RESTING HEART RATE AND ITS RELATIONSHIP WITH GENERAL AND ABDOMINAL OBESITY IN YOUNG MALE SAUDI UNIVERSITY STUDENTS

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Background: An elevated resting heart rate (RHR) has been linked with adverse cardiovascular outcomes. Obese people have altered autonomic balance that could lead to elevated RHR and altered responses to postural changes. As no comparative data are available on RHR in young normal weight (NW) and obese (OB) adults in Saudi Arabia, the present study was aimed at finding out the effect of adiposity on RHR and RHR response to change in posture. **Methods:** Second-year male students (n=231; age:19–20 years), were recruited from the Dammam University, Dammam, Saudi Arabia, during the period September 2008 to October 2009. Anthropometric measures were obtained and indices of obesity (body mass index [BMI], waist circumference [WC], waist-to-hip ratio [WHR], waist-to-stature ratio [WSR]) were calculated. RHR in standing and supine positions were obtained from radial pulse. Pearson's correlation (r) between obesity indices and RHR as well as the differences between RHR in NW and OB groups were calculated. **Results:** General obesity (BMI≥25.0 kg/m^2) was found in 45.5% students. Central obesity (WC>85 cm or WSR>50.0) was found in 36.8% students. RHR was significantly correlated with BMI, WC and WSR (r=0.305, 0.300, 0.299 respectively, $p<0.01$). Subjects above the obesity indices cut-off points had significantly higher values of RHR in both standing and supine positions compared to NW individuals ($p<0.05$). There was a greater reduction in RHR on changing the posture to supine state in OB group. **Conclusion:** A significantly higher RHR and a greater change in RHR on changing the posture point towards an altered autonomic balance in OB group of young adolescent males. This underscores the need to implement health education program to combat obesity at school and college levels.

Keywords: resting heart rate, obesity indices, body mass index, waist circumference, waist to stature ratio, waist to hip ratio

INTRODUCTION

Heart rate (HR) is an easy to measure but important indicator of cardiovascular health. Though the heart rate dynamics during and after cessation of exercise have been used extensively as markers of cardiovascular health, it is only in the past few years that resting heart rate (RHR) has gained attention as a simple but powerful marker of cardiovascular health.[1] A number of studies have linked an increase in RHR to increased incidence of cardiovascular and non cardiovascular mortality.[2,3] Obese people tend to have increased RHR as autonomic responsiveness has been shown to diminish in obese individuals.[4] This could lead to a reduced ability in the obese to adapt to environment. Obesity is a major health problem affecting young and old through out the world and is associated with a number of cardiovascular diseases and metabolic syndrome.[5–7] Thus obesity is leading directly or indirectly to increased morbidity and mortality.[8]

General obesity which is usually described in terms of body mass index (BMI) is calculated by dividing the patient's weight in kilograms by height in meters squared (kg/m^2). A person with a BMI ≥25 is classified as overweight/obese.[9] Central or visceral obesity (abdominal obesity) can simply be assessed by measurement of waist circumference. A waist circumference of 85 cm or above in males of Asian origin is indicative of central obesity.[8] Other measures including waist-to-hip ratio and waist to height ratio are also used to assess central obesity.

Abdominal obesity is considered to be more dangerous than general obesity because the visceral fat has been shown to secrete certain cytokines and chemicals that are involved in atherogenesis and alterations in the autonomic balance.[10] There is evidence that elevated resting heart rate (>80–85 beats/min) is directly associated with risk of developing hypertension, atherosclerosis and plaque disruption leading to various cardiovascular events.[11] Increased RHR is considered as an independent risk factor and a prognostic factor for cardiovascular and non-cardiovascular related diseases.[12,13]

Though the RHR is influenced by several constitutional and environmental factors, the most important determinants are parasympathetic and sympathetic influences. Thus, quantifying RHR can give an index of the load imposed on the heart and the state of imbalance between sympathetic and parasympathetic activity.[14] The autonomic dysfunction associated with obesity could lead to changes not only in RHR and arterial blood pressure, it could also alter the responses to changes in posture.[15]

There are no studies comparing resting heart rate in both standing (RHRst) and supine (RHRsup) positions in young normal weight (NW) and obese (OB) males in Saudi Arabia. Therefore, the present study was aimed to investigate the effect of adiposity on RHR in standing and supine position in young individuals and finding correlation of RHR with indices of general obesity (BMI) and abdominal obesity (WC, WHR, WSR).

