32)	79 (33)	**<0.001**	93 (39)	99 (42)	110 (46)	0.277	138 (58)	88 (37)	76 (32)	**< 0.001**
Marital Status, number (%)				**< 0.001**				**0.001**				**< 0.001**
Married	188 (79)	170 (72)	162 (68)		160 (68)	166 (70)	194 (82)		181 (76)	169 (71)	170 (72)	
Single	25 (11)	60 (25)	63 (27)		65 (27)	54 (23)	29 (12)		28 (12)	57 (24)	63 (26)	
Widow/Separated	24 (10)	7 (3)	12 (5)		12 (5)	17 (7)	14 (6)		28 (12)	11 (5)	4 (2)	
Socioeconomic Status, number (%)				**< 0.001**				**0.041**				**< 0.001**
Low	130 (55)	55 (23)	53 (22)		84 (35)	73 (31)	81 (34)		92 (39)	79 (33)	67 (28)	
Medium	73 (31)	90 (38)	73 (31)		69 (30)	74 (31)	93 (39)		94 (40)	73 (31)	69 (29)	
High	34 (14)	92 (39)	111 (47)		84 (35)	90 (38)	63 (27)		51 (21)	85 (36)	101 (43)	
Premenopausal women[2], number (%)	80 (55)	45 (58)	57 (72)	**0.037**	58 (63)	57 (58)	67 (61)	0.783	60 (43)	58 (66)	64 (84)	**<0.001**
Nulliparous[2], number (%)	10 (7)	3 (4)	12 (15)	**0.026**	8 (9)	7 (7)	10 (9)	0.861	9 (7)	6 (7)	10 (13)	0.203
Breastfeeding[2], number (%)	129 (88)	73 (95)	59 (75)	**0.001**	82 (88)	85 (86)	94 (85)	0.836	121 (88)	78 (89)	62 (82)	0.355
Height (cm), mean (SD)	161.3 (9.5)	165.6 (8.7)	166.6 (10.1)	**< 0.001**	164.6 (9.9)	164.2 (9.5)	164.7 (9.7)	0.872	161.5 (9.8)	165.0 (9.0)	167.0 (9.6)	**< 0.001**
Sitting Height (cm), mean (SD)	83.1 (5.9)	86.0 (5.5)	86.8 (6.2)	**< 0.001**	85.4 (6.0)	85.2 (5.9)	85.3 (6.3)	0.952	83.3 (6.2)	85.6 (5.6)	87.0 (5.7)	**< 0.001**
Weekly Physical Activity (METs), mean (SD)	1841 (1866)	1615 (1804)	1576 (1813)	0.233	1821 (1926)	1522 (1513)	1689 (2005)	0.202	1686 (1871)	1628 (1725)	1718 (1893)	0.863
Smoking status, number (%)				0.175				**0.004**				0.145
Never	199 (84)	177 (75)	185 (78)		200 (84)	191 (81)	170 (72)		190 (80)	193 (81)	178 (75)	
Former	23 (10)	35 (15)	31 (13)		17 (7)	28 (12)	44 (18)		32 (14)	21 (9)	36 (15)	
Current	15 (6)	25 (10)	21 (9)		20 (9)	18 (7)	23 (10)		15 (6)	23 (10)	23 (10)	

[1] Chi-square test or Analysis of variance (ANOVA); [2] Only for women

participants. We also observed inverse associations between the TDP and older participants. In the stratified analyses, other factors did not show any significant effect modification (data not shown).

In sensitivity analyses excluding participants who lost weight, who had diabetes, hypertension or abnormal blood lipid levels, estimates were very similar although some lost statistical significance due to lower number of subjects (data not shown). After exclusion of participants who recently changed their diet, all estimates were strongly attenuated and lost statistical significance.

Discussion

This is the first study to investigate dietary patterns of the Afghan population living in Kandahar province using *a posteriori* dietary approach. Three dietary patterns were identified: "Western", "Fruits and Vegetables", and "Traditional" dietary patterns. The WDP was characterised by cola beverages, refined grains, sugar and honey, dairy desserts, fruit juices, milk, sweet beverages, and sandwiches and pizza. The FVDP was characterised by fruiting vegetables, pome and stone fruits, aromatic herbs, root and tuber vegetables, and leafy vegetables. The TDP was characterised by tea and coffee, legumes, potato, fats and oil, and whole grains. After adjusting for confounders, our results suggested that WDP was positively correlated with increased overall and central obesity. Positive correlations between general and central obesity and FVDP were observed, while inverse correlations with TDP were noted, in particular among men and people with high socioeconomic status (SES).

