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RESEARCH ARTICLE

A cross-sectional study of impact of body composition and anthropometry on heart rate variability in different age groups of adults

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ABSTRACT

Background: Obesity adversely affects the homeostasis of a person through a combination of impairments to multiple physiological mechanisms. Autonomic functions are proposed to be in the core of different aspects of health and well-being. **Aims and Objectives:** The objective of this study was to assess the impact of body composition and anthropometry on heart rate variability (HRV) in different age groups of adults. **Materials and Methods:** A total of 140 healthy adults were randomly selected for this cross-sectional observational study. They were divided into three groups based on the age distributions: Group 1: 18–30 years ($n = 51$); Group 2: 31–45 years ($n = 47$); and Group 3: 46–60 years ($n = 42$). Following assessments were done in all the participants in three groups: Anthropometric measurements, body composition analysis based on the principle of bioelectric impedance, and HRV. One-way analysis of variance followed by *post hoc* analysis was done for intergroup comparisons and Spearman's correlation was done to find the correlation coefficients between HRV characteristics and anthropometric measurements and body composition characteristics. $P < 0.05$ was considered as statistically significant. **Results:** The body mass index (BMI), waist circumference (WC), waist/hip ratio (WHR), body fat%, visceral fat%, and very low frequency (VLF) were found to be increasing, whereas high frequency (HF) and total power were decreasing with age. BMI, WC, fat mass, subcutaneous fat (whole body)%, and visceral fat% were significantly correlated with frequency domain characteristics of HRV. The HF and total power of HRV were negatively correlated with BMI, WC, body fat%, and visceral fat%. In addition, the significant positive correlation between LF/HF ratio and WC and visceral fat% would point to the adverse effect of central adiposity and visceral fat on sympathovagal balance. **Conclusion:** These results reflected parasympathetic withdrawal and sympathetic predominance with increased adiposity, associated with aging.

KEY WORDS: Body Composition; Anthropometry; Heart Rate Variability; Autonomic; Aging; Obesity

INTRODUCTION

Obesity, nowadays, became a serious public health concern. The prevalence of obesity has tripled in the past four decades, and this increasing prevalence trend is noticed in almost every part of the world.[1] Obesity is considered as root cause of many serious disorders such as hypertension, ischemic heart disease, type2 diabetes mellitus, osteoarthritis, sleep apnea, and various cancers.[2] The importance of obesity and related comorbidities is increasingly being reflected in public awareness campaigns as well as health programs launched by various governments.[3,4] Obesity is a disease of energy balance. The basic components of pathophysiology of obesity include quantity and quality of food intake, feeding behavior as well as many physiological mechanisms involved in energy expenditure as well as storage.[5]

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Autonomic nervous system (ANS) plays a major role in the pathophysiology of obesity through the regulation of energy expenditure and energy storage. Both wings of ANS, parasympathetic as well as sympathetic, play their role in the integrated regulation of body weight by modulating the satiety signals, energy expenditure or calorie burns, and fat storage. The parasympathetic vagal afferent pathways play an important link in the gut-brain axis, involving large variety of adipokines and hormones.[6] Few animal studies showed that vagal nerve stimulation decreases satiety signals, leading to reduced intake of food and loss of body weight;[7] however this therapeutic strategy of vagal stimulation for treatment of obesity, does not proved successful in humans.[8] Sympathetic nervous system (SNS) act by increasing lipolysis and energy expenditure, through its nerve supply to tissues containing brown and white fat.[9] SNS is activated in obesity as physiological compensation mechanism, and it is once presumed to be an effective strategy for weight loss. However, SNS overactivity causes the development of many obesity-associated diseases such as hypertension, coronary artery diseases, and sudden cardiac death.[10,11] Thus, it can be deduced that there is a concomitant two-way relationship between obesity and ANS; and this relationship needs to be understood in better perspectives for future development of therapeutic targets of obesity and related disorders.

