Progress in Nutrition 2018; Vol. 20, N. 3: 00-00 DOI: 10.23751/pn.v20i3.5313

Original article

Macronutrient composition and body mass index vary by season in college students

Fahimeh Haghighatdoost[1,2], *Mahsa Malekahmadi*[3], *Shokouh Onvani*[1,2], *Nahid Ramezani*[1,2], *Leila Azadbakht*[1,2,4,3]

[1]Food Security Research Center, Isfahan University of Medical Sciences, Isfahan, Iran; [2]Department of Community Nutrition, School of Nutrition and Food Science, Isfahan University of Medical Sciences, Isfahan, Iran; [3]Department of Community Nutrition, School of Nutritional Science and Dietetics, Tehran University of Medical Sciences, Tehran, Iran; [4]Diabetes Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran - E-mail: azadbakht@hlth.mui.ac.ir

Summary. *Objective:* To describe seasonal variation in food intake, body weight, body mass index (BMI) and mid- upper arm circumference (MUAC) in college students. *Methods:* In this follow-up study, 120 male and 180 female college students aged 18-35 years were enrolled. All participants were visited every 3 month (four sampling points: baseline and three consecutive quarters) for 1-year period. Dietary intakes were assessed using seven- to nine-day food records on randomly selected days per quarter. Anthropometric measurements were performed by a trained dietetic according to standard protocol at four time points (12 to 15 weeks apart). *Results:* Daily caloric and carbohydrate intakes were higher by 193 kcal and 8% of total daily calorie intake during the summer compared to the winter. Fat intake was consumed in greater amount in the winter rather than other seasons. The highest weight and BMI were observed in the summer (72.9±4.6 kg and 26.22±5.3 kg/m2, respectively), whereas the lowest values were in the winter (68.7±3.6 kg and 24.7±3.8 kg/m2, respectively). The greatest difference for MUAC was found between fall and winter (-2.80±0.25 cm; P=0.001). *Conclusions:* There are seasonal variations in diet and anthropometric measurements among college students. Therefore, it must be taken into account when counseling individuals about healthy habits as well as when designing nutritional epidemiology studies.

Key words: Seasonal variation, obesity, body mass index, diet, macronutrient composition.

Abbreviation

MUAC: Mid- upper arm circumference; BMI: Body mass index.

Introduction

The obesity prevalence has been gradually increased over the past 3 decades (1,2). According to the statistics, 13% of the world's adult population (11% of men and 15% of women) are obese and 39% are overweight (38% men and 40% women) (3). Corresponding values among Iranian adults are 12.6- 25.9% and 27- 38.5%, respectively (4).

Anthropometric measurements can be influenced by genetic, epigenetic and environmental factors (e.g. dietary intakes and physical activity) (5,6). Researchers are increasingly recognizing the importance of the environmental factors in facilitating weight gain and obesity (5,7). The association of seasonal variation as an environmental variable and weight change is a new concept in nutritional epidemiology which has been poorly investigated (8-11). Seasonal variation may be related to anthropometric measurements including fat and muscle mass and body weight by affecting physical activity and dietary intakes. A large-scale monitoring population study among Netherland adults showed that subjects had higher body mass index (BMI) and waist circumference (WC) during winter compared to summer, and seasonal variation was greater for abdominal obesity rather than general obesity (12). Another short-term longitudinal study revealed that subjects had greater weight gain during the festive season holiday than other seasons (9-12).

Weight change might be associated with changes in muscle and fat mass. Therefore, it is possible that weight change by seasonal variation would be followed by changes in fat and muscle mass over the year. Indeed, participants may have higher physical activity level during summer than winter and have higher calorie intake and lower physical activity level during winter (8, 9, 13). These differences may lead to different change in fat and muscle mass. Because of differences in physical activity and dietary intakes changes among different age groups through the seasons, it is relevant to investigate such association in all age groups. To the best of our knowledge, there is little evidence in this context and no report from Iran and Asia, as a less developed country. In the current study, we aimed to examine anthropometric changes over the year and distinguish session where people eat more, active less, and gain weight.