These associations between *a posteriori* dietary patterns and general and central obesity have been previously reported in the literature, in other populations [20, 21]. Our findings of a possible positive correlation between WDP and BMI, WC and HC are in line with previous reports in populations from Iran, Canada and USA, where a high score of WDP was positively associated with obesity [22–24]. In most of the studies, including the current study, WDPs are usually high in refined grains, sweet and cola beverages, sweets, and fruit juices, which are energy-dense and low in healthy food items and nutrients [25, 26].

Our study suggests that the FVDP was positively associated with BMI, WC, HC and WHR, but associations were statistically significant only for WC and HC. This dietary pattern was similar to most prudent and healthy dietary patterns reported by different studies, which are rich in vegetables and fruits, and are suggested to be inversely associated with obesity [26–28]. In our study, this pattern was characterised mostly by the consumption of fried vegetables and whole fruits which is a common way of cooking in the Afghan population [29]. Most of the vegetables are fried in cooking oil and served with excessive fat-derived energy. Therefore, the protective effect of these "healthy/nutritious" food groups may not be seen in our study population because of different methods of food preparation compared to other populations. In addition, the availability of a variety of affordable fruits consumed in excess without any nutritional recommendations, could explain pro-obesity effects of fruits, which are naturally high in sugar content [30]. Other studies have also reported similar associations of fruits and vegetables with overweight and obesity. A study in Nepal reported no association and suggested that fatty foods may have compensated the beneficial effects of fruits and vegetables [31]. A cohort study conducted in Spain reported a positive association of any fried food using oil with obesity, suggested to be due to increasing food energy density [32].

We also found an inverse relationship between TDP and anthropometric measurements like BMI, WC, and HC, although these findings were not statistically significant. The traditional Afghan diet includes large amounts of cereals and vegetables. To the best of our knowledge, only one study has investigated dietary intake in Afghanistan, the country's second National Nutrition Survey in 2013 [2], where a 7-day food frequency questionnaire was used in a population of 15,975 participants to calculate a food consumption score. All food items in the survey were combined into eight groups to calculate a food consumption score where it was reported that more than 75% of the households had an acceptable food consumption score [2]. Based on this survey, Afghanistan also published their first national food-based dietary guidelines in 2015 to fight malnutrition. These guidelines describe food items in form of a tablecloth, which shows seven food groups for the daily diet [29]. Cereals and tubers comprise the main part of the tablecloth and cooking oil is used to prepare all main dishes of the meals. The pattern labelled as TDP in our study included whole grains, specifically bread as staple food, followed by fats and oil as the most abundantly consumed food items, which also form the key constituents of the traditional Afghan diet. Interpretation of TDP could be complex as it contains beneficial food items such as whole grains, legumes, and tea, as well as energy-dense items such as potato, fats and oil. In addition, its comparison across studies is difficult as traditional diet may vary widely from country to country or even within regions of the same country. A study conducted in China reported different results of traditional dietary patterns in various parts of the country, where a TDP with rice as a major staple food was inversely associated with the risk of general and central obesity, while a second TDP with cereals and tuber as major staple food was positively associated with general and central obesity [33]. Such findings could be due to different varieties of rice and bread and cooking

Table 5 Multiple linear regression analysis of the association between *a posteriori* dietary pattern scores and anthropometric measures[1] after correction for multiple testing

Dietary Patterns[2] (Score)	BMI			WC			HC			WHR		
	Beta	(95% CI)	*P* value	Beta	(95% CI)	*P* value	Beta	(95% CI)	*P* value	Beta	(95% CI)	*P* value
Western Dietary Pattern	0.05	(-0.01; 0.10)	0.077	0.04	(-0.01; 0.09)	0.143	0.08	(0.02; 0.13)	**0.007**	-0.03	(-0.08; 0.02)	0.242
Fruits and Vegetables Dietary Pattern	0.04	(-0.01; 0.09)	0.109	0.05	(0.01; 0.10)	**0.024**	0.06	(0.01; 0.10)	**0.031**	0.03	(-0.02; 0.07)	0.274
Traditional Dietary Pattern	-0.07	(-0.14; 0.01)	0.086	-0.05	(-0.12; 0.03)	0.211	-0.07	(-0.15; 0.00)	**0.055**	0.02	(-0.05; 0.09)	0.638

