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RESEARCH ARTICLE

Seasonal variation of body fat percentage, basal metabolic rate, and serum lipid in healthy sedentary urban adults

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ABSTRACT

Background: Animal physiology and behavior have indicated to be strongly influenced by change in seasons. In a similar way, the human body is also found to be sensitive to environmental changes like changes of seasons. Variation in conception, birth rate, immune responses, metabolism, and body composition has been shown to follow a seasonal pattern. **Aims and Objectives:** Hence, the aim of the study is to determine if there is a seasonal variation of body fat percentage (BF%), basal metabolic rate (BMR), and serum lipids in healthy sedentary urban adults in two seasons, toward the end of summer and toward the end of winter. **Materials and Methods:** This is a cross-sectional study observing seasonal variation of BF%, BMR, and serum lipids in 30 healthy sedentary urban adults consisting of 23 males and seven females age 20–60 years. Anthropometric data such as age, sex, weight, height, waist circumference, and hip circumference were taken and measured. Venous blood was collected for estimating fasting value of serum lipids. BF% was assessed by dual-energy X-ray absorptiometry scan. BMR was calculated from height, weight, and age using Harris–Benedict equation. **Results:** Significant seasonal variation of BF%, BMR, total cholesterol, triglycerides, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) is seen in the overall participants. Significant seasonal variation of BF% and LDL is seen in the obese category of participants. **Conclusion:** There is seasonal variation of BF%, BMR, and serum lipids between the end of summer and end of winter. There is also a positive correlation between body mass index (BMI) and BF%, BMR, and LDL and HDL. There is also a positive correlation between BF% and BMI, BMR, HDL, and LDL.

KEY WORDS: Basal Metabolic Rate; Body Fat Percentage; Seasonal Variation; Serum Lipids

INTRODUCTION

Animal physiology and behavior have indicated to be strongly influenced by change in seasons. The mating pattern of seasonal breeders and the migration of migratory birds are known to be governed by the seasonal variation of temperature, the length of daylight, and the availability of feed and space.[1-3] More so, it is known that the timing for all these behavioral adaptation is also timed by an internal time-keeping mechanism existing in the suprachiasmatic nucleus in the hypothalamus.[1] Underlying deep down, these behavioral changes are some functional changes too. In seasonal breeders, for example, the hypothalamic sensitivity to estrogen heightens during the breeding season resulting in the occurrence of a reproductive shift from non-breeding state to a breeding state.[1] Similar changes can also be seen with other physiological functions of the biological system concerning metabolism and their effects on body

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composition. Studies done in Chinese bulbuls (*Pycnonotus sinensis*) have shown seasonal variation in the body mass and body fat (BF) of these birds and both variables were found to be higher in spring and winter than in summer and autumn.[4] BF was especially higher in winter than in any other seasons. Another study done in European badgers (*Meles meles*) on the seasonal variation of resting metabolic rate (RMR) found that RMR was higher in summer and lowest in winter.[5] In a similar way, the human body is also found to be sensitive to environmental changes like changes of seasons. Variation in conception, birth rate, immune responses, metabolism, and body composition has been shown to follow a seasonal pattern.[6,7] A study done in Netherland in human adults on the time trends and seasonal variation of body mass index (BMI) and waist circumference found that the BMI and waist circumference were higher in spring and winter than in summer and autumn.[8] Findings from this study also showed that the seasonal variation for both men and women was stronger for abdominal obesity than for obesity itself.[8] Based on the findings of the above studies, we proposed to study the seasonal variation of BF percentage (BF%), basal metabolic rate (BMR), and serum lipids in healthy sedentary urban adults in two seasons, toward the end of summer and toward the end of winter. The measurement and estimation of the variables of interest at the end of seasons are with an intent to see the cumulative effects of each season.

MATERIALS AND METHODS

This is a cross-sectional study observing seasonal variation of BF%, BMR, and serum lipids in healthy sedentary urban adults which was approved by the institutional ethical committee.