Methods

Subjects

Participants were recruited from the students of Isfahan University of Medical Sciences. Individuals were recruited if they were 18 to 35 years old, not be on weight-control diets, be free of metabolic disorders which may affect weight status (e.g. Cushing's syndrome or hypothyroidism or hyperthyroidism) and not being pregnant or lactating. To provide a random sampling, multistage cluster random sampling method was used. First, we considered the number of all schools (n=9) and departments (n=30) in Isfahan University of Medical Sciences, and then some students were randomly selected from each department. Based on the suggested formula for cross-sectional study, 300 participants would provide adequate power (β= 80%) for the current study. However, to increase the power of study, we enrolled 500 students between February 2014 and February 2015, with at least 10 individuals from each department. Individuals were excluded if their daily energy intake was <800 or >4200 kcal (n=8). Subjects who had less than eight dietary records or had not fully attended in every five visits were also excluded (n=20). Finally, statistical analysis was conducted among 300 individuals. All subjects declared their willingness to participate in the research by providing a written informed consent. The present study was approved by the research council and ethical committee of the School of Nutrition and Food Science, Isfahan University of Medical Sciences, Isfahan, Iran.

Data collection

Demographic characteristics including sex, age and socio-economic status were collected by a self-administered questionnaire at baseline. Body weight and height of participants were measured with wearing light clothing and no shoes. The measurement of height was recorded to the nearest 0.5 cm and weight was recorded to the nearest 100 gr. BMI was calculated by dividing weight in kilogram by the square of height in meter. Overweight and obesity were defined according to BMI (154). Overweight was defined as 25≤BMI≤29.9, whilst obesity was considered as BMI≥30 kg/m^2 (8, 15).

To measure the Mid- upper arm circumference (MUAC), participant should have bent the right arm to a 90° angle at the elbow and the upper arm was parallel to the chest. Then the midpoint of right arm was ascertained and marked at the skin. The insertion tape was pulled around the marked midpoint of the arm, but not too tight that the tissue was compressed (16). The accuracy of measurement was 1 mm.

At the end of every three months weight, MUAC and BMI were measured (totally five visits). The participants were asked to recall hours they spent the previous day at different types and intensities of activities. MET values were obtained from a physical activity compendium published by Ainsworth et al.(17). All interviews were conducted by trained dietitians.

Dietary intake assessment

Dietary intakes were monthly assessed by a 3-day food record. Totally, we had at least nine weighted food records for each season. Participants were asked to record their dietary intakes in 2 non-consecutive weekdays and one weekend day except for special days (celebration and party). All participants were educated how to record their dietary intakes, meals and snacks with exact portions and standard serving sizes during 24 hours. The average number of dietary records was 36 per subject. The accuracy of food records were checked by trained nutritionists and ambiguous items were declared via phone interview. Household measurements were converted to grams. Energy and nutrient intakes were estimated by using NUTRITIONIST IV (N4) software, which was adopted for Iranian foods.

Statistical analyses

Normal distribution of dietary intakes and anthropometric measurements were tested by Kolmogorov–Smirnov. General characteristics of study population were described as means and percentages by using descriptive statistics. One-way analysis of variance (ANOVA) was performed for multiple sample comparison for continuous variables (dietary intakes, anthropometric measurements and their mean differences between seasons) across the seasons. Independent sample t-test was done to compare continuous variables between men and women in each season. Mean differences in anthropometric measurements between seasons were also compared in adjusted models for sex, physical activity and socioeconomic status by using analysis of covariance (ANCOVA). All statistical analyses were performed by Statistical Package for Social Sciences (SPSS, Inc., Chicago IL, USA; version 20). P< 0.05 was considered significant in all statistical analyses.

Results

Table 1 shows demographic characteristics of participants at baseline. Participants' average age was 21.7 (s.d.=2.3) years and 40 % of participants were male. The participant's means height and weight were 169.0 (s.d =21.0) cm and 71.2 (s.d =3.6) kg, respectively. Almost 50% of participants were normal weight and around 11.0% were obese. The average BMI was 25.6 (s.d. = 2.3) kg/m^2, and the average MAC was 22.4 (s.d =2.1) cm.