MATERIALS AND METHODS

This cross sectional study was conducted during 2008 and 2009, at University of Dammam, Dammam, Saudi Arabia, after approval from the University Ethics committee. A total of 231, Saudi male students (age: 19–20 years) studying physiology in second year of Colleges of Medicine, Dentistry, and Applied Medical Sciences, took part in the study. Students reported to the lab at 1.00 pm and measurements were started after 30 minutes during which they were briefed about the laboratory exercise, asked to fill the data form including details of their daily exercise and time spent in sports. The time period for filling the details was utilized as period of physical rest. Written consent was obtained and the subjects were examined for their weight, height and waist and hip circumference. Weight was measured in light clothing without shoes on a spring weighing balance to the nearest 0.5 kg. Height was measured in centimetres bare foot against a wall with the help of a wooden measuring scale to the nearest 0.2 cm. Measurement was done with heels close to the wall and feet close together so that weight was equally distributed, and the head in Frankforts plane. Waist circumference was measured in standing position at the level midway between the lower rib margin and the iliac crest, rounded to the nearest 0.5 cm with the help of a measuring tape. The hip circumference was measured in standing position at the widest part of the hip bones over the buttocks, in centimetres to the nearest 0.5 cm.

Resting heart rate was measured after a complete rest of 3 minutes by taking the radial pulse. Three successive readings were taken in the resting state for 60 seconds each with an interval of one minute while the person was standing. Similarly three readings for supine RHR were obtained after a further rest period of 3 minutes.

BMI (body mass index) was calculated by dividing the weight taken in kilograms by the square of the height taken in meters. WHR (waist to hip ratio) was calculated by dividing the waist measurement by the hip measurement. WSR (waist to stature ratio) was calculated by dividing the waist measurement (cm) by the height measurement (cm).

The criteria for categorising a person as normal weight (NW) or obese (OB), on the basis of BMI, WC, WHR and WSR is outlined in Table-1.[9,16,17]

The data were analyzed using the SPSS version 10. Paired *t*-tests were used to compare RHRst and RHRsup in the subjects. ANOVA or independent *t*-test as appropriate were used to compare RHR between two groups (NW, OB) as defined by the cut off points given in Table-1. Correlation between RHR and different indices of obesity and physical activity were tested using Pearson's correlation coefficient (r). A *p*-value <0.05 was considered statistically significant. Six subjects (four in the NW category and 2 in OB category had RHR greater than 100 and there RHR data was not included in the final analysis).

RESULTS

Table-2 provides the descriptive statistics of the sample population. The mean BMI was 25.3 Kg/m^2 and 45.5% of the students had general obesity as defined by BMI of 25 or above (Table-1). The number of students showing central obesity was 36.8 % as defined by either a WC greater than 85 cm or WSR of greater than 50 (Table-1). Using the WHO cut-off point (for Caucasians) of 94 cm for increased risk and 102 cm for substantially increased risk of complications the number of individuals falling into these categories of central obesity were 39 (16.9%) and 25 (11%). Central obesity defined on the basis of a WHR of greater than 0.9 was found in 20.3% of the individuals.

The mean resting heart rate in erect posture (RHRst) was 77.5±9.5 bpm (45–99 with a median of 77 bpm) whereas the mean resting heart rate in supine position (RHRsup) was 67± 8.3 bpm (42–88 with a median of 67bpm). The mean change in heart rate (ΔHR) was 10.5±6.3 bpm (0–31 with a median of 10 bpm). RHRst was significantly higher than RHRsup (p<0.0001) and they were strongly correlated with each other (r=0.786, p<0.001).

