British Journal of Nutrition

British Journal of Nutrition (2023), 129, 1086–1094 doi:10.1017/S0007114522001842

Association of chronotype with eating habits and anthropometric measures in a sample of Iranian adults

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(Submitted 30 December 2021 – Final revision received 25 May 2022 – Accepted 7 June 2022 – First published online 22 June 2022)

Abstract

There is a lack of consistency in the literature that shows a relationship between chronotype, habits of eating and obesity in Iranian adults. This cross-sectional study was conducted on 850 individuals aged ≥ 18 years, selected from health houses of Tehran, Iran. Chronotype was assessed by Horne and Ostberg morningness–eveningness questionnaire. Specific eating habits, including breakfast skipping, intakes of fruits and vegetables, fast food, processed meats, soft drinks, coffee and tea, were assessed by dietary recalls. Weight, height, BMI, waist circumference, waist to hip ratio, waist to height ratio, visceral adiposity index, body roundness index and body adiposity index were based on measured values. We used logistic regression to investigate the association between chronotypes and anthropometric measures as well as eating habits. Morning- and intermediate/evening-type chronotypes accounted for 51·4 and 48·6 % of the total individuals, respectively. Moreover, intermediate/evening-type chronotypes were shown to have a lower education of diploma (53 %), employed (49·9 %) and smokers (11·6 %) compared with morning types (both sexes). We found that intermediate/evening-type chronotypes might not be significantly related to higher anthropometric measures and following unhealthy eating habits after controlling for confounders in men and women (all $P > 0·05$). Overall, both anthropometric measures and specific eating habits were not related to chronotype among Iranian adults. Further studies are needed to clarify these relations and to consider sleep disturbances.

Keywords: Obesity: Fast food: Visceral adiposity index: Waist circumference: Adults

The prevalence of obesity is growing worldwide so that nearly a third of the global population is being overweight or obese[1,2]. The WHO also indicated that over half of Iranian adults suffer from overweight and obesity, contributing to several diseases, including diabetes, CVD and cancer[3]. Dietary habits are one of the modifiable risk factors for obesity that might be associated with an increase in cardiovascular events[4,5]. For instance, following the Mediterranean diet, which is known for higher intake of plant-based diets and a lower intake of animal foods, results in weight loss in obese people[6,7].

The circadian timing of behavioural rhythms and physiological functions, such as energy intake, sleep-wake cycle and physical activity, has shown to play a major role in body weight regulation[8–10]. The circadian rhythms in approximately all mammalian cells are generated by the circadian clocks, including the master clocks in the suprachiasmatic nucleus of the hypothalamus[11,12]. Although circadian rhythms are entrained to follow the 24 h by external light-dark cycle, there are interindividual differences in the circadian rhythms, somewhat due to genetics[13,14]. Chronotype is a biological feature that comprises interindividual disparities in the circadian phase attributed to light-dark transition and affects daily activities[15,16].

It should be noted that synchronising physiological and environmental functions like eating behaviours can be affected by chronotypes[17,18]. Chronotype based on diurnal preferences could be ranged from extreme morning and evening types[19]. Evening types were more prone to have unhealthier habits, such as lower physical activity levels, than morning types[20]. Moreover, evening types also tend to have higher risks for diabetes[21] and all-cause mortality[22]. Maukonen *et al.*, in a population-based study on adults (*n* 1097), demonstrated that evening types prefer to higher intake of soft drinks and lower intake of cereals, vegetables and whole fruits than morning types[23]. Mirghani *et al.*, in a small-scale study (*n* 169), indicated that evening types were more probably to be breakfast skippers, as well as later dinner intake over 8 weeks among medical students[24]. Findings from a Turkish study among 142 university students indicated that evening types had different habits of nutrition like

Abbreviations: BAI, body adiposity index; MEQ, morningness–eveningness questionnaire; VAI, visceral adiposity index; WC, waist circumference; WHtR, waist to height ratio; WHR, waist to hip ratio; 24HR, 24-h dietary recall.