Table 2 shows means of dietary intakes and physical activity of participants by season. In the winter, fat had the highest contribution in total energy intake (36 ±2% of daily energy intake), and in the summer, carbohydrate had the highest contribution (60 ± 5% of daily energy intake). There were no significant differences in seasonal variation of dietary intakes and physical activity between male and female.

Table 3 indicates means of anthropometric measurements by season in the entire study population, and each gender. The peaks of body weight and BMI were in the summer and the peak of MUAC was in the fall. There were no significant differences in seasonal variation of body weight, MUAC and BMI between male and female.

Table 1. Characteristics of study participants at baseline.

Variable	Male		Female	
	Mean/frequency	s.d.	Mean/frequency	s.d.
Age (years)	21.90	2.60	21.56	2.39
Male (%)	40	-	60	-
Never smoker (%)	100	-	100	-
Height (cm)	1.76	0.29	1.63	0.23
Weight (kg)	79.6	3.7	62.5	3.1
MUAC (cm)	28.93	2.9	16.91	2.5
BMI[1] classification (%)				
Normal (18.5–24.9)	52.5	-	46.93	-
Overweight (25–29.9)	38.5	-	40.97	-
Obese (≥ 30)	10.01	-	12.01	-

[1] MUAC: Mid- upper arm circumference; BMI: Body mass index

Table 2. Relevant dietary intakes by season

Variables	Winter mean	Spring mean	Summer mean	Fall mean	P-value[1]
Energy (kcal/d)	2000 ± 21	2006 ± 22	2193 ± 36	2034 ± 27	< 0.05
Male	2009±19	2012±20	2220±22	2084±23	<0.01
Female	1998±20	2000±19	2165±23	1981±21	<0.05
P-value[2]	0.18	0.21	0.16	0.15	-
Carbohydrate (%)	52 ± 5	55 ± 4	60 ± 5	56 ± 5	< 0.05
Male	53±6	55±4	61±5	57±5	<0.05
female	51±5	55±4	59±4	55±5	<0.05
P-values	0.24	0.58	0.34	0.42	-
Fat (%)	36 ± 2	31 ± 2	29 ± 2	24 ± 2	< 0.05
Male	35 ±2	31±2	28±2	23	<0.05
female	37±2	31±2	30±2	25	<0.05
P-values	0.34	0.76	0.65	0.43	-
Protein (%)	12 ± 1	14 ± 2	11 ± 1	15 ± 3	0.09
Male	12±1	14±2	11±1	15±2	0.11
Female	12±1	14±2	11±1	15±2	0.10
P-value	0.81	0.76	0.67	0.83	-
Saturated fatty acids (%)	10 ± 2	8 ± 1	8 ± 1	8 ± 1	0.18
Male	11 ±3	8 ± 1	8 ± 1	8 ± 1	0.09
female	9±2	8 ± 1	8 ± 1	8 ± 1	0.17
P-values	0.23	0.67	0.75	0.84	-
Total physical activity (MET-h/d)	8.9 ± 2.1	8.5 ± 2.0	9.3 ± 2.1	8.7 ± 2.2	0.08
Male	9.2 ±2.3	8.7±2.1	9.5±2.2	8.8±2.3	0.09
female	8.6±2.0	8.2±2.0	9.1±2.0	8.6±2.1	0.07
P-values	0.11	0.25	0.16	0.43	-

[1] This P-value compares the seasons and derived from one-way ANOVA test.
[2] This P-values compares the values between men and women and derived from independent sample t-test.

Table 4 indicates the comparison of anthropometric measurements between seasons in the entire study of population in crude and adjusted models. The means of BMI, MUAC and weight were significantly different between all seasons (P<0.05). Maximum difference for weight and BMI was between summer and winter (P=0.001). Maximum difference for MUAC was between fall and winter (-2.80±0.32; P=0.01) as well as fall and summer (-2.80±0.25; P=0.001). All relationships remained significant even after adjustment for sex, physical activity and socioeconomic status.