Comparing the RHR between NW and OB groups (Table-3) defined on the basis of index of general obesity (i.e., BMI), both the RHRst and the RHRsup in OB group were significantly higher than NW group, but the level of significance for RHRst was higher (p=0.000) as compared to RHRsup (p=0.038). The fall in RHR on assuming a supine position from an erect posture was significantly greater in OB group (17.1%) compared to NW (14.3%) (p=0.008).

Comparing the RHR between NW and OB groups defined on the basis of indices of abdominal obesity, both the RHRst and RHRsup were significantly higher in OB group than NW group but the level of significance was again much less in case of RHRsup. The change in RHR on assuming a supine posture from an erect one was also significant (17.1% vs 14.7% when using WC; 17.6% vs 14.3% when using WSR) except in case where WHR was used to group the individuals (15.9% vs 14.6%).

Further analysis of data for RHR between sedentary and physically active individuals within the OB group based on BMI and WSR did not reveal any significant differences (data not shown). Similarly no significant differences in RHR were found between the sedentary and the active individuals within the NW group.

Figure-1 shows a highly significant positive correlation between RHRst and index of general obesity (BMI) and indices of abdominal obesity (WC, WHR and WSR). Figure-2 shows a significant positive correlation between RHRsup and BMI, WC, WHR and WSR. The correlation of RHRst with indices of obesity is much stronger than RHRsup.

BMI (general obesity) was positively correlated with various indices of abdominal adiposity, i.e., WC (0.940; $p<0.01$) WHR (0.533; $p<0.01$) and WSR (0.937; $p<0.01$). The WC was also well correlated with other indices of abdominal adiposity, i.e., WHR (0.683; $p<0.01$) as well as WSR (0.982; $p<0.01$). The degree of correlation was least for WHR whereas the correlation coefficient is the same for both the WC and WSR.

DISCUSSION

To our knowledge, this is the first study that investigated the relationship between indices of general and central obesity and RHR in both erect and supine position in young Saudi males and provided evidence that both general and abdominal obesity are positively and significantly correlated with RHR in this young group. The study has shown that both RHRst and RHRsup are significantly greater in persons having general obesity or central obesity as compared to non-obese individuals. Additionally the degree of change in RHR on assuming supine position is significantly higher in individuals having either general obesity or central obesity.

Obesity: Our study corroborates the findings of other researchers about the high prevalence (45%) of over nutrition (BMI>25) among young Saudi males from this region. Overweight and obesity with its associated complications is widely prevalent among the Saudi population both in young and old ranging from 30–40%.[18] In a recent review about 16 countries in the Eastern Mediterranean region the overall prevalence of obesity (BMI>30) in male population was 16.6% compared to 28.0% in USA and 23% in UK.[19] Our study also showed that 18.6 % of young males in the medical, dental and allied health colleges of the university were having a BMI of >30. The prevalence of obesity and the metabolic syndrome is rapidly increasing in South Asian countries, leading to increased morbidity and mortality due to type 2 diabetes mellitus and cardiovascular disease.[20] Cardio-metabolic risk is high in South Asians, starting at an early age and the magnitude of obesity-attributable deaths among Asians is much more than has been appreciated. Asian populations had higher cardiovascular risk factors than Western populations at any BMI level.[21] It has been suggested that the reference cut-off points of BMI and WC for defining general obesity and abdominal obesity in Asians should be lowered.[22] The study by Wen *et al*[23] supports the use of BMI≥25.0 kg/m^2 as a new cut-off point for obesity and BMI=23.0–24.9 kg/m^2 for overweight. We used the cut off point of 25 for BMI and 85 cm for WC in our study according to these recommendations.

