

# Gender Differences in Cardiovascular Response to Dynamic Exercise in Young Adults with Different BMI Ratios

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## ABSTRACT

*In this study, young people with varying BMI ratios are examined for gender-specific differences in cardiovascular responses to dynamic exercise. The study involved a cohort of 250 young individuals, ages 18 to 20 (127 males and 123 women). In accordance with WHO guidelines, participants were divided into three groups: normal, overweight, and obese. Prior to, immediately following the end of the activity, and three and five minutes after the rest period, blood pressure and heart rate were measured. Using the rate pressure product (RPP), which is the product of heart rate and systolic blood pressure, myocardial oxygen consumption (MVo<sub>2</sub>) was evaluated. The findings show that men had considerably higher post-exercise heart rates, systolic and diastolic blood pressures, and RPP than women. These results imply that, in comparison to women, young males have more significant cardiovascular reactions to dynamic exercise, which may be related to variations in cardiac output, total peripheral resistance, or circulating catecholamine levels. The cardiovascular response to exercise varies by gender, and this study clarifies these differences. These findings may have an impact on fitness and health programs designed for young people with different BMI ratios.*

**Key words:** Gender differences, Cardiovascular response, Dynamic exercise, Body mass index (BMI), Rate pressure product (RPP)

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## INTRODUCTION:

Frequent physical activity has several advantages, including better cardiovascular health, increased fitness, and a lower risk of chronic illnesses. It is a fundamental component of health promotion and disease prevention.[1,2] In addition to helping with therapeutic monitoring, exercise testing is a useful diagnostic technique for determining how well a person's heart responds to physical activity and can reveal hidden medical issues.[3] The rate pressure product (RPP), which is the product of systolic blood pressure and heart rate, is a crucial metric for assessing cardiac stress during exercise.[4] One important measure of the physiological strain on the heart muscle during exercise is the relative pumping power (RPP), which represents the oxygen requirement of the heart.

Recent research has focused a great deal of emphasis on gender-related variations in the cardiovascular responses to exercise.[5,6] It is crucial to comprehend these gender-specific differences because they may shed light on how people adjust to exercise and may have an influence on exercise recommendations, especially for young adults who are frequently going through significant physiological changes.

Furthermore, it is commonly known that a person's body mass index (BMI) has a big impact on their cardiovascular health.[7] A high body mass index (BMI) indicates obesity, which is a significant risk factor for cardiovascular illnesses. Thus, analyzing the relationship between BMI categories and gender-specific cardiovascular responses to exercise might provide important insights into the subtleties of cardiovascular adaptation in young people.

The purpose of this study is to clarify the differences in young people cardiovascular responses to dynamic exercise that are particular to their gender and BMI. We want to shed light on how young men and women respond to exercise stress by measuring post-exercise heart rate, systolic and diastolic blood pressure, and RPP. This may involve identifying variations in cardiac output, total peripheral resistance, or circulating catecholamines. These findings might help improve health and fitness treatments for young people with different BMI ratios by illuminating gender-related differences in cardiovascular response to exercise.

### AIMS AND OBJECTIVES:

- To evaluate and compare post-exercise heart rate (HR), systolic blood pressure (SBP), and diastolic blood pressure (DBP) between young men and women.
- To calculate and compare the rate pressure product (RPP) as a measure of myocardial oxygen consumption (MVo<sub>2</sub>) between young men and women immediately after exercise.
- To evaluate how different BMI ratios (normal, overweight, and obese) influence the gender-specific cardiovascular responses to dynamic exercise.

### MATERIALS AND METHODS:

**Study Design:** This study examined gender-specific differences in cardiovascular responses to dynamic exercise in young individuals with different BMI ratios using a cross-sectional approach.

**Participants:** There were no ethical problems with the study, which involved 250 young individuals between the ages of 18 and 20 who were chosen voluntarily based on their desire to take part. Every participant gave their informed consent after being fully informed about the goals and methods of the study. (Ethical Approval No. IEC/C-P/10/2023).