The pilot study sample consisted of 30 normal healthy sedentary adults, 23 males and seven females, who were between the age of 20 and 60 years and who were permanent residents of Shillong. Recruitment of female research volunteers was difficult due to fear of exposure to radiation under dual-energy X-ray absorptiometry (DEXA) scanner in spite of providing enough information through counseling and in the subject information sheet regarding safety. Volunteers treated for metabolic diseases such as diabetes mellitus, metabolic syndrome, dyslipidemia, or subjects with hormonal disorders such Cushing syndrome or subjects under any type of medication that may affect the levels of serum lipid were excluded from the study. Females in conception were also excluded from the study. Female volunteers were subjected to pregnancy test 48 h before conducting the study. Recruitment of subjects was done by displaying flyers in and around North Eastern Indira Gandhi Regional Institute Of Health and Medical Sciences campus. Sampling of volunteers was done by consecutive random sampling based on a first-come first-served basis and selected after considering the inclusion and exclusion criteria. Written and informed consent was obtained from all volunteers in the language best understood by them.

Selected volunteers were asked to come first at the end of summer which was around August 2017 and again at the end of winter which was around February 2018–March 2018. Volunteers were asked to come after an 8 h overnight fasting to the department of physiology where their anthropometric data such as age, sex, weight, height, waist circumference, and hip circumference were taken and measured. Participants were made to remove shoes and wear only light clothing while measuring body weight and height. Venous blood was collected for fasting values of glucose and lipids. About 2 ml of venous sample was collected in plain vacutainer and the analysis of fasting glucose and lipid profile was done in AV2700 automated analyzer from Beckman coulter. Quality check was done before analyzing sample using Biorad internal quality control. Thereafter, the patient underwent BF% assessment by a DEXA scan in a Hologic Discovery W, USA, machine. Calibration of the machine was routinely done before the acquisition using a Hologic DEXA quality control phantom (Area – 53.6 cm^2, bone mineral content 52.3 g, and bone mineral density 0.98 g/cm^2). The subjects were instructed to wear light clothing and to remove any metals from their clothing. The subjects were then told to lie on the DEXA table in supine position, and then, a whole body DEXA scan was performed. BMR was calculated from height, weight, age, and gender using Harris–Benedict equation.

RESULTS

According to Table 1, the anthropometric data such as weight, height, BMI, and waist hip ratio do not show significant seasonal variation. Significant seasonal variation is, however, seen in the overall population in BF% and BMR. Height for overall participants (30) is 157.83 ± 11.67, for lean category (12) is 154.83 ± 12.57, overweight category (8) is 156 ± 10.06, and obese category (10) is 164.63 ± 10.62, for both summer and winter.

Table 2 shows that significant variation of total cholesterol, triglycerides, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) in the overall participants' significant seasonal variation of HDL is seen in lean category, triglyceride only in overweight category, and LDL only in obese category.

Table 3 in between genders, there is a significant seasonal variation in BF and BMR in both male and female. It may be noted that BF% in female is more than male and that in both genders, the mean BF is more in summer.

Table 4 both genders measured higher cholesterol in winter than summer, but cholesterol lived is within normal range. Triglyceride, however, is seen to be high in winter for male and higher in summer for female. Triglyceride in male is above the normal range. LDL is high in summer in case of both genders. HDL is higher in winter in both male and female.

Table 5 shows strong correlation between BF% and BMI, BMR, and HDL in both seasons and LDL only in summer. Table 6 also shows strong correlation between BMI and BMR, BF%, HDL, and LDL.

Statistical Analysis

Data were analyzed using SPSS version 18. Descriptive statistics were tabulated in the form of mean and standard deviation for each variable. Paired *t*-test was applied to compare the variation between summer and winter and $P < 0.05$ was considered as statistically significant. Correlation of variables was derived using Pearson's correlation.