Table-1: Distribution of subjects into normal and obese groups based on the cut-off points of obesity indices

Obesity indices	Cut-off	Normal n (%)	Obese n (%)
Body Mass Index (BMI)	25 kg/m^2	126 (54.5)	105 (45.5)
Waist Circumference (WC)	85 cm	146 (63.2)	85 (36.8)
Waist to Hip Ratio (WHR)	0.85	150 (64.9)	81 (35.1)
Waist to Stature Ratio (WSR)	50	146 (63.2)	85 (36.8)

n= number of subjects

Table-2: Descriptive statistics of the subjects (n=231)

Variable	Mean±SD	Range		
		minimum	maximum	median
Height (cm)	170.7±6	156	191	170
Weight (kg)	73.8±19.9	43	168	70
Waist circumference (WC) cm	82.2±15.3	60	147	79
Hip circumference (HC) cm	97.8±13.5	69	147	96
Body mass index (BMI) kg/m^2	25.3±6.2	16.3	49.9	24.4
Waist to hip ratio (WHR)	0.84±0.07	0.63	1.09	0.83
Waist to stature ratio (WSR)	48.1±8.6	35.1	80.1	46.8

Table- 3: Effect of obesity on RHR in standing and supine position and difference in HR n=225

Obesity indices	RHRst (bpm)		RHRsup (bpm)		ΔHR (bpm)	
	NW	OB	NW	OB	NW	OB
BMI	75.4±9.1	79.9±9.4**	65.9±7.6	68.3±8.9*	9.4±6.1	11.7±6.4**
WC	75.6±9.1	80.5±9.4**	65.9±7.8	68.7±8.7*	9.7±6.1	11.8±6.4*
WHR	76.1±9.3	79.9±9.4**	66.2±8.0	68.4±8.6	9.9±6.2	11.5±6.5
WSR	75.6±8.9	80.7±9.7**	66.1±7.8	68.6±8.9*	9.5±6.2	12.1±6.3*

*$p<0.05$, **$p<0.01$

Data is expressed as Mean±SD; NW: Normal weight (below cut off point), OB: obese (above cut off point for the respective index of obesity) as defined in Table-1. BMI: body mass index, WC: waist circumference, WHR: waist to hip ratio, WSR: waist to stature ratio, RHRst: resting heart rate in standing position, RHRsup: resting heart rate in supine position, ΔHR: change in heart rate due to change in posture from standing to lying down position.

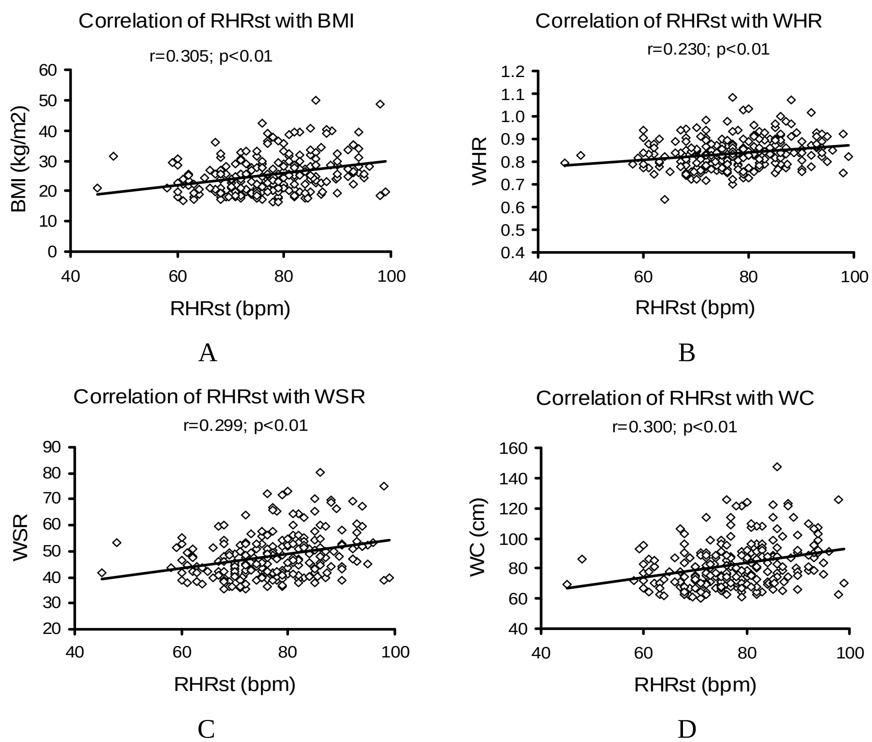

Figure-1: Correlation of resting heart rate in standing position with indices of obesity