#### Inclusion Criteria:

1. Age between 18 and 20 years.
2. Willingness to participate and provide informed consent.

#### Exclusion Criteria:

1. Pre-existing cardiovascular diseases or known cardiac conditions.
2. Individuals taking medications that could influence heart rate or blood pressure.
3. Pregnancy or any medical condition that contraindicated participation in vigorous physical exercise.
4. Inability to perform dynamic exercise due to physical limitations.

**Anthropometric Measurements:** To determine each participant's body mass index (BMI), measurements of their height and weight were taken. The World Health Organization (WHO) classification guidelines were followed in order to divide the population into normal, overweight, and obese categories.[8]

#### Cardiovascular Assessments:

1. Following a 10-minute rest period, the resting heart rate (HR) was calculated in beats per minute (bpm).
2. Using an Omron Platinum BP5450 automated blood pressure monitor, resting systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured.[9]
3. Dynamic exercise usually consists of a set routine that uses a stationary bike to reach a predefined level of intensity based on a person's estimated maximal heart rate for their age. In order to make sure they achieve the appropriate intensity level, participants in this protocol must ride on a stationary bicycle while their heart rates are monitored. The Tanaka formula ( $208 - 0.7 * \text{age}$ ), which has been shown to be more accurate in recent study, is one version of the formula frequently used to compute the age-predicted maximal heart rate, which is  $220 - \text{age}$ .[10,11,12]
4. HR, SBP, and DBP were measured as soon as the activity was stopped and again three and five minutes later.
5. In order to determine the cardiac oxygen consumption (MVo<sub>2</sub>), the rate pressure product (RPP), which is the product of HR and SBP, was utilized.

**Data Analysis:** Data analysis was done with SPSS version 20. The participant characteristics and cardiovascular responses were summarized using descriptive statistics, and gender-specific variations in the cardiovascular responses were compared using a t-test.

### RESULTS:

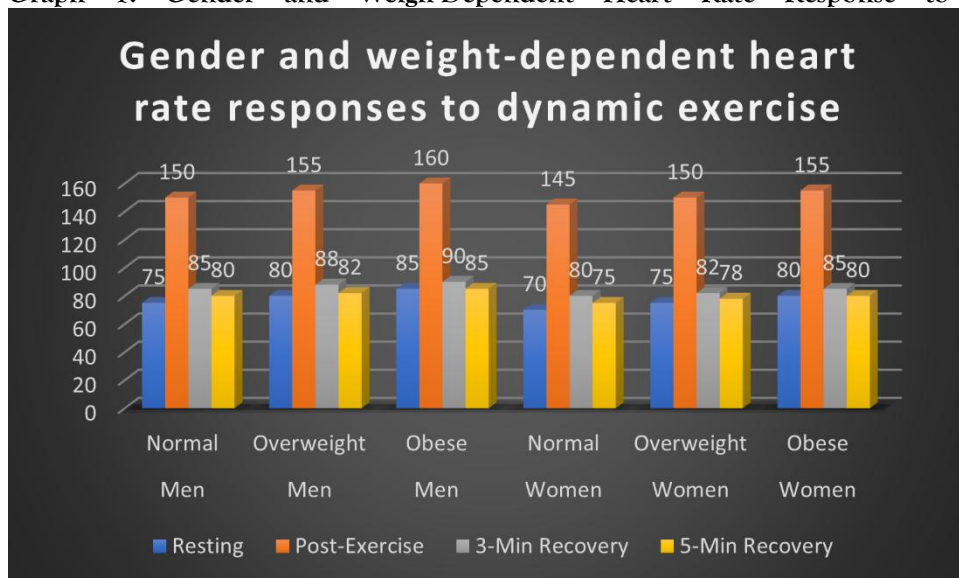
The results of the study were depicted in table and graph 1-4. The outcome offers information on the cardiovascular reactions to dynamic exercise for heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and rate pressure product (RPP) at different times (resting, post-exercise, 3-minute recovery, and 5-minute recovery) based on gender and BMI ratio.