ANS functions and its reactivity in different circumstances are assessed by many methods; it includes screening of indirect autonomic reflexes, agglomeration of signs indicating autonomic dysfunction, reflex sympathetic dystrophy screening, and heart rate variability (HRV) testing. Comparing among all the methods of ANS testing in human adults, HRV or beat-to-beat variability in heart rate is the most recent until now. HRV is a purely non-invasive method; it is very much convenient in clinical outpatient department as well as for research laboratory settings. At the same time, this method is very efficient in diagnosing the dominance or blunting of a particular wing of ANS.[11-13]

For obesity measurements, body mass index (BMI) is used since long time. The World Health Organization defines and classifies obesity on the basis of BMI. However, many studies show that the use of BMI to define obesity has low-to-moderate sensitivity, although it is highly specificity.[14,15] Furthermore, it is well understood that regional distribution of fat and muscles is more important clinically as compared to overall body weight or BMI. Bioelectric impedance analysis of body composition assesses body fat%, fat-free mass, regional distribution of subcutaneous fats, visceral fats, skeletal muscle mass, etc.[16,17] In this study, the impact of nutritional status on HRV in different age group of adults has been assessed. The nutritional status was measured by anthropometric measurements and body composition analysis (including regional distribution of body fat and skeletal muscles).

MATERIALS AND METHODS

This study was carried out in the Department of Physiology, Dr. Ram Manohar Lohia Institute of Medical Sciences, Lucknow, Uttar Pradesh, India, a tertiary care teaching hospital in urban setting. The study design was cross-sectional and observational in nature. The study was done during May 2018–January 2019. The data collection was started after getting permission from the Institutional Ethics Committee. All the apparently healthy volunteers of age group 18–60 years old were the study participants.

The sample size calculation was based on the prevalence of obesity in the Indian adults and the population under study. The prevalence of obesity in adults is about 10% in India.[18,19] At the confidence interval 95% and taking prevalence as ≈10%, the calculated sample size was 139. Therefore, a minimum of 140 participants, who fulfilled the criteria for selection during the above-mentioned study period, were selected for the study.

Inclusion Criteria

All the willing participants, of both genders, being apparently healthy, and belonging to the age group of 18–60 years were included in the study.

They were divided into three groups based on the age distributions: Group 1: 18–30 years, Group 2: 31–45 years, and Group 3: 46–60 years

Exclusion Criteria

Participants with endocrine disorders (such as diabetes mellitus, Cushing's syndrome, and thyroid disorder), anemia, cardiovascular disorder, neuropsychiatric disorder, chronic illness, and autonomic neuropathy, participants who are addicted to alcohol, smoking, tobacco chewing, and drug abuse, and participants using any medication that could affect the sleep architecture such as sedative-hypnotic, antidepressants, and antipsychotic drugs were excluded from the study.

The following assessments were done in all the participants in three groups:

- Anthropometric measurements: Body height (H); body weight (W); BMI/Quetelet index ($BMI= W/H^2$); waist circumference (WC); hip circumference (HC); and waist/hip ratio (WHR).
- Body composition (body composition analyzer based on the principle of bioelectric impedance): Body fat%, fat mass, fat mass index, fat-free mass (Kg), subcutaneous fat (whole body)%, subcutaneous fat (trunk)%, subcutaneous fat (arms), subcutaneous fat (legs), visceral fat%, skeletal muscle mass (kg), and skeletal mass%.
- HRV (4-channel polygraph, AD instruments); Frequency domain HRV very low frequency (VLF),

low frequency (LF), high frequency (HF), LF/HF ratio, and total power.

Statistical Analysis

The quantitative data obtained were expressed as mean ± standard deviation with the help of Microsoft Excel workbook. Intergroup comparisons of data were done by one-way analysis of variance (ANOVA), followed by *post hoc* analysis. The Spearman's correlation of HRV characteristics with age, anthropometric measurements, and body composition analysis was done and presented in the form of correlation coefficients (r value) to assess the strength of associations between different parameters. $P < 0.05$ was considered to be statistically significant.

RESULTS

Table 1 shows significant differences between Groups 1 and 2 for age, W, BMI, WC, and HC; between Groups 1 and 3 for age, W, BMI, WC, HC, and WHR; and between Groups 2 and 3 for age and WC. Table 2 shows significant differences between Groups 1 and 2 for visceral fat%; between Groups 1 and 3 for body fat%, fat mass, and subcutaneous fat% of trunk and legs; and between Groups 2 and 3 for body fat% and fat mass. Table 3 shows significant differences between Groups 1 and 2 for LF/HF and total power; between Groups 1 and 3 for VLF, HF, LF/HF, and total power; and between Groups 2 and 3 for VLF, HF, LF/HF, and total power. Table 4 shows a significant positive correlation between VLF and age; there was a significant negative correlation between HF and age, between LF/HF and WC, and between total power and age, total power and BMI, and total power and WC. Table 5 shows significant positive correlations between VLF and body fat%, LF and subcutaneous fat (whole body)%, HF and skeletal muscle mass, and LF/HF and visceral fat%; there were significant negative correlations between HF and body fat%, HF and fat mass, total power and fat mass,