BMI: body mass index, WC: waist circumference, WHR: waist to hip ratio, WSR: waist to stature ratio, RHRst: resting heart rate in standing position; bpm: beats per minute, r=Pearson's correlation

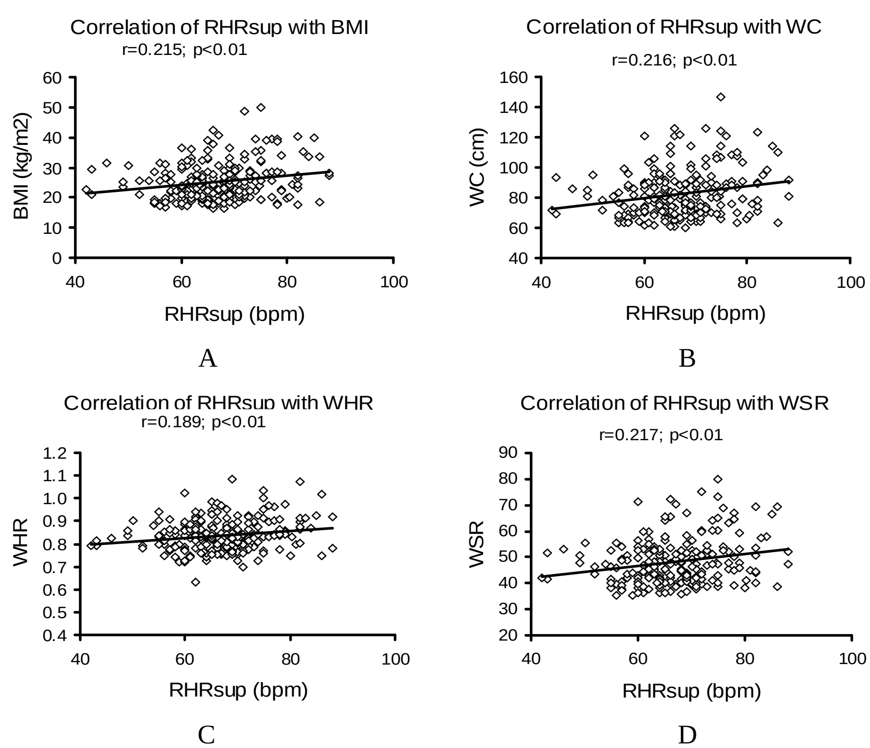

Figure-2: Correlation of resting heart rate in supine position with indices of obesity

BMI: body mass index, WC: waist circumference, WHR: waist to hip ratio, WSR: waist to stature ratio, RHRsup: resting heart rate in supine position; bpm: beats per minute, r=Pearson's correlation

General obesity versus central obesity: The results of the present study also showed that the degree of abdominal obesity was less as compared to general obesity in our young male student population. Abdominal obesity is not commonly assessed in clinical practice and relatively few clinicians have full awareness about the measurement and implications of central (visceral or abdominal) obesity.[24] The distribution of body fat is important as patients with abdominal obesity are at greater cardiovascular risk.[25,26] Visceral adipose tissue secretes a variety of bioactive substances, termed adipocytokines, such as leptin, tumour necrosis factor-α (TNF-α), interleukin-6 (IL-6), angiotensinogen, and non-esterified fatty acids (NEFA), which play a role in development of hypertension and metabolic syndrome.[10] It has been related to autonomic nervous derangement[27] especially sympathetic neural active-tion.[26] Extremely obese subjects (WC>102 cm) with visceral obesity have a marked insulin resistance and a remarkable degree of sympathetic activation.[28] Studies have also provided evidence supporting the superiority of measures of abdominal obesity, especially WSR, over BMI, for detecting cardiovascular risk factors in both men and women.[29] In one study a high waist circumference increased the risk of glucose intolerance and diabetes, independent of the risk reflected by high BMI.[30] In another study of the overweight children WSR was found to be more strongly associated with adverse risk-factor levels than BMI.[31]