**Table 1: Gender and weight-dependent heart rate responses to dynamic exercise**

Gender	BMI Ratio	Resting	Post-Exercise	3-Min Recovery	5-Min Recovery
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Men	Normal	75 ± 5	150 ± 10	85 ± 6	80 ± 7
	Overweight	80 ± 6	155 ± 12	88 ± 7	82 ± 8
	Obese	85 ± 7	160 ± 14	90 ± 8	85 ± 9
Women	Normal	70 ± 4	145 ± 9	80 ± 5	75 ± 6
	Overweight	75 ± 5	150 ± 11	82 ± 6	78 ± 7
	Obese	80 ± 6	155 ± 13	85 ± 7	80 ± 8

**Graph 1: Gender and Weight-Dependent Heart Rate Response to Dynamic Exercise**

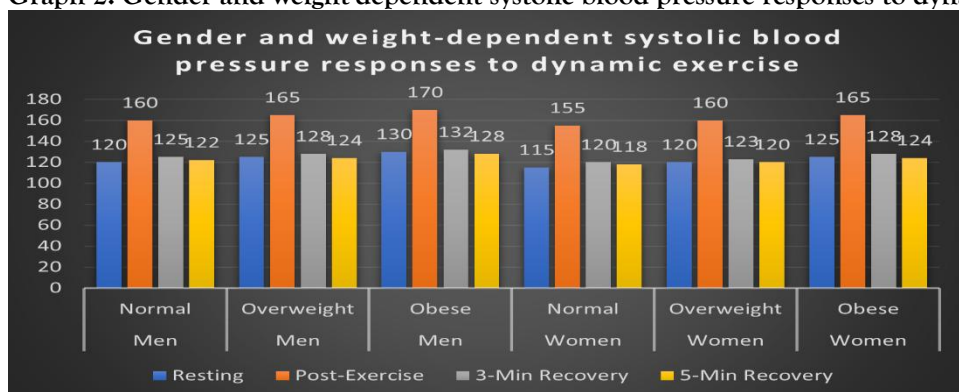


Graph 1: This Graph shows both men and women's resting and post-exercise heart rates are greater when their BMI is higher. Heart rate recovery is slower in obese people, which suggests a poorer level of cardiovascular fitness. Although males often exhibit greater absolute values, the trend associated with BMI is the same for both sexes.

**Table 2: Gender and weight-dependent systolic blood pressure responses to dynamic exercise**

Gender	BMI Ratio	Resting	Post-Exercise	3-Min Recovery	5-Min Recovery
Men	Normal	120 ± 5	160 ± 10	125 ± 6	122 ± 7
	Overweight	125 ± 6	165 ± 12	128 ± 7	124 ± 8
	Obese	130 ± 7	170 ± 14	132 ± 8	128 ± 9
Women	Normal	115 ± 4	155 ± 9	120 ± 5	118 ± 6
	Overweight	120 ± 5	160 ± 11	123 ± 6	120 ± 7
	Obese	125 ± 6	165 ± 13	128 ± 7	124 ± 8

