A METHODICAL APPROACH TO SCRUTINIZE THE ROLE OF BODY MASS INDEX IN HEART RATE INCREMENT AND RECOVERY

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ABSTRACT

OBJECTIVES

Heart rate (HR) is a crucial health indicator and is also one of the health factors we need to pay explicit attention to. Body Mass Index (BMI) is considered a cofactor in heart-related issues like heart rate increment and recovery. Thus a study was conducted to determine the relationship between BMI and the rate of heart rate increment and recovery.

METHODOLOGY

A total 24 participants aged 17-20 were examined during elliptical machine training once a week continuosly for three months. Their regular resting heart rate and change in heart rate during and after the elliptical workout were recorded and compared with BMI.

RESULTS

The HR increments were noted alongside BMI for male participants below BMI 21.13, and female participants below BMI 20.16. The heart rate increment tempo decreases alongside the increased BMI for both sexes afterwards. The heart rate recovery (HRrecovery) for male participants falls with the BMI increase to ~25 and increases thereafter. The female participants show a differing trend: HRrecovery rates increase following BMI growth till BMI ~ 20 and then decrease parabolically till the maximum BMI among female participants. The findings suggest no linear and non-significant correlation between BMI and heart rate increment or HRrecovery. The coefficient of determination is too tiny (R2 = 0.1395 for males and R2 = 0.003 for females) to indicate the causation between BMIs and HRrecovry.

CONCLUSION

This is the first study scrutinizing the role of body mass index on heart rate increment and heart rate recovery. Thus BMI should not be used as the cofactor or risk for heart activity or impaired functions.

KEYWORDS: *Body Mass Index, Heart Rate, Heart Rate Increment, Heart Rate Recovery*

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INTRODUCTION

The heart rate is the number of heartbeats per minute. It is a vital indicator of fitness levels and the predictor of multiple health problems. Heart rate varies between ages and heart conditions. The heart rate can be influenced by various factors and conditions, including body sizes, height, weather, emotions, body positions, blood pressure, smoking, caffeine consumption, and alcohol utilization.[1,2,3] The heart usually pumps 5 - 6 liters of blood per minute in a resting state and beats 60 to 100 times per minute. During physical

activities, the muscles need an immense amount of oxygen for cell respiration, carried by the hemoglobin in the blood. Thus, the heart has to pump out a considerable amount of oxygenated blood to the body. The cardiac output (stroke volume × heart rate) has to be boosted through a more regular heartbeat or higher stroke volume. The autonomic nervous system (ANS) is primarily responsible for this regulation of heart rate. As exercise intensity increases, parasympathetic withdrawal and sympathetic activation cause the heart rate to increase until a maximum value.[4] Recent studies have indicated that obese bodies require enormous blood for oxygen and nutrient supply, which means higher cardiac output during any physical workout activity.[5,6] Thus their heart rate readings are regularly higher for them. This might also be true in fitness training. HRrecovery is the decrease in heart rate following the ending of physical training. It reflects the reactivation balance of the parasympathetic nervous system (PNS) and the withdrawal of the sympathetic nervous system. The PNS reactivation contributes to the difference in HRrecovery between different persons. This effect of PNS reactivation is usually measured 1 minute after the termination of the exercises.[7] Some studies reported a correlation between BMI and resting heart rate, as BMI is a good indicator of obesity.[8,9,10] It will be pretty helpful when considering the Correlation of BMI with HR increment during physical exercises and HRrecovery afterwards. Considering this, a pilot and first of its kind study was concluded in the IBD nan shi fu zhang, Nanjing Normal University, China. In this study, 24 participants aged 17 - 20 were examined during elliptical machine training once a week, continuously for three months. Their regular resting heart rate and change in heart rate during and after the elliptical workout were recorded and analyzed.