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breakfast skipping, eating big portions of foods and higher intake of low-quality foods compared with morning types[25]. Furthermore, the US small-scale study among 137 college students indicated that evening types were more prone to have higher weight gain and BMI over 8 weeks of follow-up[26]. Additionally, some social rhythms (e.g. working schedules) may force mainly evening chronotypes to differ from their intrinsic chronotype. This misalignment between biological and social times is known as social jet lag[27]. Besides, social jet lag has been related to poor health behaviours and increased risk of obesity[27,28]. However, the relation between chronotype and obesity has been contradictory[26,28]. There are insufficient data on the association between chronotype, eating habits and anthropometric measures among adults in developing countries that might have caused some bias in figuring out the particular features of adult obesity. Therefore, we aimed to explore whether chronotypes are linked to anthropometric measures in Iranian adults. In addition, the association of chronotype with eating habits was also evaluated to see whether the relation is different across chronotypes.

Methods

Study population

This is a cross-sectional study that was conducted on 850 adults (20–59 years old) from September 2018 to February 2019. Study participants were recruited by the method of classified two-stage cluster sampling from five districts of the Tehran province, including North, South, West and east, and the urban core. The subjects were randomly chosen from five districts (forty health houses), and then the number of subjects in each centre was obtained in the following manner: total sample size (850)/the number of health houses (40). The community health centres (health houses) cover approximately 6000–10 000 patients and consist of physicians and health technicians[29]. These centres are accountable for elective as well as emergency case management. The primary function of these centres is to provide health care services to the community it serves[30].

Eligible subjects were 20–59 years old, satisfied to participate in the study, with no major health problems, living in Tehran city and members of health houses. Individuals with diabetes, cancer, chronic kidney and liver disease, CVD, rheumatoid arthritis, Parkinson and other chronic diseases were excluded, as were those with pregnancy or lactation status.

The study was affirmed by the Medical Ethics Committee of the Tehran University of Medical Sciences, Tehran, Iran (Ethic number: IR.TUMS.MEDICINE.REC.1400·446) and written informed consent was provided by all individuals who participated in the study.

Chronotype assessment

Horne and Ostberg developed morningness–eveningness questionnaire (MEQ). It contains nineteen questions that were related to daily performance and sleep time preferences[19]. The range of scores varies from 16 to 86. The higher scores demonstrate a propensity towards morningness and the lower scores demonstrate a tendency towards eveningness. The validity and reliability of the MEQ for evaluating the chronotypes were established and found to be appropriate[31]. We first divided subjects into three groups, according to their chronotypes (morning-, intermediate- and evening-type chronotypes)[32]. With this classifying method, we had a small number of people in the evening group (*n* 15) compared with the other two groups (morning type (*n* 437) and intermediate type (*n* 400)) which made it difficult to compare the three groups due to a decrease in statistical power. Thus, we divided the people into two groups (intermediate/evening (score range: 16–58) *v.* morning types (score range: 59–86))[32]. By conducting this procedure, 138 men and 128 women were morning types and 299 men and 285 women were intermediate/evening types.

Anthropometric measures

Height was measured with a sensitivity of 0·1 cm, applying a stadiometer (Seca 206), unshod. Weight was measured with a sensitivity of 0·1 kg, applying digital scales (Seca 808) with light clothing. BMI was calculated as weight (kg) divided by height square (m^2). Waist circumference (WC) was assessed among lower rib and iliac crest, in the exhaled state, with light clothing, applying a tape metre (Seca 201)[33]. Waist to hip ratio (WHR) was calculated by dividing WC (cm) to hip circumference (cm). Waist to height ratio (WHtR) was calculated as WC (cm) divided by height (cm).

Visceral adiposity index (VAI) was dependent on WC (cm) and BMI (kg/m^2) and two biochemical factors (TAG (mg/dl) and HDL-cholesterol (mg/dl)). VAI has a different formula for men and women. This index was used to indicate the visceral fat[34].

$$Men: VAI = \left(\frac{WC}{39\cdot 68 + (1\cdot 88 \times BMI)}\right) \times \left(\frac{TG}{1\cdot 03}\right) \times \left(\frac{1\cdot 31}{HDL}\right)$$

$$Women: VAI = \left(\frac{WC}{39\cdot 58 + (1\cdot 89 \times BMI)}\right) \times \left(\frac{TG}{0\cdot 81}\right) \times \left(\frac{1\cdot 52}{HDL}\right)$$

Body roundness index was a good expression for body fat and dependent on WC (cm) and height (cm)[34].

$$BRI = 364\cdot 2 - 365\cdot 5 \times \sqrt{1 - \left(\frac{\left(\frac{WC}{2\pi}\right)^2}{(0\cdot 5\ height)^2}\right)}$$