WC, WHR and WSR are good indicators of abdominal obesity. Increased WC represents increased abdominal fat or visceral fat. WHR takes into account the distribution of body fat in the abdominal region but it may remain the same even when there is a change in body size because WC and HC can increase or decrease proportionately. WSR takes into consideration both the height and WC and the WSR will change only when there is a change in WC in grown up adults.[32,33] BMI, on the other hand, does not take into account the proportion of weight related to increased muscle mass or the distribution of excess fat within the body, both of which affect health risks associated with obesity. Individuals with a similar BMI can vary considerably in their abdominal-fat mass.

RHR: Though it is known that RHR is positively correlated with BMI,[34] the relationship with indices of visceral obesity had not been investigated in young healthy individuals. We observed a significant correlation of RHR with BMI, WC and WSR. Again the individuals with general obesity had RHR similar to those with abdominal obesity and higher than their respective NW groups. The change in RHR due to postural change did not show a significant difference between the generally obese and abdominally obese. This observation is different from reports of Grassi *et al* who observed a greater cardiovascular effect in individuals with visceral obesity.[35] It is probably because in the present study, the index of general obesity was well correlated with indices of abdominal obesity. Another reason for this discrepancy could be that most of our subjects who belonged to OB group did not have marked abdominal obesity and only 25 out of 225 individuals (11%) showed a WC>102 cm.

The mean values for RHR as obtained in the present study are comparable to other studies in young individuals in Saudi Arabia (78±2 in 19 year old boys)[36], but that study excluded underweight and obese individuals. It also showed that the RHR in sitting position progressively decreased from birth till 17 years but then stabilized by the age of 17 yrs. Rabbia *et al*[14] measured blood pressure (BP) and RHR by radial pulse in sitting position at 5, 10, 15 min of rest and found that BP but not RHR declined significantly from the first to the last determination. RHR in 18 year old males was stabilized at 74.5±7.4 bpm though it also followed a progressive decreasing trend with age—a finding similar to that by Al Qurashi *et al*.[36] RHR was found to be positively and significantly correlated with blood pressure. Salameh *et al*[37] also reported a mean RHR of 73±9 in 15–20 years old males. The RHR in standing position of 17 year old black (72.5±1.65; n=57) and white (82.1±0.8; n=376) youths in USA were also close to the results found in the present study, but the blacks showed RHR of 6–12 bpm less than whites.[38] A RHR of 74.1 was also observed in a large population study of 19 year old male University students in Belfast.[39] These studies emphasize the point that it is important to have local data for RHR in young individuals as ethnic differences can lead to significant variations in RHR.

An elevated heart rate (HR) is a warning about an increased risk of cardiovascular dysfunction.[3] It has been shown that an increase in heart rate by 10 beats per minute was associated with an increase in the risk of cardiac death by at least 20%, and this increase in the risk was similar to the one observed with an increase in systolic blood pressure by 10 mm Hg.[40,41] The literature indicates that a heart rate of more than 80 bpm significantly increases the risk of cardiovascular complications, morbidity, and mortality.[1] Studies have also found a continuous increase in risk with HR above 60 beats/min.[2] In the NHANES study, a heart rate higher than 84 beats/min implied a greater risk of cardiovascular mortality as well as all cause mortality.[42] Evidence also suggests that slower HR while in sinus rhythm is associated with longevity.[43]

Several mechanisms have been put forward to explain the association between high heart rate, atherosclerosis, and cardiovascular events. The pulsatile stress caused by increased heart rate could directly increase the myocardial oxygen consumption and induce fatigue and fracture of elastic fibres within the arterial wall. Indeed clinical studies have shown significant associations between heart rate and functional alterations of large arteries, mainly arterial stiffness.[11]