Table 1: Intergroup comparison of age and anthropometric measurements of three groups

Variables	Group 1 (*n*=51)	Group 2 (*n*=47)	Group 3 (*n*=42)	ANOVA (*P* value)	*Post hoc*
Age (years)	25.18±4.20	37.03±5.16	51.29±6.76	0.0001	1 versus 2; 2 versus 3; 1 versus 3
Height (H) (cm)	163.94±12.01	161.82±18.39	162.89±14.55	0.418	-
Weight (W) (kg)	61.79±10.05	64.24±17.09	65.97±15.42	0.036	1 versus 2; 1 versus 3
BMI	22.95±2.02	24.69±1.53	25.13±3.62	0.040	1 versus 2; 1 versus 3
WC (cm)	86.73±16.06	90.17±11.12	94.21±11.88	0.008	1 versus 2; 2 versus 3; 1 versus 3
HC (cm)	90.47±14.48	95.08±14.61	98.63±17.72	0.001	1 versus 2; 1 versus 3
WHR	0.90±0.15	0.91±0.24	0.95±0.19	0.021	1 versus 3

BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, WHR: Waist/Hip ratio, ANOVA: Analysis of variance

Table 2: Intergroup comparison of body composition analysis measurements in three groups

Variables	Group 1 (*n*=51)	Group 2 (*n*=47)	Group 3 (*n*=42)	ANOVA (*P* value)	*Post hoc*
Body fat%	26.52±7.19	27.12±5.83	31.21±4.74	0.016	1 versus 3; 2 versus 3
Fat mass (Kg)	15.95±3.68	18.41±3.01	22.01±7.18	0.002	1 versus 3; 2 versus 3
Fat mass index	5.77±1.69	6.35±1.51	8.52±2.69	0.419	-
Subcutaneous fat (whole body)%	18.67±6.63	20.85±5.79	21.90±5.87	0.136	-
Subcutaneous fat (trunk)%	16.45±6.04	17.52±5.08	19.92±5.28	0.035	1 versus 3
Subcutaneous fat (arms)	26.21±12.20	29.81±10.36	30.22±8.67	0.046	1 versus 3
Subcutaneous fat (legs)	25.25±10.78	28.57±8.52	30.53±7.85	0.103	-
Visceral fat%	5.78±1.20	8.02±1.49	11.89±4.85	0.020	1 versus 2, 1 versus 3
Skeletal muscle mass (kg)	21.86±4.29	20.14±4.07	18.55±4.29	0.097	-
Skeletal muscle%	32.29±4.55	29.33±4.05	27.55±2.61	0.210	-

ANOVA: Analysis of variance

Table 3: Intergroup comparison of HRV characteristics in three groups

Variables	Group 1 (*n*=51)	Group 2 (*n*=47)	Group 3 (*n*=42)	ANOVA (*P* value)	*Post hoc*
VLF	33.41±17.97	36.22±12.37	46.95±20.13	0.032	1 versus 3; 2 versus 3
LF	28.91±14.08	26.08±10.03	29.13±12.68	0.091	-
HF	36.55±20.81	35.02±14.35	22.95±16.24	0.010	1 versus 3; 2 versus 3
LF/HF	1.24±1.24	0.89±0.54	2.05±1.77	0.008	1 versus 2; 1 versus 3; 2 versus 3
Total power	1772.21±1229.73	1462.88±1278.79	924.39±723.72	0.00001	1 versus 2; 1 versus 3; 2 versus 3

HRV: Heart rate variability, VLF: Very low frequency, LF: Low frequency, HF: High frequency

Table 4: Spearman's correlation (correlation coefficients) of HRV characteristics with age and anthropometric measurements

Variables	VLF	LF	HF	LF/HF	Total power
Age	0.411*	0.409	−0.578*	0.136	−0.226*
H	0.108	0.301	0.329	0.243	0.357
W	0.483	0.446	−0.194	0.242	−0.350
BMI	0.285	0.436	−0.417	0.311	−0.406*
WC	0.432	0.269	−0.246	0.478*	−0.331*
HC	0.234	0.367	−0.422	0.384	−0.292
WHR	0.251	0.428	0.379	0.573	0.173

*indicates $P<0.05$. HRV: Heart rate variability, BMI: Body mass index, WC: Waist circumference, HC: Hip circumference, WHR: Waist/Hip ratio, H: Height, W: Weight, VLF: Very low frequency