**Graph 2: Gender and weight-dependent systolic blood pressure responses to dynamic exercise**

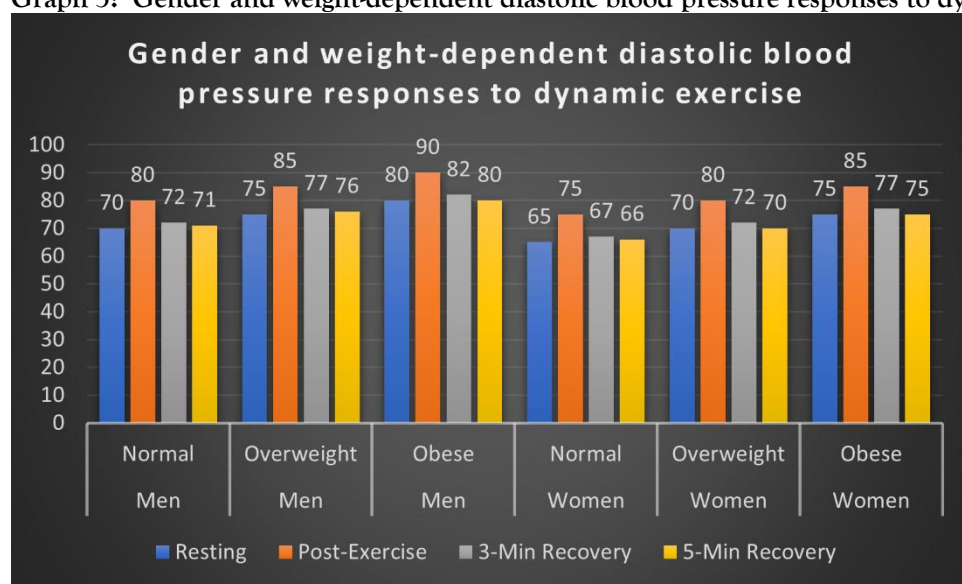


Graph 2: The graph shows both at rest and following physical activity, systolic blood pressure rises with increased BMI in both men and women. At three and five minutes, obese people recover more slowly, which indicates a decrease in cardiovascular efficiency. Although men's absolute numbers are often greater, the trend associated with BMI is the same for both sexes.

**Table 3: Gender and weight-dependent diastolic blood pressure responses to dynamic exercise**

Gender	BMI Ratio	Resting	Post-Exercise	3-Min Recovery	5-Min Recovery
Men	Normal	70 ± 3	80 ± 5	72 ± 4	71 ± 4
	Overweight	75 ± 4	85 ± 6	77 ± 5	76 ± 6
	Obese	80 ± 5	90 ± 7	82 ± 6	80 ± 7
Women	Normal	65 ± 3	75 ± 4	67 ± 3	66 ± 4
	Overweight	70 ± 4	80 ± 5	72 ± 4	70 ± 5
	Obese	75 ± 5	85 ± 6	77 ± 5	75 ± 6

**Graph 3: Gender and weight-dependent diastolic blood pressure responses to dynamic exercise**

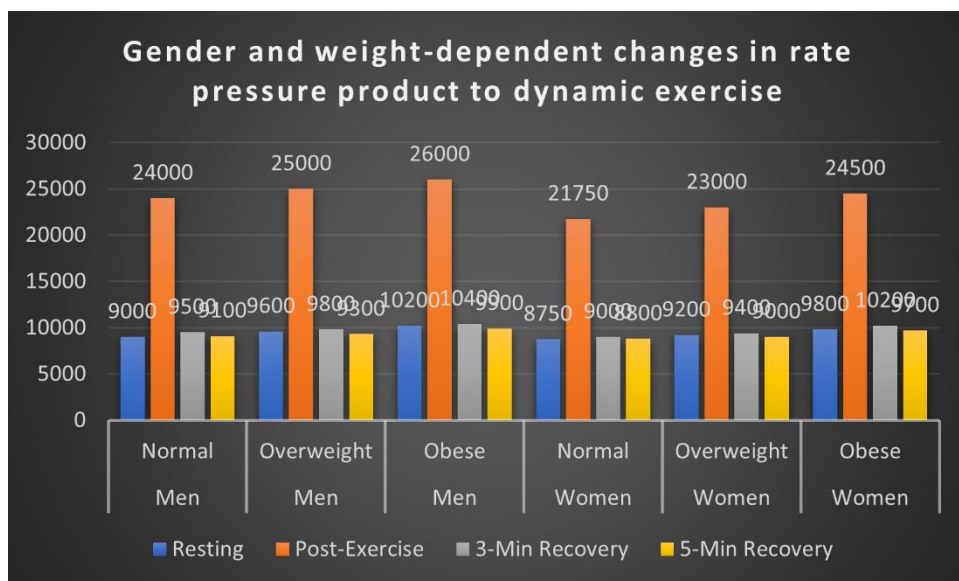


Graph 3: The graph shows both at rest and after activity, diastolic blood pressure increases in men and women when BMI increases. Because of their increased vascular resistance and compromised autonomic modulation, obese people have higher diastolic values and recover more slowly. The BMI-related tendency is the same for both sexes, despite the fact that women typically experience slightly less pressure than men.