[1]Linear regression coefficient associated with an increase in 1 S.D. of the principal component score and of anthropometric measures. [2]Adjusted for age, sex, total energy intake, socioeconomic status, marital status, education, and physical activity level. Bonferroni approach to adjust for multiple testing errors with a threshold of *p* value = 0.004. BMI, body mass index; WC, waist circumference; HC, hip circumference; WHR, waist-to-hip-ratio.

methods used for preparation of these traditional food items.

The differences between men and women remain indeed a point of discussion and are not easy to interpret. Differences in physical activity and energy requirements for instance may partly explain the different results for men versus women, but other factors may also contribute to these differences in anthropometric results for men versus women. Out-of-home foods have been associated with anthropometric changes due to their high energy and low nutrient densities [34]. In addition, sociocultural beliefs and practices in the Afghan society may also play a role in this matter like in other south Asian countries such as India. In a traditional family, due to household hierarchies, women feed other family members first, eat less or consume leftovers at the time of shortage of food [35]. These factors may lead to different dietary patterns among men and women in our study population.

Some limitations should be considered when interpreting the results of this study. First, it is a cross-sectional study and one cannot infer causality. As such positive associations between the fruits and vegetables dietary pattern and obesity could for instance reflect the reported diet of obese people trying to lose weight. Therefore, these findings should be confirmed further in prospective studies. Second, misreporting (which includes over-reporting and under-reporting) in assessing dietary intake with food frequency questionnaire could be a limitation of FFQ in our study, which should be taken into account. Third, selection bias could not be ignored as we did not use random sampling while recruiting study participants and have used convenient sampling. Finally, the use of principal component analysis for deriving dietary patterns and selecting the number of patterns is prone to subjective decisions of the researchers, although we used eigenvalues, scree plots, interpretability and similarity with other dietary studies to cautiously asses the diet. Although fruits and vegetables dietary patterns are usually inversely associated with obesity, it is highly recommended that all countries investigate their own dietary patterns according to their unique cultural diet and types of local food consumption, considering also food processing and culinary preparations (e.g. use of oils in vegetable preparations) [20]. Beside these limitations, our study also has some strengths. Dietary patterns among Afghans have not been analysed before and this is the first study to use data-driven method for evaluating dietary patterns in Afghanistan. In addition, in this study, we comprehensively evaluated diet among adult men and women of all age groups keeping in mind the potential confounders.

Though some indicators of nutritional status in the Afghan population have improved, the public health burden of malnutrition is still among the highest in the

