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Gender difference in parasympathetic function by HRR1min after graded treadmill exercise in healthy obese young adults

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ABSTRACT

Background: Heart rate recovery at 1st min (HRR1min) following exercise, an indicator of parasympathetic function is found to be impaired in obese children, adolescents, and elderly people. In children, adolescents and elderly people impaired that HRR1min was significantly associated with obese females (OF) than in males. This study aims at establishing the gender difference in HRR1min among obese young adults (18–30 years age). **Aims and Objectives:** This study was conducted to assess parasympathetic function by HRR1min after graded exercise, in apparently healthy obese young adult males and females and to evaluate for gender difference in them. **Materials and Methods:** Fifty obese young adults (25 males and 25 females with body mass index [BMI] ≥30) and 50 age- and gender-matched controls (25 males and 25 females with BMI ≤24.9) were subjected to graded treadmill exercise. Maximum heart rate reached during exercise and heart rate at 1st min of recovery phase were recorded and HRR1min was calculated as the difference of above. The data were analyzed. **Results:** The study showed significant decrease in mean HRR1min in obese males compared to OF (mean 18.04±3.6 vs. 30.00±8.55, P<0.001), there is significant delay in HRR1min when OF and males were compared with their gender-matched controls. **Conclusion:** Parasympathetic function by HRR1min after exercise is significantly decreased in male obese young adults when compared with female obese young adults and are at higher risk of developing metabolic syndrome and cardiovascular disorders.

Key words: Heart rate recovery at 1st min; Parasympathetic function; Male and female obese young adults

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INTRODUCTION

There is increased prevalence of obesity in young adults. Obesity is proved to be the risk factor of metabolic and cardiovascular disorders. Autonomic dysfunction has been shown to be associated with obesity.[1] Autonomic dysfunction becomes evident when subjected to stress like exercise.[2] Increase in heart rate during exercise is due to both parasympathetic withdrawal and sympathetic activation.[3] After cessation of exercise, heart rate recovers to the normal level by parasympathetic reactivation and sympathetic withdrawal.[1] Heart rate recovery at 1st min (HRR1min) post-exercise is more indicative of parasympathetic function.[4] Therefore, HRR1min after exercise has been proposed to be an indicator of parasympathetic activity (PSA) and an abnormally slower HRR1min after exercise would indicate impaired parasympathetic function (vagal activity).[1,3]

Significant drop in HRR in study group in comparison with age- and gender-matched controls is considered as increased risk for chronic metabolic disorders and cardiovascular morbidity and mortality.[5] Delayed HRR1min after graded treadmill exercise (GTX) was found to be associated with Type 2 diabetes mellitus, carotid atherosclerosis, metabolic syndrome and its components, cardiovascular disorders, arrhythmias, and sudden death. It is also identified as a strong predictor of mortality in patients undergoing stress

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test, independent of ischemia.[4,6-10] According to CARDIA study done on participants aged between 18 and 30 years, slower HRR does not proceed to the development of metabolic syndrome, but appears in whom the syndrome components are already present.[7]

In a study on elderly subjects, aged >75-year with and without metabolic syndrome components showed that metabolic syndrome components were strongly associated with attenuated HRR in women than in men.[11] In another study on apparently healthy children (mean age of 12 years), HRR1min was higher in boys and correlated inversely with age-adjusted body mass index (BMI) in both boys and girls indicating no gender difference in HRR1min in obese children.[12]

There are few studies associating HRR1min (parasympathetic function) after exercise among obese young adults and their gender difference. This study is done to evaluate HRR1 min after GTX in apparently healthy male and female obese young adults, without any other metabolic syndrome component and is compared with age and gender matched healthy young adults with normal BMI as controls.

Aims and objectives

1. To assess HRR1min after graded exercise in healthy Obese young adults and in age and gender matched controls with normal BMI.
2. To evaluate for gender difference in HRR1 min after exercise among obese males and females and compare with controls.