Body adiposity index (BAI) was a direct indicator of body fatness and independent of further adjustment for other characteristics like sex and age. BAI was also dependent on hip circumference (cm) and height (m)[35].

$$BAI = \frac{Hip\ circumferemce\ (cm)}{Height\ (m)^{1\cdot 5}} - 18$$

Clinical assessment

After 8–12 h of fasting, 10 ml of blood samples was collected from all participants for blood sample collection. Serum and blood samples were centrifuged, poured into clean cryotubes and stored at –80°C until the analysis was performed. HDL was assessed by applying the cholesterol oxidase phenol-amino-pyrine method and TAG was assessed by applying the enzymatic method, based on glycerol-3-phosphate oxidase phenol-amino-pyrene with the automatic machine (Selectra E, Vitalab) with inter- and intra-assay coefficient variances lower than 10 %.

Dietary assessment

The participant's intake of food and drinks, in the past 24 h, was captured by trained dietitians using three non-consecutive days 24-h dietary recalls (24HR), which were structured and included two weekdays and one weekend day. The first 24HR were recorded by face-to-face interview and the other two 24HR were recorded by telephone interview. The 24HR was a standardised five-pass approach originated from the USA Department of Agriculture (USDA)[36]. Then, the nutrients intake of individuals was analysed by Nutritionist IV software.

Participants were also asked to report the definite time of the largest and smallest energy contents of meals and of all other snacks. The number of main meals and snacks that were consumed per day and eating breakfast was recorded. Breakfast was marked as a meal consumed before 11.00 hours, lunch between 11.00 and 16.00 hours and dinner between 17.00 and 23.00 hours[9,37].

Covariates

In accordance with inclusion and exclusion criteria, participants were selected and interviewed to gather data on demographics, menopause, physical activity, smoking status and supplement intake. We indicated widely validated International Physical Activity Questionnaire to measure physical activity of the subjects. Then, subjects were divided into three categories based on metabolic equivalents (MET), defined as very low (< 600 MET-min/week), low (600–3000 MET-min/week), moderate and high (> 3000 MET-min/week)[38]. Blood pressure was assessed two times, in the seated position, after a 10–15-min rest, using a digital sphygmomanometer (Beurer, BC 08), and the average of systolic and diastolic blood pressure was measured.

Statistical analysis

The statistical analysis was conducted applying SPSS version 26 (IBM). For comparison of the general characteristics, according to chronotypes, an independent sample t test and χ^2 test were performed for continuous and categorical variables, respectively. One-way ANOVA and χ^2 tests were used for continuous and categorical variables to present the differences between eating habits, according to chronotypes. We also used an independent sample t test to compare differences between chronotypes and anthropometric measures. In addition, we separately analysed data for men and women since there were discrepancies by sex on eating behaviours and anthropometric measures.

BMI was classified into two groups, including underweight/normal weight (< 25 kg/m^2) and overweight/obese (≥ 25 kg/m^2)[39]. We used sex-specific cut-points to classify WC and WHR. WC was classified into two groups as < 90 $v.$ ≥ 90 in males and < 80 $v.$ ≥ 80 cm in females[40].WHR was classified into two groups, including < 0·95 $v.$ ≥ 0·95 in males and < 0·80 $v.$ ≥ 0·80 in females[41]. WHtR was classified into two groups as < 0·5 $v.$ ≥ 0·5[42]. VAI was divided into two categories based on the prediction of the metabolic syndrome: <4·11 $v.$ ≥ 4·11 in males and < 4·28 $v.$ ≥ 4·28 in females. Body roundness index was classified into two groups as <4·75 $v.$ ≥ 4·75 in males and < 6·17 $v.$ ≥ 6·17 in females[34]. BAI was classified into two groups using cut-points based on population-based BMI cut-off values as < 25·6 $v.$ ≥ 25·6 in males and < 37·7 $v.$ ≥ 37·7 in females[43].