Table 5: Spearman's correlation (correlation coefficients) of HRV characteristics with body composition analysis

Variables	VLF	LF	HF	LF/HF	Total power
Body fat%	0.301*	0.482	−0.467*	0.234	−0.335
Fat mass	0.417	0.392	−0.342*	0.314	−0.517*
Fat mass index	0.374	0.365	−0.289	0.359	−0.461
Subcutaneous fat (whole body)%	0.255	0.478*	−0.457	0.368	−0.479*
Subcutaneous fat (trunk)%	0.334	0.223	−0.412	0.401	0.313
Subcutaneous fat (arms)	0.259	0.363	0.372	0.481	0.324
Subcutaneous fat (legs)	0.283	0.454	0.361	0.510	0.280
Visceral fat%	0.403	0.451	−0.194	0.296*	−0.346*
Skeletal muscle mass	0.241	0.530	0.453*	0.363	0.322
Skeletal muscle%	0.479	0.228	0.217	0.435	0.443

*indicates $P<0.05$. HRV: Heart rate variability, VLF: Very low frequency

total power and subcutaneous fat (whole body)%, and total power and visceral fat%.

DISCUSSION

The present study was conducted to evaluate the impact of body composition and anthropometry on HRV in different age groups of adults. The relationship between frequency domain characteristics of HRV, body weight, BMI, waist and hip circumferences, body fat%, indices of body fat distribution, and skeletal muscles was studied. The mean ages of three groups were as follows: Group 1 = 25.18 ± 4.20; Group 2 = 37.03 ± 5.16, and Group 3 = 51.29 ± 6.76. The BMI, WC, WHR, body fat%, visceral fat%, and VLF were more in Group 3 as compared to other groups, whereas HF and total power were lesser. Age, BMI, WC, fat mass, subcutaneous fat (whole body)%, and visceral fat% were significantly correlated with frequency domain characteristics of HRV. The HF and total power of HRV were decreased with BMI, WC, body fat%, and visceral fat%. These results reflected parasympathetic withdrawal and sympathetic predominance in association with increased adiposity associated with aging. In addition, the significant positive correlation demonstrated in the present study, between LF/HF ratio and WC and visceral fat%, would point to the adverse effect of central adiposity and visceral fat on sympathovagal balance.

The findings in our study were in accordance with the study carried out by Shetty *et al*. who reported that higher BMI causes significant changes in ANS functions that included decreased parasympathetic tone and increased sympathovagal balance.[20] Chen *et al*. reported that body weight was significantly positively correlated with LF/HF ratio and negatively correlated with HF.[21] Another study by Krishna *et al*. found that overweight subjects showed a significant increase in LF in normalized units. Yadav *et al*. reported that the increased central adiposity (measured by WHR) was strongly associated with reduced cardiac parasympathetic and increased sympathetic activity in obese individual, defined by BMI.[22] However, few earlier studies reported that BMI and WC were not associated with any of HRV indexes.[23] With respect to aging, HRV decreases with normal aging. This decline of HRV is associated with an increased risk of morbidity and mortality. This finding is also in accordance with a study by Umetani *et al*.[24] and Acharya *et al*.[25]

Our study demonstrates that young adults had better autonomic tone marked by parasympathetic dominance. This enables young adults to undergo day-to-day physical as well as mental challenges in better way when compared to middle-aged and older adults. Overall, our study demonstrated that young adults had better anthropometric measurements, better nutritional status, and autonomic tone. The physiological mechanism of alteration of autonomic functions in middle age adults is incompletely understood and most likely multifactorial. The changes in body composition and anthropometric measurements toward the increasing adiposity are one of the important factors, so attempt should be made by every person to remain in better fitness state to delay the age-related comorbidities.

Regarding limitations, in this study, we missed to measure the metabolic disorders by laboratory investigations and relied heavily on the questionnaire-based finding of adults being healthy. As we understand that pre-clinical (asymptomatic) stages of metabolic disorders can cause autonomic disturbances also. In our study, we did not focus on the finding and the mechanism of fluctuation of cardiac autonomic function. Another limitation of this study is being a cross-sectional study design; the cause–effect relationship could not be established.

CONCLUSION

The results of this study reflected that, with an increase in age, there occurs significant parasympathetic withdrawal and sympathetic overactivity. The increased adiposity and, more particularly, increasing central adiposity and visceral fat with aging process are associated with major contributing factor for autonomic disturbance as reflected by reduced heart rate variability.

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