METHODOLOGY

The participant's BMI and physical examination were performed at the experiment's beginning. Participants were asked to determine their BMIs with a BMI measuring machine (phoenix pbmi-200p, China) and calculate their height and weight according to the equation. Temperature and humidity in the examination room were measured using the hydrometer (Home Brew Ohio PF-KS80-08O0 and Hygrometer (CEM® Temp & Humidity DT-83) before and during each experiment, and the data was collected. Variations in temperature and humidity were reduced to keep data measurements more accurate. After adequately preparing for the experiment, the participants were asked to rinse their forearms under clean water for 5 seconds and then dry them using the tissue. This was important to maximize direct contact of the arms to the optical sensors of the external heart rate monitoring apparatus (Apple® Series 5, USA (Model A2157)).[2] The heart rate monitoring apparatus was attached to each participant's left wrist and tightened to ensure accurate measurements. Participants were then asked to stand and rest their arms by placing them on a desk (the same height as their chests). Then they were directed to put their fingers on the Digital Crown to activate Electrocardiogram (ECG) heart rate context, which induces a more accurate measurement than the streaming context. The participants do this until their heart rate stops fluctuating, and the data at this point were collected. The heart rate monitoring apparatus was attached and tightened on the left arm of the participants, as explained previously. The participants were then advised to take a position on already programmed digital Elliptical machines (Vision Fitness® elliptical machine (S60). and NordicTrack - Commercial 14.9 Model: NTEL71420 SKU:6424904) for the workout. Elliptical machines are the best appliance for a high-power cardiovascular exercise that engages several other muscle groups and are less stressful on the knees, hips, and back than any other working-out machine. Participants started working out, and the stopwatch in Elliptical machines automatically started. The participants stop once the stopwatch reaches 1 minute 30 seconds, and the participants stand to rest until their heart rate falls back to the resting heart rate. During this period, the data were stored in the heart rate monitoring apparatus and Elliptical machines and were collected accordingly. ll experiments were carried out on campus in the department gym to prevent safety hazards during transportation. The campus gym has multiple first-aid kits available and has alarms to establish instant contact with the campus infirmary if there are sudden injuries. Preparation activities were done before the actual experiment to prevent accidental injury and the influence of body poses on the heart rate (the sudden change of body pose from sitting to standing may cause an increase in heart rate for up to 20 seconds).[1] All participants were notified that they could withdraw from the experiment immediately if they felt uncomfortable. Participants in this experiment were all voluntary and were given the right to withdraw from this

study anytime they wanted. They were also asked to consider their fitness conditions before enrolling in this study. Experiments were conducted according to the participant's schedules not to distract them from their personal work. All participants agreed to the terms and conditions before starting the study.All data about participant's BMI data are kept anonymous. Lights were kept turned off in the gym during the daytime, and elliptical machines were shut down as soon as the experiment finished.

RESULTS

All the data collected were then analyzed and evaluated statistically. According to the data, the time taken for the participants to reach the maximum heart rate decreases from BMI 18.01 - 21.127 (male), and 17.39 - 22.61 (female). The rate of this decrease represents absolute values of the gradient of the tangents of the regression curves. However, an increase was observed in the time taken, as shown in Fig. 2. The total increment in heart rate increases in an illustrative manner from BMI 18.01 - 26.19 (male) and 17.39 - 20.16 (female) (Fig 1 and 2).

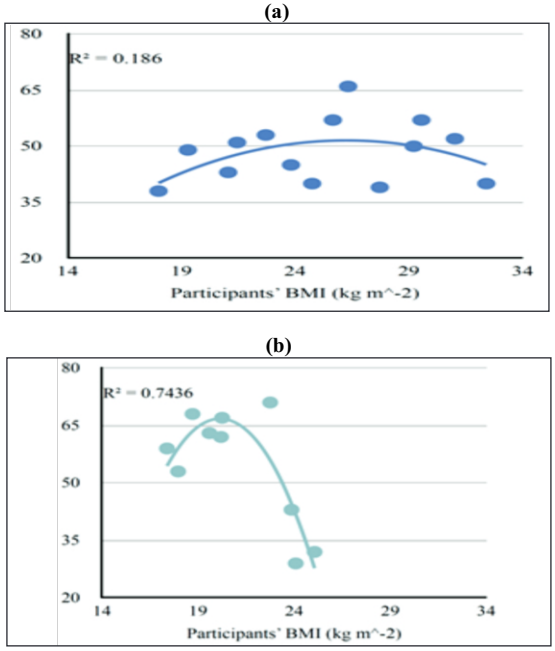


Fig 1: The representation of increment/decrease of heart rate at diffent BMI. (A) BMI of male participants and change in heart rate (min to max). (B) BMI of female participants and change in heart rate (min to max).

An enormous total increase in heart rate between BMI 18.01 - 21.13 (male) and 17.39 - 20.16 (female) is accompanied by reduced total time to reach the maximum heart rate, indicating an increasing rate of increase in heart rate during fitness activities among BMI 18.01 - 21.13 (male) and 17.39 - 20.16 (female). The maximum heart rate increase appears at around BMI 21.13 (male) and 20.16 (female). However, among participants with larger BMIs, decreasing change in heart rate is accompanied by extended time to reach the maximum heart rate, indicating a decreasing rate of heart rate increment, which is not providing evidence for the previous research [1, 8].