MATERIALS AND METHODS

This comparative study was done after obtaining approval of the Institutional ethical committee and the informed consent from the subjects. The subjects were selected among medical students and staff of Medical College and Hospital.

Inclusion criteria

A 18–30 year aged 50 obese (O) healthy young adults (25 obese males [OM] and 25 obese females [OF] with BMI ≥30) were included in the obese group and 50 age- and gender-matched healthy young adults (25 control males [CM] and 25 control females [CF] with Normal BMI ≤24.9) were considered as controls.

Exclusion criteria

Subjects with history of Type 2 diabetes mellitus, hypertension, dyslipidemia, metabolic, respiratory, and cardiovascular disorders were excluded from the study. Those with abnormal ECG at rest, with family history of premature cardiac deaths among 1st relatives, those on drugs altering autonomic functions like beta-blockers or who developed cardio vascular symptoms during exercise were also excluded from the study. Females during menstrual cycles, during pregnancy, or lactation were not included in the study.

Individuals satisfying inclusion and exclusion criteria were made to rest for 10 min and resting heart rate (HRrest), BP and ECG were recorded. Height and weight of subjects were recorded and BMI (kg/m^2) was calculated using Quetelet index.[13-15]

Those included in the study were subjected to symptom limited GTX according to modified Bruce protocol using standardized Treadmill of research grade, T 2100 GE medical systems.[5] Maximum achievable heart rate is age dependent and is calculated using formula – Achievable HRmax=205.8−(0.685×age).[11,14,16] They were made to exercise till they attained at least 85% of achievable HRmax with continuous vigilance of ECG display on monitor.[5] Once targeted heart rate was reached, it was recorded as HRmax and subject was asked to cool down by exercising at the speed of 1.5 mph and 0% inclination. The HR was recorded exactly after 1 min (HR1min) during this phase.[5] HRR1min was calculated as (HRR1min=HRmax−HR1min).[8] After exercise, subjects were monitored at rest for 15 min in the lab.

RESULTS

Statistical analysis of the relevant data of both the groups was done using statistical program SPSS version 11 and variables were presented as Mean±SD. Groups were compared and analyzed using Chi-square test. P≤0.05 was considered to be statistically significant.

In this study, HRR1min was assessed in 50 apparently healthy obese subjects (25 males – OM and 25 females – OF with BMI ≥30) and was compared with 50 (25 males – CM and 25 females – CF with BMI ≤24.9) age- and gender-matched healthy individuals, as controls. The subject's age, gender, and sample size was matched among obese and controls. Weight and BMI showed significant difference when obese was compared with controls (Mean±SD of BMI being 33.04±2.007 and 21.32±2.024, respectively, with P<0.001). Heart rate parameters of both obese and control group are presented in the Table 1.

Differences in heart rate parameters of male and female subjects of study and control groups were recorded and analyzed by Chi-square test. Gender comparison of HRR1min among OM and CM, OF and CF, OM and OF, and CM and CF are done and presented in Table 2.

Table 1: Heart rate parameters in controls and study group

Parameters (n=50)	Controls Mean±SD	Obese Mean±SD
HRrest	78.34±7.125	82.62±7.368
HRmax	168.46±4.239	166.02±5.509
HR1 min	130.18±9.699	142±8.827
HRR1 min=HRmax−HR1 min	42.42±5.326	24.02±8.872

HRrest: Resting heart rate, HRmax: Max. Heart rate, HR1 min: Heart rate at 1 min, HRR1 min: Heart rate recovery at 1st min

Table 2: Comparison of HRR1 min in both the genders of obese and control groups

Groups	HRR1 min (Mean±SD)	P-value
Controls (C) n=50	42.42±5.326	<0.001*
Obese (O) n=50	24.02±8.872	
HRR1 min among OM and CM;		
CM n=25	43.04±6.16	<0.001*
OM n=25	18.04±3.61	
HRR1 min among OF and CF;		
CF n=25	41.80±4.36	<0.001*
OF n=25	30.00±8.55	
HRR1 min among OF, OM; CF and CM		
OF n=25	30.00±8.554	0.000**
OM n=25	18.04±3.611	
CF n=25	41.80±4.368	0.406
CM n=25	43.04±6.168	