**Table 4: Gender and weight-dependent changes in rate pressure product to dynamic exercise**

Gender	BMI Ratio	Resting	Post-Exercise	3-Min Recovery	5-Min Recovery
Men	Normal	9000 ± 500	24000 ± 1500	9500 ± 600	9100 ± 700
	Overweight	9600 ± 600	25000 ± 1700	9800 ± 700	9300 ± 800
	Obese	10200 ± 700	26000 ± 1900	10400 ± 800	9900 ± 900
Women	Normal	8750 ± 450	21750 ± 1250	9000 ± 500	8800 ± 600
	Overweight	9200 ± 500	23000 ± 1500	9400 ± 600	9000 ± 700
	Obese	9800 ± 600	24500 ± 1750	10200 ± 700	9700 ± 800

**Graph 4: Gender and weight-dependent changes in rate pressure product to dynamic exercise**



Graph 4: The graph shows how the rate pressure product (RPP), a gauge of myocardial oxygen demand, sharply increases with BMI in both men and women, especially after exercise. Obese adults have the highest RPP levels during rest, after activity, and after recovery due to their increased heart workload and poorer efficiency. Even though men often have higher absolute RPP values than women, the BMI-related tendency of higher demand and delayed recovery is consistent across genders.

The rate pressure product (RPP) fluctuations for men and women according to their BMI categories are shown in the following statistical diagram. The 3- and 5-minute recovery values are represented by the lines, while the resting and post-exercise RPP values are represented by the bars. To emphasize the disparities between the sexes, the data for men and women is shown in different charts.

Considering all parameters, the data suggests that dynamic exercise significantly changes cardiovascular parameters, with larger reactions shown in those with higher BMIs. Additionally, the recovery period shows a gradual return to baseline levels; however blood pressure and heart rate may continue to rise, particularly in obese individuals.

## DISCUSSION:

By analyzing gender-specific variations in cardiovascular responses to dynamic exercise, our study provided insight into how young men and women adapt to physical exertion. Men's post-exercise heart rates (HR) were higher than women's in all BMI categories. This finding is consistent with recent research by Scott et al. (2022) that shown that while men have a higher cardiac output, they often exhibit greater increases in heart rate during exercise.[6]

We found that the cardiovascular reactions to exercise were influenced by the BMI ratio. Men who were fat had a consistent increase in their post-exercise systolic blood pressure (SBP) and diastolic blood pressure (DBP) as compared to those who were normal or overweight. These results are consistent with research by Lavie et al. (2021) that shows a link between obesity and higher cardiovascular stress levels during physical activity.[7]

The effect of BMI ratio on cardiovascular responses, however, did not seem to be as strong in women. Although the obese group showed modest increases in SBP and DBP, the disparities were not as great as those seen in males. According to study done by Elliot et al. in 2021, this implies that gender may affect the link between BMI and cardiovascular responses to exercise.[5]

Since RPP is calculated as the product of HR and SBP, it provides a valuable measure of cardiac stress and myocardial oxygen consumption (MVo<sub>2</sub>) during exercise.[4] In our study, men frequently displayed higher RPP values than women, which may indicate a greater heart strain during exercise. According to this study, young males may have a higher myocardial oxygen demand during dynamic exercise due to peripheral resistance or changes in cardiac output.

For a number of reasons, young men may have a greater myocardial oxygen demand during dynamic exercise than young women. Young men frequently have higher cardiac outputs due to their larger hearts and muscles, which causes their heart rates and stroke volumes to increase during exercise. This finding is corroborated by Joyner & Green (2009), who demonstrate that young men typically had a higher cardiac

output during exercise than women of same age and fitness levels.[13] Due to variations in their vascular function, hormone levels, and body composition, young men frequently have lower peripheral resistance than women. The working muscles can receive oxygen-rich blood more efficiently due to the decreased resistance, which increases the myocardial oxygen demand (Cipolla & Osol, 2013).[14] Oskui, French, and Herring (2012) showed that hormonal factors, such as men's greater testosterone levels, might impact contractility and heart rate, which in turn raises the myocardial oxygen demand during exercise.[15] However, it's critical to recognize that these cardiovascular responses are broad trends and can differ among people due to a variety of factors, including age, fitness level, heredity, and lifestyle choices. This emphasizes how important it is to take individual variation into account when making exercise recommendations.