Discussion

This study suggests significant seasonal fluctuations in weight, BMI and MUAC as well as dietary intakes including energy, fat and carbohydrate. Greater energy and carbohydrate intakes in summer concurred with greater BMI and weight. No seasonal fluctuations were observed in physical activity and protein intake. The results of this study illustrate that increased carbohydrate intake has more effect on calorie intake and weight gain than increased fat intake.

It is well established that there is seasonal fluctuations in anthropometric measurements, particularly

Table 3. Relevant anthropometric measurements and physical activity by season

Variable	Winter mean	Spring mean	Summer mean	Fall mean	P-value[1]
Weight (kg)	68.7 ± 3.6	70.3 ± 3.3	72.9 ± 4.6	71.9 ± 5.2	< 0.05
Male	70.1±3.9	72.2±3.7	74.8±4.9	73.8±5.7	<0.05
female	66.9±3.1	68.1±3.0	70.6±4.5	69.3±5.1	<0.05
P-values[2]	0.03	0.01	0.03	0.01	-
MUAC[3] (cm)	20.3 ± 5.6	21.4 ± 4.6	22.3 ± 5.1	23.1 ± 4.6	< 0.05
Male	22.1±5.8	22.3±4.7	23.9±5.3	24.5±4.6	<0.05
Female	18.5±5.4	19.2±4.5	21.0±5.0	21.6±4.5	<0.05
P-values	0.04	0.05	0.07	0.09	-
BMI[3] (kg/m^2)	24.7 ± 3.8	25.28 ± 4.1	26.22 ± 5.3	25.8 ± 5.9	< 0.01
Male	26.1 ±3.9	26.1±5	27.7±5.4	26.5±5.8	<0.01
female	22.9±3.5	24.3±5.1	25.0±5.2	24.2±5.4	<0.01
p-values	0.01	0.09	0.10	0.08	-

[1] This P-value compares the seasons and derived from one-way ANOVA.
[2] This P-value compares the values between men and women and derived from independent sample t-test.
[3]MUAC: Mid- upper arm circumference; BMI: Body mass index

Table 4. Comparison of anthropometric measurements between seasons

Variables	Spring						Summer				fall		Season
	Summer		fall		Winter		fall		Winter		Winter		P value
	Mean difference	P value	Mean difference	P value	Mean difference	P value	Mean difference	P value	Mean difference	P value	Mean difference	P value	
Weight (kg)													
Crude	2.59±0.23	0.01	1.54±0.11	0.01	-1.60±0.24	0.01	-1.02±0.12	0.03	-4.12±0.50	0.001	-3.21±0.42	0.001	0.001
Adjusted model[1]	2.50±0.21	0.02	1.49±0.10	0.03	-1.50±0.22	0.01	-1.00±0.13	0.04	-4.10±0.48	0.001	-3.20±0.44	0.001	0.001
BMI (kg/m^2)													
Crude	0.95±0.24	0.01	0.52±0.19	0.05	-0.54±0.13	0.03	-0.42±0.07	0.02	-1.55±0.39	0.001	-0.97±0.12	0.01	0.01
Adjusted model	0.92±0.21	0.01	0.50±0.14	0.05	-0.51±0.11	0.04	-0.40±0.06	0.03	-1.49±0.34	0.001	-0.95±0.16	0.01	0.01
MUAC													
Crude	0.95±0.23	0.01	1.71±0.23	0.01	0.90±0.28	0.01	-2.80±0.32	0.01	-2.06±0.31	0.01	-2.80±0.25	0.001	0.001
Adjusted model	0.90±0.27	0.01	1.69±0.20	0.01	0.87±0.25	0.01	-2.72±0.33	0.01	-2.00±0.26	0.01	-2.76±0.27	0.001	0.001

[1] adjusted for sex, physical activity, socioeconomic status.

weight and BMI. However, it seems depending on study population and behavioral factors, the pattern and magnitude of these fluctuations might be different. For example, in college students, due to differences in dietary intakes and physical activity levels during different seasons, larger fluctuations might be expected in comparison with a middle-aged population who have similar schedule in different seasons of the year. Findings from Ma's study support this assumption. Consistent with our findings Ma revealed seasonal variation in body weight in middle-aged adults (47.6 yr), but their fluctuations were considerably less than ours (18).