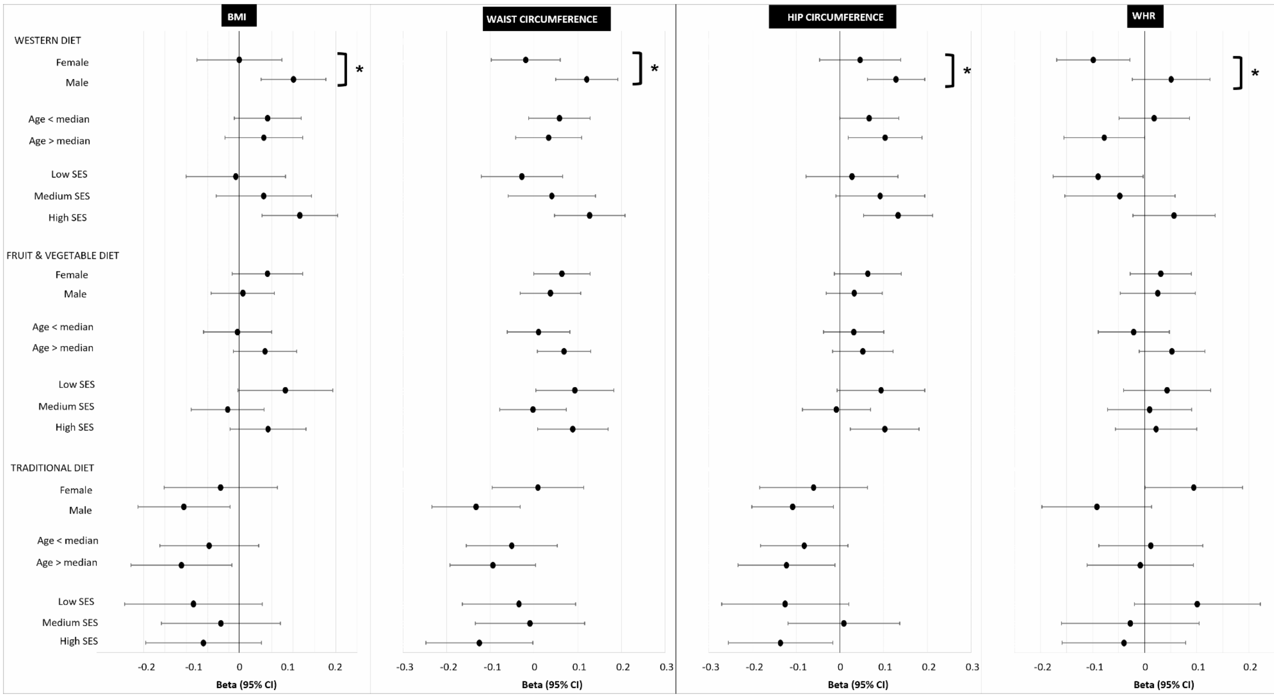

Fig. 1 Multiple linear regression analysis of the association between *a posteriori* dietary pattern scores and anthropometric measures, stratified by gender, age and SES#. Adjustment variables: age, sex, socioeconomic status, total daily energy intake, marital status, education, and physical activity. # Number of participants according to sex, median age and socioeconomic status: female = 302, male = 409, age below the median = 367, age above the median = 344, low socioeconomic status (SES) = 238, medium SES = 236, and high SES = 237. * P interaction < 0.05

world according to the 2013 National Nutrition Survey. Out of 34 provinces of Afghanistan, Kandahar is the second largest province located in the southern region of the country, with a population of around 1,000,000. Around 68% of the population of Kandahar lives in rural districts while 32% lives in urban areas and the income for all wealth groups is dependent on agriculture. In 2014, this province was the most vulnerable province in Afghanistan with the highest vulnerable index in health, nutrition, conflict displacement, civilian casualties and security incidents [36]. However, data from NNS 2013 data showed that overall, 75% households had acceptable food consumption, 18% had borderline and 6.3% had poor food consumption.

Conclusion

Through this study, we identified three distinct dietary patterns among the adult population of Afghanistan. Our findings suggest weak associations between a Western dietary pattern and general and central obesity. These results, together with the weak associations of fruits and vegetables and traditional dietary patterns with obesity deserve further evaluation in a larger sample and with more detailed dietary intake assessment methods that also consider preparation methods and food processing. To better evaluate the nutrition transition and a transformation toward consumption of Westernised diets, national nutrition surveys of all age groups should be undertaken periodically. The association between dietary patterns of the Afghan population and obesity also needs to be evaluated prospectively. Further reproducibility and validity studies are required to measure *a posteriori* (data driven) dietary patterns in other regions of the country and explore the associations of food intake with overweight and obesity.

Abbreviations

IRB	Institutional review board
IPAQ	International physical activity questionnaire
FFQ	Food frequency questionnaire
PCA	Principal component analysis
WDP	Western dietary pattern
FVDP	Fruits and vegetables dietary pattern
TDP	Traditional dietary pattern
WC	Waist circumference
HC	Hip circumference
BMI	Body mass index
SES	Socioeconomic status
WHR	Waist to hip ratio

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Author contributions

LD, AWW, IH and MJG: study concept, design, and supervision. MSS, IH, CB, PF, and LD: methodology, data analysis, and interpretation. MSS and AWW: data collection. MSS, IH and LD: drafting the manuscript. MSS, IH, SR, CB, PF, MJG, AWW, and LD: revision and editing of the manuscript. All authors have read and approved the final manuscript.

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Data availability
The dataset of the current study is available to researchers from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
All procedures involving research study participants were approved by the Institutional Review Board (IRB) of the Kandahar University. Participation in the study was voluntary. Written informed consent was obtained from all participants. This study was conducted according to the guidelines laid down in the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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