We also categorised specific eating behaviours so that we classified fruit and vegetable intake into two groups as < 206 $v.$ ≥ 206 g/d since the intake of fruit and vegetable was lower (on overage: 2·58 servings/d (206 g/d)) than the WHO recommended guidelines (5 servings/d) among Iranian adults[44]. Responses of having more than 3 d/week eating breakfast classified as 'having breakfast' and less than 3 d/week eating breakfast classified as 'skipping breakfast'. Tea consumption was classified into two groups, including (< 480 $v.$ ≥ 480 g/d)[45]. Soft drinks, fast food and processed meats were classified into two groups based on median split (soft drinks: < 9·3 $v.$ ≥ 9·3 g/d, fast food: < 29 $v.$ ≥ 29 g/week and processed meats: < 1 $v.$ ≥ 1 g/d). OR and 95 % CI were achieved using logistic regression to investigate the association of the chronotype (independent variable) with anthropometric measures (BMI, WC, WHR, WHtR, VAI, VRI and BAI) (dependent variables). Moreover, logistic regression was conducted to evaluate the association between chronotype (independent variable) and specific eating habits (dependent variables). The risk was described in an adjusted model for age, energy intake, marital status, smoking, education, occupation, sleep duration, physical activity, supplement intake and menopause. The statistical significance level was accepted at 0·05 for all analyses.

Results

Characteristics of participants

Eight hundred fifteen adults were incorporated in the study (68·7 % females; 44·5 (SD 11) years). In Table 1, the general characteristics of participants according to chronotypes were reported. Morning- and intermediate/evening-type chronotypes accounted for 51·4 and 48·6 % of the total individuals, respectively. Intermediate/evening-type chronotypes were shown to have a lower education of diploma (53 %), employed (49·9 %) and smokers (11·6 %) compared with morning types. The mean of TAG and HDL among intermediate/evening types was 146 (SD 80) mg/dl and 49·9 (SD 10·4) mg/dl. Moreover, the mean of TAG and HDL among morning types was 140 (SD 80) mg/dl and 49·7 (SD 9·91) mg/dl, respectively. In addition, the interviewed males and females did not differ significantly in age and the other general characteristics except for SBP and DBP among males, based on their chronotypes. So, intermediate/evening-type males had higher levels of SBP and DBP than morning types (P_{SBP} = 0·03 and P_{DBP} = 0·04).

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Table 1. General characteristics of participants according to chronotypes in men and women
(Numbers and percentages; mean values and standard deviations)

	Chronotype									
	Men (*n* 266)					Women (*n* 584)				
	Morning		Intermediate/evening			Morning		Intermediate/evening		
Variables	*n*	%	*n*	%	*P**	*n*	%	*n*	%	*P**
n	138		128			299		285		
Age (year)										
Mean	44·7		45·9		0·31	44·1		44·9		0·35
SD	9·85		9·91			11·2		10·8		
Education					0·58					0·96
Illiterate	8	5·8	8	6·3		31	10·4	26	9·1	
Under diploma	42	30·4	36	28·1		75	25·1	71	24·9	
Diploma	32	23·2	39	30·5		97	32·4	93	32·6	
Educated	56	40·6	45	35·2		96	32·1	95	33·3	
TAG (mg/dl)										
Mean	136		143		0·47	145		149		0·51
SD	78·1		83·0			75·8		76·9		
HDL (mg/dl)										
Mean	50·0		50·9		0·37	50·0		49·3		0·25
SD	10·6		11·6			9·79		9·82		
SBP (mmHg)										
Mean	118		124		0·03	118		118		0·23
SD	25·6		18·5			15·8		15·3		
DBP (mmHg)										
Mean	77·3		80·9		0·04	79·2		78·8		0·28
SD	14·4		13·8			9·89		8·85		
Occupation					0·01					0·97
Employed	67	48·6	40	31·3		60	20·1	53	18·6	
Housekeeper	35	25·4	43	33·6		202	67·6	196	68·8	
Retried	34	24·6	45	35·2		25	8·4	24	8·4	
Unemployed	2	1·4	0	0·0		12	4·0	12	4·2	
Marital status					0·58					0·20
Married	121	87·7	116	90·6		236	78·9	215	75·4	
Single	14	10·1	11	8·6		36	12·0	31	10·9	
Divorced	3	2·2	1	0·8		27	9·0	39	13·7	
Menopause										0·21
Yes	–		–		–	121	40·5	130	45·6	
No	–		–			178	59·5	155	54·4	
Smoking status					0·23					0·67
Not smoking	112	81·2	104	81·3		283	94·6	271	95·1	
Quit smoking	6	4·3	11	8·6		9	3·0	10	3·5	
Smoker	20	14·5	13	10·2		7	2·3	4	1·4	
Physical activity					0·13					0·75
Low	78	56·5	84	65·6		195	65·2	182	63·9	
Moderate	60	43·5	44	34·4		104	34·8	103	36·1	
Supplement intake					0·42					1·00
Yes	27	19·6	20	15·6		43	14·4	41	14·4	
No	111	80·4	108	84·4		256	85·6	244	85·6	

DBP, diastolic blood pressure; SBP, systolic blood pressure.
* Calculated by χ^2 and independent sample *t* test for qualitative and quantitative variables, respectively and *P*-value < 0·05 indicates significant level.