Our findings indicated MUAC is related to weight and BMI, it is compatible whit Banik's study(19). In our study all of them were at minimum level in winter, but findings from Lemma's study indicated MUAC was more related to another factor named maximum voluntary contraction [MVC] than BMI (20). Previous reports proposed that circumference measurements specially limb circumferences like MUAC might be sensitive indirect measurements of peripheral muscle; therefore, it would be more appropriate to look into the changes in MUAC as a measurement of declining of muscle mass than BMI (21-23). As shown in our study, peak of MUAC was in the fall as well as the peak of protein intake; therefore, it could be inferred that muscle mass would be greater in the fall rather than other seasons in this study. The results of Jahnset al's study confirmed that dietary intake vary by season but they reported energy intake was not different(24). Their objective group was different with us.

Findings regarding fluctuations in energy and macronutrient intakes are controversial. Whereas some evidence does not confirm such variations either in calorie (25-27) or in macronutrients intake (25, 28), others have reported variations in energy and macronutrient intakes by season (8). In spite of considerable agreement regarding the fluctuation in fat and carbohydrate intakes by season (18, 29), there is debate for protein. In line with our findings, most of earlier studies (18, 26, 27, 30, 31), but not all (32), showed that protein intake did not vary by season, though its changes were marginally significant in our study. Although there is agreement regarding the variation in energy, fat and carbohydrate by season (8), there are differences in the peak of fat or carbohydrate intake between studies. Inconsistent with our findings showing a peak intake of carbohydrate in summer and a peak intake for fat in winter, Ma and colleagues revealed a peak for carbohydrate and fat in winter and summer, respectively (18). However, the intake of fat was larger in winter in male industrial employees who had greater BMI in winter rather than summer (8). Greater consumption of carbohydrate during summer in our study might be related to higher intake of ice cream, fruits and drinks rich in sugar in the summer than other seasons to compensate loosing body water (33).

An explanation underlying greater body weight and BMI during summer might be related to dietary macronutrient composition. In spite of similar protein consumption by seasons, fat and carbohydrate intakes were differently consumed in summer and winter. There is evidence supporting the satiating properties of high fat/low carbohydrate diet rather than a low carbohydrate/high fat diet and its favorable effect on short-term weight loss (34). Moreover, because our participants were college students who were studying in three seasons except for summer, we hypothesize that greater anthropometric measurements in summer might be related to lower psychological stress, which consequently could be associated with higher intake of carbohydrates and energy. Pagels's study showed there was difference in physical activity intensity by weather variation, their objective group was school children(35).

Our study has some strength. First of all, larger sample size of this study rather than previous studies in this context let us to extract more accurate findings (25, 26, 36). Second, our study population was healthy college students who aged 18-35 years, and therefore, had more similar lifestyle rather than other studies' population which conducted on a wide age range of participants. Although this could limit the generalizability of our findings, it could remove the potential source of residual confounders, especially physical activity, and make more reliable our findings. Third, using 24-h dietary record to assess dietary intakes provide more accurate data than food frequency questionnaires (FFQs) and recall which used in earlier studies (37). The limitations of our investigation were: Diet and physical activity information were obtained from self-reported 24-h records. Although there is always the potential for misclassification due to error in self-reporting, the error is minimized by training the participants.

Conclusion

In conclusion, the present study indicated that seasonal variations of daily caloric intake, fat and carbohydrate intakes could be concurred with variations in body weight, MUAC and BMI among college students. These fluctuations were not different between male and female. No significant fluctuations were observed in physical activity and protein intake.

Acknowledgments

This research project was supported by the Food Security Research Center, Isfahan University of Medical Sciences, Isfahan, Iran.

Financial support

This work was supported by the Isfahan University of Medical Sciences.