DISCUSSION

The purpose of the study is to investigate if there is any seasonal variation of BF%, BMR, and serum lipids between end of summer and end of winter.

The findings of our study reveal the existence of variation between summer and winter of BF%, BMR, and serum lipids in the overall or general population of the study sample. BF% is significantly higher in summer than winter in the overall population and in the obese BMI category as well. In human, variation of BF% and BMI between summer and winter seasons was found to be absent in some studies.[9,10] This is unlike in animals where BF% increases in winter as a result of adaptation to change in climatic temperature.[4,5] In human, effects of physical adaptation are probably blunted

Table 1: Anthropometric variables, BF% and BMR during summer and winter

Variables	Summer	Winter	Significance
Weight (Kg)			
Overall	65.93±21.81	66.13±21.39	0.682
Lean	46.92±2.83	47.98±9.80	0.461
Overweight	67.70±9.77	67.40±8.28	0.730
Obese	92.25±16.77	92.38±17.33	0.875
BMI (Kg/m²)			
Overall	25.95±6.28	26.02±6.07	0.725
Lean	19.41±0.671	19.72±2.32	0.406
Overweight	27.59±1.53	27.49±1.62	0.760
Obese	33.73±2.38	33.64±2.32	0.599
W/H			
Overall	0.94±0.07	0.93±0.06	0.921
Lean	0.89±0.07	0.90±0.05	0.602
Overweight	0.93±0.04	0.92±0.02	0.304
Obese	1.01±0.064	1.01±0.069	0.832
BF%			
Overall	33.42±9.76	32.30±9.34	0.001
Lean	24.25±2.05	23.18±7.11	0.116
Overweight	37.98±6.29	37.05±5.09	0.081
Obese	41.48±4.02	40.06±3.64	0.012
BMR (calories)			
Overall	1445.30±277.56	1462.63±269.52	0.014
Lean	1287.41±47.39	1304.91±164.18	0.165
Overweight	1442.7±230.76	1457.7±224.1	0.177
Obese	1685.37±315.8	1705.37±291.69	0.189

BMR: Basal metabolic rate, BMI: Body mass index, BF: Body fat

Table 2: Biochemical variables during summer and winter

Variables	Summer	Winter	Significance
Total cholesterol (mg/dl)			
Overall	180.06±38.23	192.10±41.32	0.020
Lean	169.16±8.92	174.41±30.19	0.507
Overweight	182.5±52.51	203.9±57.15	0.052
Obese	193.37±24.36	203.87±24.3	0.219
Triglycerides (mg/dl)			
Overall	167.8±89.72	168.8±89.86	0.924
Lean	148.66±25.91	143.5±89.75	0.637
Overweight	161.4±110.71	199.7±135.07	0.049
Obese	204.5±52.01	168.12±48.26	0.144
LDL (mg/dl)			
Overall	102.1±35.26	84.79±26.76	0.001
Lean	83.91±9.51	72±32.96	0.172
Overweight	114.4±34.65	95.8±39.09	0.076
Obese	114.6±30.22	90.21±14.52	0.023
HDL (mg/dl)			
Overall	43.16±17.39	45.98±17.18	0.003
Lean	54.25±6.15	57.83±21.32	0.046
Overweight	35.8±10.96	37.9±7.85	0.173
Obese	35.75±5.75	38.32±3.74	0.128

LDL: Low-density lipoprotein, HDL: High-density lipoprotein

Table 3: Gender difference of anthropometric variables, BF% and BMR during summer and winter

Variables	Summer	Winter	Significance
Weight (kg)			
Male	65.35±24.69	65.48±24.25	0.832
Female	67.36±7.64	68.29±7.04	0.510
BMI (Kg/m²)			
Male	24.98±6.77	25.03±6.52	0.840
Female	29.14±2.68	29.27±2.53	0.647
W/H			
Male	0.94±0.08	0.94±0.07	0.920
Female	0.93±0.03	0.93±0.04	1
BF%			
Male	30.13±8.71	29.26±8.5	0.028
Female	44.1±2.18	41.86±1.85	0.002
BMR (calories)			
Male	1493.08±295.34	1504.39±291.88	0.107
Female	1288.28±122.51	1325.42±100.37	0.070