The differences between dietary intakes and eating habits according to chronotypes

The differences between eating habits, according to chronotypes, are presented in Table 2. Males with the intermediate/evening-type chronotype were indicated to have a lower intake of total fibre ($P=0·01$) than morning types after adjustment for covariates. Also, intermediate/evening-type males were indicated to have a habit of eating snacks during the day ($P=0·02$) than morning types. Of 584 females, those with intermediate/evening-type chronotypes were significantly more likely to eat breakfast later ($P<0·001$) after covariates adjustment. However, our analysis did not present any significant difference for the other eating habits among the two groups.

Logistic regression demonstrated no significant relation between chronotype and specific eating habits in men and women after controlling for confounders (all $P>0·05$) (online Supplementary Table S1).

The anthropometric measures of participants according to chronotypes

Table 3 presents the anthropometric measures of participants according to chronotypes. No significant differences were

https://doi.org/10.1017/S0007114522001842 Published online by Cambridge University Press

Table 2. The differences between, dietary intakes and eating habits according to chronotypes in men and women
(Mean values and standard deviations)

	Chronotype									
	Men (*n* 266)					Women (*n* 584)				
Variables	Morning		Intermediate/ evening			Morning		Intermediate/ evening		
n	138		128		*P*†	299		285		*P*†
Energy intake, dietary intake and eating habits										
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Total daily energy intake (kcal/d)**	2593	864	2667	912	0·45	2311	835	2300	894	0·26
Energy intake in breakfast (kcal/d)**	377	119	379	126	0·82	410	124	423	129	0·20
Energy intake in lunch (kcal/d)**	494	152	503	153	0·66	545	152	548	156	0·75
Energy intake in dinner (kcal/d)**	492	167	484	162	0·60	494	142	497	149	0·79
Carbohydrate (% of total energy)*	56·9	11·0	55·2	11·9	0·27	57·0	9·46	57·1	9·28	0·46
Protein (% of total energy)*	13·9	3·09	13·5	3·37	0·27	13·8	2·99	13·7	2·69	0·57
Fat (% of total energy)*	30·1	10·9	31·1	5·97	0·27	28·9	8·98	29·2	8·02	0·63
Total fibre (g/d)*	19·5	10·8	16·5	7·55	0·01	17·9	8·09	18·3	9·29	0·71
Fruits and vegetables (g/)*	742	459	803	465	0·29	703	433	691	393	0·74
Tea (g/d)*	212	118	200	126	0·38	484	93·0	489	87·9	0·60
Coffee (g/d)*	15·0	11·5	13·4	11·5	0·31	13·5	11·6	13·5	11·7	0·89
Soft drinks (g/d)*	13·5	11·3	13·9	11·1	0·86	12·3	11·2	12·1	11·7	0·88
Processed meats (g/d)*	1·50	2·17	1·38	1·44	0·55	1·33	1·33	1·41	1·57	0·55
Fast food (g/d)*	27·6	13·2	28·3	12·8	0·62	44·6	27·9	46·9	30·4	0·35
	n	%	*n*	%		*n*	%	*n*	%	
Skipping breakfast					0·51					1·00
Yes	21	15·2	24	18·8		49	16·4	46	16·1	
No	117	84·8	104	81·3		250	83·6	239	83·9	
Meal frequency										
Snack/d					0·02					0·22
1	22	16·1	28	21·9		29	9·7	37	13·0	
2	48	35·0	59	46·1		111	37·1	115	40·4	
3	67	48·9	41	32·0		159	53·2	133	46·7	
Main meals					0·66					0·83
1	29	21·2	30	23·4		56	18·7	51	17·9	
2	108	78·8	98	76·6		243	81·3	234	82·1	
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Meal times										
Breakfast time (hours:minutes)**	8:03	0:42	8:12	0:45	0·07	7:56	0:40	8:12	0:45	< 0·001
Lunch time (hours:minutes)**	14:01	0:34	13:57	0:35	0·39	13:59	0:32	13:57	0:33	0·26
Dinner time (hours:minutes)**	20:44	0:32	20:45	0:36	0·69	20:39	0·32	20·44	0:36	0·13