References

1. Ogden CL, Carroll MD, Curtin LR et al. (2010) Prevalence of high body mass index in US children and adolescents, 2007-2008. Jama 303, 242-9. doi: 10.1001/jama.2009.2012.
2. Esmaillzadeh A, Mirmiran P, Azadbakht L et al. (2006) High prevalence of the metabolic syndrome in Iranian adolescents, Obesity 14, 377-82.
3. Obesity and overweight: World Health Organization; (2014). Available from: http://www.who.int/mediacentre/factsheets/fs311/en/ (accessed January 2015).
4. Jafari-Adli S, Jouyandeh Z, Qorbani M et al. (2014) Prevalence of obesity and overweight in adults and children in Iran; a systematic review. Journal of diabetes and metabolic disorders 3, 121.
5. Mitchell NS, Catenacci VA, Wyatt HR et al. (2011) Obesity: Overview of an Epidemic. Psychiatric Clinics of North America 34, 717-32.
6. Azadbakht L, Haghighatdoost F, Esmaillzadeh A. (2016) White Rice Consumption, Body Mass Index, and Waist Circumference among Iranian Female Adolescents. J Am Coll Nutr 35, 491-499.
7. Azadbakht L, Haghighatdoost F, Keshteli AH et al. (2016) Consumption of energy-dense diets in relation to metabolic syndrome and inflammatory markers in Iranian female nurses. Public Health Nutr 16, 1-9.
8. Ogden CL, Carroll MD, Kit BK et al. (2014) Prevalence of childhood and adult obesity in the United States, 2011-2012. Jama 311, 806-14.
8. Shahar DR, Froom P, Harari G et al. (1999) Changes in dietary intake account for seasonal changes in cardiovascular disease risk factors. European journal of clinical nutrition 53, 395-400.
9. Sasaki T, Sakamoto K, Akaho R et al. (1998) Familial transmission of seasonal changes in sleep and eating function in the general population. Psychiatry research 81, 211-7.
10. Fraga A, Caggianesse V, Carrera O et al. (2015) Seasonal BMI differences between restrictive and purging anorexia nervosa subtypes. The International journal of eating disorders 48, 35-41.
11. Visscher TL, Seidell JC. (2004) Time trends (1993-1997) and seasonal variation in body mass index and waist circumference in the Netherlands. International journal of obesity and related metabolic disorders. journal of the International Association for the Study of Obesity 28, 1309-16.
12. Moreno JP, Johnston CA, Chen TA et al. (2015) Seasonal variability in weight change during elementary school. Obesity (Silver Spring, Md) 23, 422-8.
13. Van Staveren WA, Deurenberg P, Burema J et al. Seasonal variation in food intake, pattern of physical activity and change in body weight in a group of young adult Dutch women consuming self-selected diets. International journal of obesity 10, 133-45.
14. WHO child growth standards and the identification of severe acute malnutrition in infants and children A Joint Statement by the World Health Organization and the United Nations Children's Fund 2009. Available from: http://www.who.int/maternal_child_adolescent/documents/9789241598163/en/. (accessed 02 August 2015).
15. Finucane MM, Stevens GA, Cowan MJ et al. (2011) National, regional, and global trends in body-mass index since 1980: systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9.1 million participants. Lancet 377, 557-67.
16. Asiimwe SB. (2016) Simplifications of the mini nutritional assessment short-form are predictive of mortality among hospitalized young and middle-aged adults. Nutrition (Burbank, Los Angeles County, Calif) 32, 95-100.
17. Ainsworth BE, Haskell WL, Whitt MC et al. (2000) Compendium of physical activities: an update of activity codes and MET intensities. Medicine and science in sports and exercise 32, Suppl. 9, S498-504.
18. Ma Y, Olendzki BC, Li W et al. (2006) Seasonal variation in food intake, physical activity, and body weight in a predominantly overweight population. European journal of clinical nutrition 60, 519-28.
19. Banik SD, Ghosh M, Bose K.(2016) Anthropometric and body frame size characteristics in relation to body mass index and percentage body fat among adult Bengalee male brick-kiln workers from Murshidabad, West Bengal, India. Anthropologischer Anzeiger; Bericht uber die biologisch-anthropologische Literatur.
20. Lemma F, Shetty P. (2009) Seasonal variations in the relationship between mid-upper arm circumference and maximum voluntary contraction among Ethiopian farmers. European journal of clinical nutrition 63, 513-20.
21. Dhandapani S, Kapoor A, Gaudihalli S et al. (2015) Study of trends in anthropometric nutritional indices and the impact of adiposity among patients of subarachnoid hemorrhage. Neurology India 63, 531-6.
22. Mogendi JB, De Steur H, Gellynck X et al. (2015) Efficacy of mid-upper arm circumference in identification, follow-up and discharge of malnourished children during nutrition rehabilitation. Nutrition research and practice 9, 268-77.
23. Dale NM, Myatt M, Prudhon C et al. (2013) Using mid-upper arm circumference to end treatment of severe acute malnutrition leads to higher weight gains in the most malnourished children. PloS one 8, e55404.
24. Jahns L, Johnson LK, Scheett AJ et al.(2016) Measures of Diet Quality across Calendar and Winter Holiday Seasons among Midlife Women: A 1-Year Longitudinal Study Using the Automated Self-Administered 24-Hour Recall. Journal of the Academy of Nutrition and Dieteticspii: S2212-2672(16)30868-1.
25. Bernstein S, Zambell K, Amar MJ et al. (2016) Dietary Intake Patterns Are Consistent Across Seasons in a Cohort of