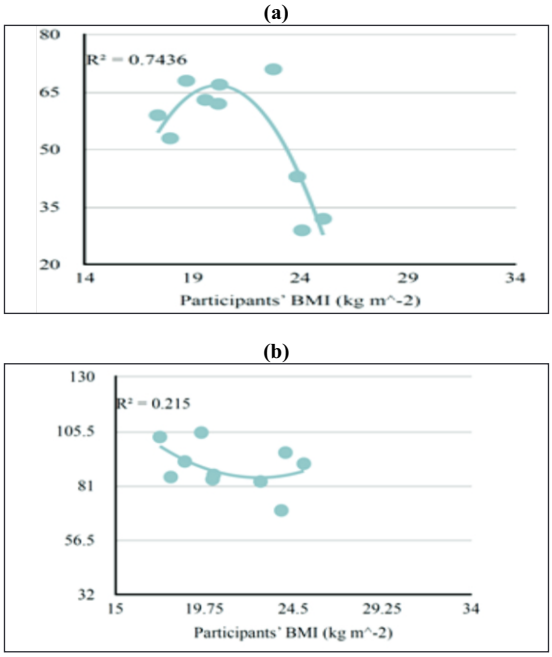
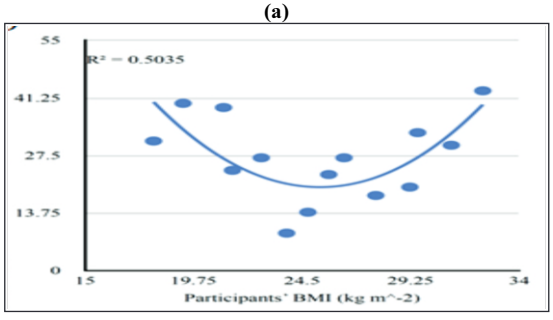


Fig 2: The representation of time for maximum heart rate and BMI (a) BMI of male participants and time taken to reach the maximum heart rate. (b) BMI of female participants and time taken to get the maximum heart rate

The HRrecovery reflects the effect of PNS reactivation and is usually measured 1 minute after the termination of fitness training. As shown in Fig. 4(a), the male and female participants illustrate a different trend in 1-minute recovery. For male participants, 1-minute recovery was recorded with a gradual decrease between BMI of 18.01 and 25.27. After that, a steady increase was documented from BMI 25.27 to 32.41.



(b)

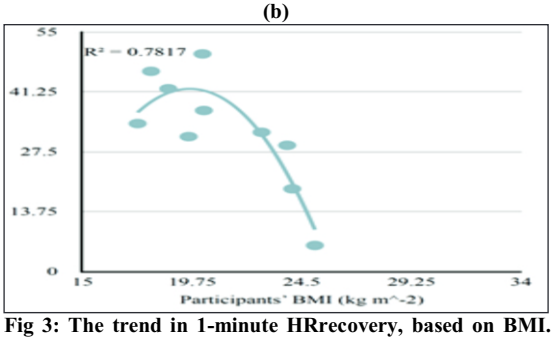
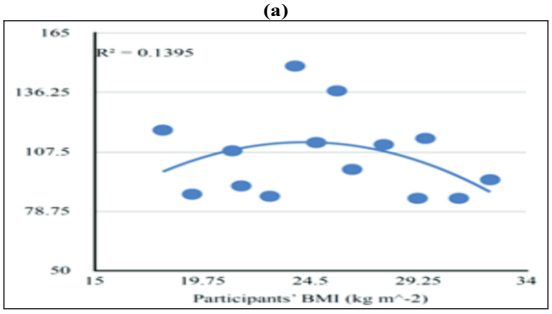


Fig 3: The trend in 1-minute HRrecovery, based on BMI. (a) Scatterplot on BMI of male participants and 1-minute heart rate recovery. (b) Scatterplot on BMI of female participants and 1-minute heart rate recovery.

On the other hand, the female participants show a parabolic increase in 1-minute heart rate recovery with a BMI range of 17.39 to 19.64 rather than decreasing like the male counterparts. However, in the BMI range of 19.64 to 25.07, the 1-minute recovery decreases illustratively, with no further increase in female participants (Fig. 3(b)). By comparing the result of 1-minute heart rate recovery (Fig. 3(a)) and final HRrecovery of male participants (Fig. 4(a)), it was found that male participants with a BMI of around 25 have the most negligible recovery in one minute and take the most time to recover to their resting rate. In contrast, a weak correlation was observed between BMI and total recovery time for female participants (Fig. 4(b)). However, the trend still suggests that around BMI 20, the total time reaches the minimum when 1-minute recovery reaches the maximum. The data also suggests a positive trend among male participants HRrecovery and BMI (Fig. 3 and 4). The HRrecovery first decreases in an illustrative manner till a BMI of ~25, and then an increasing trend has been observed. However, in female participants, the recovery rate increases until BMI ~20 and decreases in an illustrative manner.