* Adjusted for age and enery intake.
** Adjusted for age.
† Calculated by χ^2 and one-way ANOVA for qualitative and quantitative variables, respectively and *P*-value < 0·05 indicates significant level.

observed between chronotypes and anthropometric measures in both sexes (all $P > 0{\cdot}05$).

We used logistic regression to investigate the association between chronotypes and anthropometric measures (obesity and abdominal obesity measures), based on BMI, WC, WHR, WHtR, VAI, VRI and BAI (Table 4). Logistic regression revealed that intermediate/evening chronotypes have no significant relation with an increase in anthropometric measures after adjusting for potential covariates, including age, energy intake, marital status, smoking, education, occupation, sleep duration, physical activity, supplement intake and menopause in both sexes (all $P > 0{\cdot}05$).

Discussion

The current study aimed to explore the association of chronotype and eating habits with anthropometric measures in Iranian adults. However, we found no significant relation between chronotype and following specific eating habits. Moreover, no obvious differences were observed between chronotypes and anthropometric measures and indexes. These findings suggest that intermediate/evening-type chronotypes might not be significantly related to higher anthropometric measures and following unhealthy eating habits among Iranian adults.

Chronotypes and eating habits

Our study indicated no significant relation between chronotypes and specific eating habits after controlling for covariates. In contrast, a review study that analysed data from thirty-six studies indicated that evening types followed an unhealthier diet associated with obesity. Therefore, these people were more likely to fail in weight loss programmes[46]. In addition, previous studies demonstrated that evening-type chronotype was related to binge eating[47] and greater intake of energy[48], mainly from lower intake of fruits and vegetables[8] and higher intake of fast food[49].

Table 3. The anthropometric measures of participants according to chronotypes
(Mean values and standard deviations)

	Chronotype									
	Men (*n* 266)					Women (*n* 584)				
	Morning		Intermediate/ evening			Morning		Intermediate/ evening		
Variables	Mean	SD	Mean	SD	*P*†	Mean	SD	Mean	SD	*P*†
n	138		128			299		285		
Weight (kg)	80·7	16·1	80·4	12·3	0·87	70·0	11·1	70·5	12·6	0·58
Height (cm)	170	7·24	170	7·08	0·84	159	6·91	158	11·5	0·60
BMI (kg/m^2)	27·6	4·44	27·6	3·81	0·88	27·6	4·73	27·9	5·13	0·85
WC (cm)	94·6	13·7	96·1	10·0	0·29	89·8	11·5	89·8	12·8	0·09
WHR	0·92	0·08	0·93	0·06	0·11	0·86	0·16	0·86	0·08	0·85
WHtR	0·55	0·07	0·56	0·06	0·22	0·56	0·08	0·57	0·08	0·11
VAI	3·88	2·95	4·16	3·20	0·47	5·99	4·10	6·35	4·58	0·31
BRI	4·56	1·55	4·76	1·43	0·28	4·80	1·83	5·07	2·01	0·09
BAI	28·0	4·99	28·2	4·48	0·66	34·0	6·99	34·6	6·69	0·29

BAI, body adiposity index; BRI, body roundness index; VAI, visceral adiposity index; WC, waist circumference; WHR, waist to hip ratio; WHtR, waist to height ratio.
† Calculated by independent sample *t* test, and *P*-value < 0·05 indicates significant level.