BMR: Basal metabolic rate, BMI: Body mass index, BF: Body fat by the behavioral adaptation and technological advancement in overcoming temperature changes. Turning to our study, the decrease in the BF% in the overall participants can be interpreted as a loss of fat in winter because measurement of winter BF% was conducted after the summer measurement. This can possibly occur in human species and in residents of places like Shillong where winter is cold but not so severe as to compel them to retreat into a state of rest that may be equivalent to hibernation in animals. As a result, the quantum of human physical activity in winter remains the same as in summer and all participants work in the same public sector health-care institution. The constancy in the level of physical activity and the raised BMR which is found to be high in winter, in this study, can explain the reduction of BF% in winter in humans. There is no consensus on seasonal variation of BMR as some studies demonstrate higher BMR in winter than summer,[9,11,12] whereas one study showed lack of seasonal variation in BMR.[10] When the overall participants are divided into lean category, overweight category, and obese category on the basis of calculated BMI, the pattern of the finding in all categories is found to be almost similar to the overall population. Putting aside the seasonal variation outcome, it is interesting to see, if we look at the lean category that for a mean BMI of 19.68 ± 2.25 kg/m^2, the mean BF% is 24.25 ± 7.11 in summer. When the overall participants were divided into males and females category, it is found that the BF% is higher in summer than winter for males and higher in winter than summer in females. Even gender wise, the BF% appears to be high for BMI. This BF% appears to be high for BMI if compared with findings in other studies.[13,14] The overall participants in our study show a mean BMI of 25.95 ± 6.28 kg/m^2 and a mean BF% of 33.42 ± 9.76 in summer. BF% in our participants is high probably because participants are mainly non-vegetarian and consume high-fat non-vegetarian food items. Participants, in this study, were all from the Khasi tribal community residing in Shillong city, which belong to the state of Meghalaya in India, with the exception of one participant, who although is a permanent resident of Shillong, is of a different ethnic background. Besides, the customary diet of this ethnic group, genotype ethnicity may also have a role in contributing to the finding as people of Khasi origin are naturally of short stocky body type belonging to the mongoloid race of Mon Khmer origin.[15] Regarding ethnicity, reference can be made to a study conducted on other mongoloid communities such as the Chinese and the Malays which showed a lesser BF% for a BMI that is just a little less than our study.[14] It may be mentioned here that the obesity phenotype of higher BF% at a lower BMI seen in our study is in agreement with findings observed in Asian Indians.[16-18] The finding inferred in our study needs to be investigated further and if there is a concurrence or a reproduction of the same result, then we need to look into its implication on health status.

The serum lipids such as total cholesterol, triglycerides, and HDL are found to be significantly higher in winter than summer, with the exception of LDL only which is higher in summer than winter in overall participants. When categorized into males and females, serum total cholesterol,

Table 4: Gender difference of biochemical variables during summer and winter

Variables	Summer	Winter	Significance
Total cholesterol (mg/dl)			
Male	181.08±41.07	192.82±43.14	0.036
Female	176.71±29.38	189.71±37.66	0.346
TG (mg/dl)			
Male	172.86±94.27	180.47±98.59	0.528
Female	151.14±76.78	130.42±33.9	0.356
LDL (mg/dl)			
Male	100.25±36.93	85±30.13	0.013
Female	111.2±32.21	84.72±16.76	0.055
HDL (mg/dl)			
Male	45.56±18.72	48.3±18.81	0.016
Female	35.28±9.03	38.37±6.45	0.095