*Significant difference; **Highly significant difference. C: Controls, O: Obese, CM: Controls males, OM: Obese males, CF: Controls females, OF: Obese females, HRR1 min: Heart rate recovery at 1st min

On statistical analysis, mean HRR1min is significantly impaired in obese compared with controls. Highly significant decrease in HRR1min is observed when OM were compared with OF. Although significant impairment of HRR1min was observed when OM were compared with CM and when OF were compared with CF. Insignificant difference is noted when CM and CF were compared.

DISCUSSION

HRR1min after graded exercise is a predictor of parasympathetic function. This study is to assess HRR1min after GTX in young (18–30 year) obese adults and age- and gender-matched controls with normal BMI. This study revealed that there is significant attenuation of HRR1min post-exercise in obese group compared to controls and there is highly significant difference in attenuation of HRR1min after exercise is OM compared to OF, though OF showed significantly greater attenuation of HRR1min when compare with CF. Likewise OM also showed significant decrease in HRR1min when compare with CM. There is no significant gender difference in HRR1min post-exercise in CM and CF.

There are some studies supporting our findings as in Brinkworth et al., study on 46±1.3 years obese subjects with BMI >27 kg/m^2, mean HRR1min was 33±1.4 which was similar to the present study.[17] CARDIA study done on 18–30 years apparently healthy young adults showed that, subjects with higher BMI had lower HRR and had higher fasting insulin though were euglycemic. On follow-up of these individuals, the risk of developing Type 2 diabetes was 3–4-fold greater. This study has suggested that impaired parasympathetic function precedes development of overt diabetes mellitus.[8] Similar gender difference was observed by Sung et al., study on 51±9 year old subjects with metabolic syndrome component and BMI >25 kg/m^2 showed that HRR was significantly lower in men compared to women.[1] A similar finding as that of this study, on healthy obese young adult females provides evidence that overweight/obese (18–24 year) healthy females were associated with significantly decreased early HRR and delayed vagal reactivation after exercise when compared to CF.[18] Another study done on children aged 8–10 years and adolescents aged 14–16 years showed an inverse association of HRR with obesity traits and related cardiometabolic risk factors in boys and no such association was found in girls or adolescents.[19] A study done on healthy young adults (18–27 years), both men and women with good cardiorespiratory fitness, showed no gender difference in HRR1min following exercise, similar to that found in our study of similar age group control men and women.[20]

A contrasting finding to this study on gender difference in young obese adults of similar age group as ours showed no significant association between various obesity indices and HRR.[21] However, their study was on a small sample size and they have not specified at what duration following exercise they have noted HRR. Nilsson et al., study on elderly subjects aged >75-year showed that metabolic syndrome components more strongly correlated to HRR in women than in men.[11] Here, we need to consider the postmenopausal age group. A study supporting this explanation is a study which demonstrates that premenopausal women have dominant vagal and subordinate sympathetic activity compared with age-matched men and estrogen plays an important role in gender differences, they also found that conjugated estrogen replacement therapy facilitates vagal tone and attenuate sympathetic regulation of heart rate in postmenopausal women.[22] The above age-related difference could be due to hormonal effects, especially cardioprotective effects of estrogen in reproductive age group. In addition, good physical fitness in young adults when compared to that of growing children and senescent age group might also play a role.[16,22,23]

Obesity is an important risk factor for cardiovascular disease and vagal autonomic dysfunction being an early

metabolic and cardiovascular risk marker, the mechanisms by which weight gain reduces parasympathetic tone is yet to be fully clarified. One possible explanation is that obesity is associated with chronic inflammation of adipose tissue.[3-4,12] Inflammatory adipokines secreted by white fat, like tumor necrosis factor alpha and interleukin, affect the cardiac autonomic balance through the central nervous system, promoting sympathetic hyperactivity, especially in obese individuals, counteracting increased PSA and acetylcholine levels, which inhibit release of these inflammatory cytokines.[6-7,12] It is through inflammatory states and autonomic nervous system dysfunction that obese patients have a higher risk of morbidity and mortality.[8,10] Brinkworth et al., study compared and found that parasympathetic function by HRR1min at base line and after 12 weeks of exercise training improved after exercise training with weight loss in obese individuals.[17] Vagally mediated HRR after exercise was accelerated in well-trained athletes.[24]