Healthy Adults in a Metropolitan Population. Journal of the Academy of Nutrition and Dietetics 116, 38-45.
26. Cai H, Shu XO, Hebert JR et al. (2004) Variation in nutrient intakes among women in Shanghai, China. European journal of clinical nutrition 58, 1604-11.
27. Hebert JR, Gupta PC, Mehta Het al. (2000) Sources of variability in dietary intake in two distinct regions of rural India: implications for nutrition study design and interpretation. European journal of clinical nutrition 54, 479-86.
28. Yannakoulia M, Drichoutis AC, Kontogianni MD et al. (2012) Season-related variation in dietary recalls used in a paediatric population. Journal of human nutrition and dietetics : the official journal of the British Dietetic Association 23, 489-93.
29. de Castro JM. (1991) Seasonal rhythms of human nutrient intake and meal pattern. Physiology & behavior 50, 243-8.
30. Hackett AF, Appleton DR, Rugg-Gunn AJet al. (1985) Some influences on the measurement of food intake during a dietary survey of adolescents. Human nutrition Applied nutrition 39, 167-77.
31. Krauchi K, Wirz-Justice A. (1988) The four seasons: food intake frequency in seasonal affective disorder in the course of a year. Psychiatry research 25, 323-38.
32. Doyle W, Crawley H, Robert H et al. (1999) Iron deficiency in older people: interactions between food and nutrient intakes with biochemical measures of iron; further analysis of the National Diet and Nutrition Survey of people aged 65 years and over. European journal of clinical nutrition 53, 552-9.
33. Prasad M, Lumia M, Erkkola M et al. (2010) Diet composition of pregnant Finnish women: changes over time and across seasons. Public health nutrition 13, 939-46.
34. Martin CK, Rosenbaum D, Han H et al. (2011) Change in food cravings, food preferences, and appetite during a low-carbohydrate and low-fat diet. Obesity (Silver Spring, Md) 19, 1963-70.
35. Pagels P, Raustorp A, Guban P et al. (2016) Compulsory School In- and Outdoors-Implications for School Children's Physical Activity and Health during One Academic Year. International journal of environmental research and public health13, pii: E699. doi: 10.3390/ijerph13070699.
36. Bilsborough JC, Greenway K, Livingston S et al. (2015) Changes in Anthropometry, Upper Body Strength and Nutrient Intake in Professional Australian Football Players During a Season. International journal of sports physiology and performance. Published online: 2015.
37. Harray AJ, Boushey CJ, Pollard CM et al. (2015) A Novel Dietary Assessment Method to Measure a Healthy and Sustainable Diet Using the Mobile Food Record: Protocol and Methodology. Nutrients 7, 5375-95.

Correspondence:
Leila Azadbakht, PhD
Department of Community Nutrition
School of Nutrition and Food Science
Isfahan University of Medical Sciences
Isfahan, Iran
Tel: (+98) 3117922719
Fax: (+98) 311 6682509
Email: azadbakht@hlth.mui.ac.ir