(a)



(b)

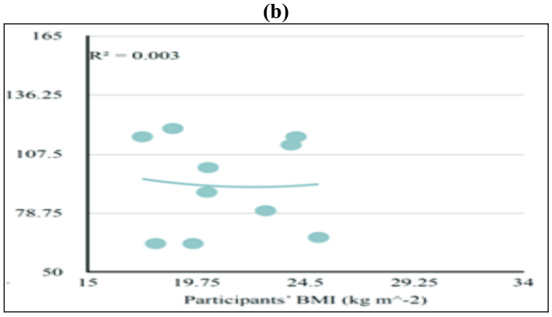


Fig 4: Final HRrecovery and trend in BMI (a) BMI of male participants and total time is taken for heart rate recovery. (b) BMI of male participants and total time is taken for heart rate recovery.

However, despite the trend lines showing the correlated data trends, the coefficient of determination is sometimes too small to indicate a validated causation relationship between BMI and the other factor.

Table 1: Experimental Groups Arrangement

Group #	Sex	BMI Interval (Uncertainty)	P-No	P-Code	BMI (kg/m2) in 2 s.f
Group 1	Female	16 ≤ BMI < 18	02	F1	17.39
				F2	17.97
Group 2	Female	18 ≤ BMI < 20	02	F3	19.60
				F4	18.72
Group 3	Female	20 ≤ BMI < 22	02	F5	20.20
				F6	20.26
Group 4	Female	22 ≤ BMI < 24	02	F7	23.87
				F8	22.76
Group 5	Female	24 ≤ BMI < 26	02	F9	24.09
				F10	25.07
Group 6	Male	18 ≤ BMI < 20	02	M1	18.01
				M2	19.30
Group 7	Male	20 ≤ BMI < 22	02	M3	21.46
				M4	21.07
Group 8	Male	22 ≤ BMI < 24	02	M5	23.83
				M6	22.72
Group 9	Male	24 ≤ BMI < 26	02	M7	24.76
				M8	25.67
Group 10	Male	26 ≤ BMI < 28	02	M9	27.73
				M10	26.34
Group 11	Male	28 ≤ BMI < 30	02	M11	29.22
				M12	29.56
Group 12	Male	30 ≤ BMI < 32	02	M13	31.03
				M14	32.41

Where P represent the participants

DISCUSSION

This experiment was meant to discuss the relationship between BMI and HR increase and recovery. As HR is a crucial health factor, it could be the base of the discussion on the effect of obesity and being too thin on human bodies. Additionally, the rate of HR increment and HRrecovry can also be the factors that may be used to assess the intensity and effectiveness of specific physical exercises. This is the first study scrutinizing the role of body mass index on heart rate increment and heart rate recovery. Our research didn't derive the same trend between BMI and heart rate compared to previous studies, which demonstrated a positive correlation between obesity and max heart rate.[11,12,13,14] However, a larger BMI is one indicator of obesity: The participants with larger BMIs (male/female) tend to show minor HR increments than those with medium-to-high BMIs. This irregularity is likely caused by stress levels and irregular sleeping patterns that boost the HR of those with relatively lower BMIs.[15,16] According to the data, for male participants below BMI 21.13 and female participants below BMI 20.16, their heart rate increases as BMI increases, which fits the original hypothesis. Similar results were reported by other studies as well.[17,18] However, a parabolic decreasing trend was noted from BMI of 21.13 (male) and 20.16 (female) to the maximum BMI. Regarding the HRrecovry, male and female participants' data show a differing trend: for the male, there is a decrease in HRR rate till BMI ~25, and then an increase till the maximum BMI, while the female participants showed a rise to BMI ~20 and then decreased.

LIMITATION

To derive a more robust relationship between BMI, HR increment, and HRrecovry, the number of participants should be increased in future studies. The increased number of participants will reduce the effect of the external environment, stress levels, and menstrual cycles on the HR trends. The atmosphere in which participants rest after fitness exercises could be better managed to avoid other factors that influence HR: for example, chatting with other participants may induce excitement and cause HR increment, further delaying HRR. Further studies can be established to discuss the optimal exercise intensity or the extent to which one physical activity is effective for one particular BMI range.

CONCLUSION

Our results experiment concluded a non-significant correlation between BMI and HRrecovry, the coefficient of determination is too small ($R2 = 0.1395$ for males and $R2 = 0.003$ for females) to indicate the causation between BMIs and HRrecovry. Thus BMI should not be used as the cofactor or risk for heart activity or impaired functions.

CONFLICT OF INTEREST: None

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