Above finding alerts obese young adults about obesity associated risk of subclinical metabolic and cardiovascular morbidity and mortality with ray of hope to reverse the risk by decreasing weight and body fat content by regular exercise maintaining physical fitness and healthy lifestyle.

Limitations of the study

Strength of our study is our relatively large sample size and the limitations of the study being, it is a single center experience, most of our study subjects are working class people with raised BMI which do not consider sedentary group. Further follow-up study on at risk, obese group would confirm that attenuated HRR1min is an early marker of metabolic disorders and cardiovascular morbidity and mortality.

CONCLUSION

Parasympathetic function by HRR1min after graded exercise is significantly decreased in obese young adults, more so in obese young adult males compared to OF. HRR1min after GTX shows no gender difference in age-matched controls. HRR1min after exercise is a significant prognostic marker and along with other investigations an early predictor of metabolic disorders and cardiovascular morbidity and mortality in obese young adults.

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REFERENCES

1. Sung J, Chon YH and Park JB. Metabolic syndrome is associated with delayed heart rate recovery after exercise. J Korean Med Sci. 2006;21(4):621-626.
https://doi.org/10.3346/jkms.2006.21.4.621
2. Laederach Hofmann K, Mussgay L and Rúddel H. Autonomic cardiovascular regulation in obesity. J Endocrinol. 2000;164(1):59-66.
https://doi.org/10.1677/joe.0.1640059
3. Hegazy AM and Abdelkader BA. Clinical significance of impaired heart rate recovery after treadmill exercise test in hypertensive patients. Kuwait Med J. 2004;36(1):19-25.
4. Jae SY, Carnethon MR, Heffernan KS, Fernhall B, Lee MK and Park WH. Heart rate recovery after exercise and incidence of Type 2 diabetes in men. Clin Auton Res. 2009;19(3):189-192.
https://doi.org/10.1007/s10286-009-0007-4
5. Cole CR, Foody JM, Blackstone EH and Lauer MS. Heart rate recovery after submaximal exercise testing as a predictor of mortality in a cardiovascularly healthy cohort. Ann Intern Med. 2000;132(7):552-555.
https://doi.org/10.7326/0003-4819-132-7-200004040-00007
6. Jae SY, Carnethon MR, Heffernan KS, Choi YH, Lee MK, Park WH, et al. Slow heart rate recovery after exercise is associated with carotid atherosclerosis. Atherosclerosis. 2008;196(1):256-261.
https://doi.org/10.1016/j.atherosclerosis.2006.10.023
7. Kizilbash MA, Carnethon MR, Chan C, Jacobs DR, Sidney S and Liu K. The temporal relationship between heart rate recovery immediately after exercise and the metabolic syndrome: The CARDIA study. Eur Heart J. 2006;27(13):1592-1596.
https://doi.org/10.1093/eurheartj/ehl043
8. Cole CR, Blackstone EH, Pashkow FJ, Snader CE and Lauer MS. Heart-rate recovery immediately after exercise as a predictor of mortality. N Engl J Med. 1999;341(18):1351-1357.
https://doi.org/10.1056/nejm199910283411804
9. Lin LY, Kuo HK, Lai LP, Lin JL, Tseng CD and Hwang JJ. Inverse correlation between heart rate recovery and metabolic risks in healthy children and adolescents: Insight from the National Health and Nutrition Examination Survey 1999-2002. Diabetic Care. 2008;31(5):1015-1020.
https://doi.org/10.2337/dc07-2299
10. Lins TC, Valente LM, Filho DC and e Silva OB. Relation between heart rate recovery after exercise testing and body mass index. Rev Port Cardiol. 2015;34(1):27-33.
https://doi.org/10.1016/j.repc.2014.07.006
11. Nilsson G, Hedberg P, Jonason T, Lönnberg I and Ohrvik J. Heart rate recovery is more strongly associated with the metabolic syndrome, waist circumference, and insulin sensitivity in women than in men among the elderly in the general population. Am Heart J. 2007;154(3):460.e1-7.
https://doi.org/10.1016/j.ahj.2007.06.025
12. Singh TP, Jonathan R and Kimberlee G. Determinants of heart rate recovery following exercise in children. Med Sci Sports Exerc. 2008;40(4):601-605.
https://doi.org/10.1249/mss.0b013e3181621ec4
13. Lohman TG, Roche AF and Martorell R, editors. Anthropometric Standardization References Manual. Champaign, Illinois: Human Kinetic Books; 1988.
14. Perls T and Fretts RC. Why Women Live Longer Than Men; 1997. Available from: https://www.researchgate.net/publication/248446318_why_women_live_longer_than_men