LDL: Low-density lipoprotein, HDL: High-density lipoprotein, TG: Triglyceride

Table 5: Pearson correlation coefficient of BF% versus BMI, BMR HDL, LDL, and TG

Variables	Correlation coefficient: Winter	Summer	Remark
BMI	0.793**	0.785** 99% significant	
BMR	0.407*	0.369*	95% significant
HDL	−0.516**	−0.477**	99% significant
LDL	0.246	0.388*	Summer is 95% winter is not
TG	0.166	0.326	#Not significant
Cholesterol	0.274	0.211	#Not significant

**Correlation is significant at the 0.01 level (two tailed), *Correlation is significant at the 0.05 level (two tailed), #Correlation is not significant, BMI: Body mass index, BMR: Basal metabolic rate, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, TG: Triglyceride, BF%: Body fat percentage

Table 6: Pearson correlation coefficient of BMI versus BMR, BF%, HDL, LDL, TG, and cholesterol

Variables	Correlation coefficient: Winter	Summer	Remark
BMI	0.685**	0.692**	99% significant
BF%	0.801*	0.785*	99% significant
HDL	−0.541**	−0.541**	99% significant
LDL	0.340#	0.410*	95% significant
TG	0.203#	0.336#	#Not significant
Cholesterol	0.319	0.285	#Not significant

**Correlation is significant at the 0.01 level (two tailed), *Correlation is significant at the 0.05 level (two tailed), #Correlation is not significant, BMR: Basal metabolic rate, BMI: Body mass index, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, TG: Triglyceride, BF%: Body fat percentage triglycerides, and HDL are found to be higher in winter in case of males and only total cholesterol and HDL are found to be higher in winter in case of females. In reference to serum lipids, a study conducted by the division of endocrinology, University of Colorado Health Sciences Center in normal weight humans showed higher total cholesterol, LDL, and triglycerides in winter which is in line with our study with respect to total cholesterol and triglycerides in winter.[19] Other similar studies reported higher total cholesterol, HDL, and triglycerides in winter.[20,21] One more study conducted by endocrinology research unit, Mayo Clinic, reported higher values of total cholesterol, LDL, HDL, and triglycerides in winter.[10] There is consistency in many study amidst some differences here and there, of higher values of serum lipids in winter which is implicated for hemoconcentration that happens due to plasma volume contraction in response to cold and possible dehydration during winter.[20] Another study has implicated this seasonal variation of serum lipids on the variation of dietary fat and saturated fat intake, which according to the study, were higher in winter.[21]

It may be noted that there is also a positive correlation between BMI and BF%, LDL, and HDL. There is also a positive correlation between BF% and BMI, total cholesterol, LDL, HDL, and triglycerides. This is also reported in studies done in different parts of the world.[22-24]

The limitation with our study is the estimation of BMR as it is not directly measured but derived by calculation from weight, height, age, and gender using Harris–Benedict's equation. The study is also limited by the design, as the collection of sample and the measurement of anthropometric variables and body composition were done at the end of summer around August and at the end of winter around March. If data collection and measurements were done in peak of winter and peak of summer season, the results and outcome could have been different. Effects of cold response that could occur as in early winter or peak of winter could possibly produce different findings that acclimatization could have altered our findings at the end of season. Furthermore, if the study could have included spring and autumn, then we could have obtained results that could reveal whether or not variation exists in all four seasons. The revelation of the existence of seasonal variation of BF%, serum lipids, and BMR in this study may influence and change the way clinician assesses conditions of dyslipidemia and obesity in patients during different seasons.

CONCLUSION

According to our study, there is a seasonal variation of BF%, BMR, and serum lipids between the end of summer and end of winter. There is also a positive correlation between BMI and BF%, BMR, and LDL and HDL. There is also a positive correlation between BF% and BMI, BMR, HDL, and LDL. This finding could be useful for reference by clinicians for interpretation of serum lipid levels and to consider seasonal effect in case of a rise in the serum lipids during the end of winter or a fall at the end of summer.

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