Obesity and the cardiac autonomic nervous system are intrinsically related. A 10% increase in body weight is associated with a decline in parasympathetic tone, accompanied by a rise in mean heart rate, and conversely, heart rate declines during weight reduction.[12,44,45] Reductions in vagal activity with increment in weight may be one mechanism for the arrhythmias and other cardiac abnormalities that accompany obesity. Shigetoh and Adachi[46] demonstrated that higher heart rate might predispose to the development of obesity and diabetes mellitus, implying the role of sympathetic system in the development of obesity and DM. In obese normotensive subjects a reduction in body weight exerts a marked reduction in sympathetic activity owing to central sympathoinhibition. This could be the consequence of a restoration of the baroreflex control of the cardiovascular system with weight loss.[47] Since autonomic disturbances appear to be reversible with weight reduction improvement obtained from weight loss should be beneficial for the health of individuals with obesity and diabetes.[48]

Postural changes and RHR: RHR changes are known to occur when one moves from a recumbent to an upright position or vice versa. In the present study there was a greater change in RHR 17% in obese group compared to NW group (14%). It could be explained on the basis of a relatively higher sympathetic tone in the obese group than NW or the parasympathetic tone was comparatively less in OB compared to NW. Either of the two mechanisms could lead to a relatively higher RHR in both standing and supine position in obese group. However, the effects of autonomic dysfunction would be reduced in supine position especially if they are related to the sympathetic activation.[47] This is probably why the difference in RHRsup between NW and OB groups is less significant as compared to RHRst, and the correlation of RHRsup with adiposity is weaker than that of RHRst.

As the differences in RHR between NW and OB groups were similar in individuals categorized on the basis of either BMI (for general obesity) or WSR (for central obesity), it indicates that the autonomic function controlling postural related cardiovascular changes in our subjects were operating similarly in these subjects. Two possibilities exist; one is that the subjects in our population who exhibited central obesity did not have marked deposition of fat except for very few individuals (BMI>35, n=20). Secondly, the autonomic dysfunction takes time (may be 5–10 years) to develop so that the effects are not manifested in our subjects who were very young (19–20 years old).

Mechanism underlying the changes in RHR due to postural change: The changes in the BP and HR that occur in humans on standing up or lying down are due for the most part to baroreceptor reflexes.[49] The baroreceptors are stimulated by distension of structures in which they are located, and discharge at an increased rate when the pressure in these structures rises. Increased baroreceptor discharge inhibits the tonic discharge of sympathetic nerves and excites the vagal innervation of the heart leading to vasodilatation, venodilatation, fall in BP, bradycardia and a decrease in cardiac output.

The limitation of this study regarding methodology is limited number of subjects all of whom were males. In addition, the heart rate was obtained manually without using automated machines. Nevertheless, this manual radial pulse measurement is the time tested and standard procedure if done properly (counting for full one minute after a period of proper rest in a steady state condition). Accurate measurements of immediate and long term changes in RHR on change of posture require more sophisticated equipment and measurement of HRV is better than simple measurements of RHR. The present study concentrated on the longer term stable responses after changing the posture.

One major benefit of this study could be that the young students may be advised to alter their eating habits and lifestyle by demonstrating to them an immediate observable effect of obesity on RHR. This is particularly useful at this stage of life when the subjects are in the adolescent years because the weight gain after 18 years of age increases cardio-vascular risk even in patients with normal body mass index.[25] A recent study in India showed a low prevalence of multiple cardiovascular risk factors (including dyslipidemias, diabetes and obesity) in adolescents but a rapid escalation of these risk factors by age of 30–39 years.[22] During a 5y transitional period between adolescence and young adulthood, the proportion of adolescents becoming and remaining obese into adulthood was very high.[50] Thus a healthy lifestyle, including dietary and physical activity modification, especially in early adolescence may play an essential part in the battle against atherosclerosis, obesity and metabolic syndrome.

CONCLUSION

There is a significant positive correlation between obesity indices and RHR with the obese group exhibiting a significantly faster RHR compared to NW group. This continuous faster RHR in these young individuals exhibiting either abdominal obesity or general obesity could contribute to various cardiovascular problems later in life. Our findings strengthen the previously reported usefulness of RHR in providing an early sign of card-iovascular risks in young adults. It further stresses the need to prevent obesity early in life to avoid life-threatening consequences in advancing age.

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