15. BMI Classification. World Health Organization. Available from: https://www.who.int/bmi/index.jsp?intropage=intro_3.html.pdf [Last accessed on 2010 Sep 11].
16. Robergs RA and Landwehr R. The surprising history of the "HRmax=220-age" equation". J Exerc Physiol. 2002;5(2):1-10.
17. Brinkworth GD, Noakes M, Buckley JD and Clifton PM. Weight loss improves heart rate recovery in overweight and obese men with features of the metabolic syndrome. Am Heart J. 2006;152(4):693.e1-6.
https://doi.org/10.1016/j.ahj.2006.07.019
18. El Agaty SM, Kirmani A and Labban E. Heart rate variability analysis during immediate recovery from exercise in overweight/obese healthy young adult females. Ann Noninvasive Electrocardiol. 2017;22(3):e12427.
https://doi.org/10.1111/anec.12427
19. Laguna M, Aznar S, Lara MT, Lucía A, and Ruiz JR. Heart rate recovery is associated with obesity traits and related cardiometabolic risk factors in children and adolescents. Nutr Metab Cardiovasc Dis. 2013;23(10):995-100.
https://doi.org/10.1016/j.numecd.2012.10.002
20. De Mendonca GV, Teodósio C and Bruno PM. Sexual dimorphism in heart rate recovery from peak exercise. Eur J Appl Physiol. 2017;117(7):1373-1381.
https://doi.org/10.1007/s00421-017-3627-8
21. Anand A, Verma N, Tiwari S and Verma D. Correlation of obesity indices with heart rate recovery as a marker of autonomic function in healthy young adults. J Family Med Prim Care. 2020;9(7):3370-3373.
https://doi.org/10.4103/jfmpc.jfmpc_112_20
22. Liu CC, Kuo TB and Yang CC. Effects of estrogen on gender-related autonomic differences in humans. Am J Physiol Heart Circ Physiol. 2003;285(5):H2188-H2193.
https://doi.org/10.1152/ajpheart.00256.2003
23. Moodithaya SS and Avadhany ST. Comparison of cardiac autonomic activity between pre and post menopausal women using heart rate variability. Indian J Physiol Pharmacol. 2009;53(3):227-234.
24. Imai K, Sato H, Hori M, Kusuoka H, Ozaki H, Yokoyama H, et al. Vagally mediated heart rate recovery after exercise is accelerated in athletes but blunted in patients with chronic heart failure. J Am Coll Cardiol. 1994;24(6):529-1535.
https://doi.org/10.1016/0735-1097(94)90150-3

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PHK- Definition of intellectual content, concept, literature survey, design, clinical protocol, manuscript preparation, editing, and manuscript revision, prepared first draft of manuscript, implementation of study protocol, data collection, data analysis, statistical analysis and interpretation, manuscript submission of article; **SS-** Review manuscript, coordination and manuscript revision.

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