Table 4. The association between anthropometric measures (obesity and abdominal obesity measures) and chronotypes in men and women (Odds ratios and 95 % confidence intervals)

Chronotypes group				
Outcome measures			Morning type	
Men	Model*	Intermediate/evening type (reference)	OR	95 % CI
BMI (ref: < 25 kg/m^2)†	Adjusted OR (% CI)	1	0·82	0·40, 1·67
WC (ref: < 0·90 cm)†	Adjusted OR (% CI)	1	0·72	0·31, 1·66
WHR (ref: < 0·95)†	Adjusted OR (% CI)	1	0·70	0·37, 1·32
WHtR (ref: < 0·5)†	Adjusted OR (% CI)	1	1·41	0·61, 3·25
VAI (ref: < 4·11)†	Adjusted OR (% CI)	1	0·72	0·40, 1·29
BRI (ref: < 4·75)†	Adjusted OR (% CI)	1	0·99	0·54, 1·81
BAI† (ref: < 25·6)†	Adjusted OR (% CI)	1	1·07	0·55, 2·09
Women				
BMI (ref: < 25 kg/m^2)†	Adjusted OR (% CI)	1	1·06	0·67, 1·68
WC (ref: < 80 cm)†	Adjusted OR (% CI)	1	1·45	0·86, 2·43
WHR (ref: < 0·80)†	Adjusted OR (% CI)	1	1·22	0·76, 1·97
WHtR (ref: < 0·5)†	Adjusted OR (% CI)	1	1·30	0·76, 2·24
VAI† (ref: < 4·28)†	Adjusted OR (% CI)	1	0·89	0·60, 1·32
BRI (ref: < 6·17)†	Adjusted OR (% CI)	1	0·64	0·38, 1·07
BAI† (ref: < 37·7)†	Adjusted OR (% CI)	1	0·83	0·53, 1·30

BAI, body adiposity index; BRI, body roundness index; ref, reference; VAI, visceral adiposity index; WC, waist circumference; WHR, waist to hip ratio; WHtR, waist to height ratio.
Cut-points for anthropometric measures/indexes: BMI (≥ 25 *v.* < 25 kg/m^2), WC (men ≥ 90 *v.* < 90 cm, women ≥ 80 *v.* < 80 cm), WHR (men ≥ 0·95 *v.* < 0·95, women ≥ 0·8 *v.* < 0·8), WHtR (≥ 0·5 *v.* < 0·5), VAI (men ≥ 4·11 *v.* < 4·11, women ≥ 4·28 *v.* < 4·28), BRI (men ≥ 4·75 *v.* < 4·75, women ≥ 6·17 *v.* > 6·17) and BAI (men ≥ 25·6 *v.* < 25·6, women ≥ 37·7 *v.* < 37·7).
* Calculated by logistic regression and *P*-value < 0·05 indicates significant level.
† Adjusted for age, energy intake, marital status, smoking, education, occupation, sleep duration, physical activity, supplement intake and menopause.

In comparison, morning-type chronotypes were more prone to have cognitive restrain and were more prone to have lower disinhibition and inclination to hunger[50]. Beaulieu *et al.*, in a study of forty-four adults (aged 18–25 years), indicated that morning-type individuals had a lower tendency for higher intake of fast food and had a smaller appetite than evening-type individuals[51]. Thus, previous studies have shown that evening types have adverse health behaviours. Although we combined intermediate- and evening-type groups due to the small number of evening types (*n* 15), our results were more likely to reflect just the differences between intermediate and morning types and it might not capture the evening-type chronotype. Moreover, this discrepancy with the previous study might indicate that not everyone takes advantage of having a morning-type chronotype. Moreover, our study did not consider the following eating habits, including food addiction, watching TV during meals, binge eating and eating duration, which might be the factors that caused our relationship to be insignificant.

Chronotypes and anthropometric measures

We observed no significant relationship between chronotype and anthropometric measures after controlling for covariates. A finding from a cohort study involving 390 healthy young adults indicated no significant relationship between chronotype and anthropometric outcomes, including BMI, WHR and WHtR[52]. Also, a Spanish cohort study among 4243 adults with 3·5 years of follow-up indicated no relation between total energy intake

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in the evening and weight gain[53]. The majority of other studies investigating the relation between chronotype and anthropometric outcomes indicated that evening types had higher BMI and were more likely to gain weight than morning types[26,54].

A study by Amicis *et al.*, in a cross-sectional study among 416 European adults, demonstrated that for a 1 point increment in reduced MEQ score, evening types had 0·5 cm greater visceral fat and 2 cm greater WC than morning types[55]. BAI, body roundness index and VAI are new indices that effectively predict cardiovascular events and metabolic abnormalities[34,56]. However, we did not find any association between chronotype and these new indexes. Plausible explanations for this discrepancy might be due to the cross-sectional design of our study or differences in individual characteristics. For instance, young adults are likely to have raised tolerance to shift works[57]. Moreover, most of our participants were women and overweight. It should be noted that women and overweight individuals are more likely to underreport their weight compared with normal body weight individuals and men[58]. In addition, some methodological problems, such as different dietary assessment methods and variations in assessing and classifying chronotypes (the fact intermediate- and evening-type groups were combined due to the small number of evening types), might lead to inconsistent findings. In other words, diurnal preferences were investigated using MEQ[19]. However, most of our participants were of the age to be a working population. Hence, the MEQ might not reflect what they were actually doing in terms of their habits as it relates to chronotype.

As mentioned previously, evening types are exposed to following unhealthier food intake[23,59] and are at higher risk of obesity[26], type 2 diabetes[21] and all-cause mortality[22] than morning types. One possible mechanism underlying the relation between chronotype and obesity risk might be increased plasma C-reactive protein level[60]. C-reactive protein level is greater in the evening chronotype[61], an impact that might be possibly described by alterations in the activity of the autonomic nervous system[62]. In addition, evening chronotype is related to greater cortisol response to a standardised laboratory stressor. Also, there was a positive relation between cortisol response and obesity[60]. Lipid metabolism in the liver and adipose tissue is regulated by glucocorticoids that stimulate hepatic gluconeogenesis and cause short-term insulin resistance[63] and thus, it promotes abdominal visceral fat mass as well as weight gain through elevated cortisol secretion[64]. Altogether, these effects could cause metabolic dysfunction in evening type chronotypes[60]. Considering such chronotype-related factors, more studies are needed to elucidate this association.

Strengths and limitations

To the best of our knowledge, this is the first study to evaluate the relationship between chronotype, eating habits and anthropometric measures among Iranian adults, which could design new policies to avoid obesity in the Iranian population. Clinical trial findings mentioned that adults involved in weight control programmes benefit more from a chronotype-related diet than traditional recommendations[65]. Additionally, we analysed data for men and women separately. In addition, our sample size was high and we also included new indices, which were related to cardiometabolic risks[34,56] and evaluated their relations with chronotype.

Our study had several limitations that needed to be acknowledged. First, we used 24HR for dietary assessment, which may have non-differential misreporting bias. Second, the cross-sectional design of this study may not find a true cause and effect relation between chronotype, eating habits and anthropometric measures. Furthermore, applying the USDA food composition table to estimate micro- and macronutrients might influence our results since USDA food composition table does not have the same nutrient content as the same food available in Iran. Also, some of the analyses that were conducted in our manuscript were post-hoc exploratory and not prospectively determined.

Moreover, we classified subjects into two groups based on their chronotypes (intermediate/evening and morning types). Besides, if we divided subjects into three groups, according to their chronotype (morning-, intermediate- and evening-type chronotype)[32], the evening group had only thirteen members compared with the other two groups (morning type (n 437) and intermediate type (n 400)), which caused the participants could not be divided balance; as a result, this led to a decrease in statistic power. As this study included a small number of evening types, it might not capture this particular group and thus the results more likely reflect just the differences between morning and intermediate types. Besides, this unusual distribution of chronotypes might be due to age of the participants because the average age of our participants was 44·7 years and this can be a factor that causes an imbalance between chronotypes distribution. For example, Paine *et al.*, in a study of 2526 adults living in New Zealand (average age: 40 years), indicated that the mean score of the chronotype was 58·1[66]. Moreover, another study of 526 French adults (average age: 51 years) showed that the mean score of chronotype was 59·6[67]. On the other hand, a previous study showed that individuals tend to be more morning oriented with increases in the age[68]. However, more than 50 % of the total variance is attributed to the heritability of morningness–eveningness[68].

Conclusion

Overall, our cross-sectional study did not indicate an association between chronotype and anthropometric measures and specific eating habits among Iranian adults. Further studies are needed, considering the limitations of our study and combined sleep disturbances with chronotypes, which might change our results.

Acknowledgements

Authors thanks all those who participated in this study.

We did not receive any funding for this study.

A. L. and M. M. collected the data. S. Z. M. performed the statistical analysis. S. Z. M., A. L. and M. M. wrote the first draft contribution from S. S. B. S. Z. M., A. L., M. M. and S. S. B. reviewed the draft. S. S. B. revised the manuscript for the final version. All of the authors are responsible for the final manuscript.

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Supplementary material

For supplementary material referred to in this article, please visit https://doi.org/10.1017/S0007114522001842

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