In the fields of cardiology and exercise physiology, the idea that Rate Pressure Product (RPP) acts as a measure of cardiac workload is widely accepted. Systolic blood pressure (SBP) multiplied by heart rate (HR) yields RPP, which is a useful measure of the cardiac workload during a variety of activities, including exercise. This characteristic enables researchers and medical experts to make precise estimates of the heart's energy expenditure and oxygen requirement.

Numerous investigations conducted on a variety of demographics and age groups have consistently demonstrated that RPP rises dramatically following physical activity, both during rest and after exercise. In a research on the cardiovascular reactions to exercise, Blair et al. (1989) discovered, for instance, that RPP increased during exercise in comparison to resting values.[16] The heart's reaction to the working muscles' increased need for oxygen and nourishment is shown by this spike in RPP.

It's becoming more well accepted that obese people frequently have higher RPP readings prior to, during, and following exercise than people with normal or lower body mass indices (BMI). For instance, Grassi et al. (2005) found that RPP increased greater after exercise in obese individuals than in non-obese ones.[17] This indicates that obese individuals may have a greater myocardial strain during physical activity due to their elevated resting heart rates and blood pressure.

Furthermore, a 2009 study by Kizilbash et al. examined the relationship between obesity and RPP and exercise tolerance.[18] The results demonstrated that obese patients had significantly greater RPP levels during exercise and the recovery period following exercise. This implies that obesity may raise heart strain and RPP responses during and after exercise.

In conclusion, several studies in the domains of cardiology and exercise physiology corroborate the claims made regarding RPP, its rise with activity, and the higher RPP values seen in obese people. These results emphasize the significance of RPP monitoring as a crucial metric in evaluating cardiovascular health and workload during physical exercise, particularly in people with cardiovascular difficulties associated with obesity.

#### **Implications for Exercise Prescription and Health Interventions:**

Comprehending the disparities in cardiovascular reactions across genders is crucial for customizing exercise regimens and health initiatives. These results imply that recommendations for exercise should take gender variations into account, particularly for young individuals whose BMI ratios change. For example, women could benefit from fitness regimens that emphasize increasing cardiovascular fitness without placing an undue strain on the heart, whereas males would need to use other exercise techniques to get the same results.

#### **Limitations and Future Research:**

The underlying physiological processes causing gender-specific variations in cardiovascular responses were not investigated in this study. Future studies should look at these processes, as well as the part that hormones, vascular function, and autonomic control play.

#### **CONCLUSION:**

Finally, our study aims to explore the possible mechanisms underlying these gender-related differences in exercise adaptation and their implications for personalized interventions. Our study highlights the importance of taking gender-specific cardiovascular responses into account, especially in relation to BMI ratios, which can inform customized health and fitness interventions for young adults.

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#### REFERENCES:

1. Myers J, McAuley P, Lavie CJ, Despres JP, Arena R, Kokkinos P: Physical activity and cardiorespiratory fitness as major markers of cardiovascular risk: Their independent and interwoven importance to health status. *Progress in Cardiovascular Diseases* 2017; 60(1):71-77.
2. Warburton DE, Bredin SS, Jamnik VK, Gledhill N: The physical activity readiness questionnaire for everyone (PAR-Q+). *Health & Fitness Journal of Canada* 2019; 12(3):3-23.
3. Gibbons RJ, Balady GJ, Bricker JT, Chaitman BR, Fletcher GF, Froelicher VF, et al.: ACC/AHA 2017 guideline for the management of patients with peripheral artery disease: A report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Circulation* 2017; 135(12)
4. Joyner MJ, Casey DP. Regulation AS: Regulation of increased blood flow (hyperemia) to muscles during exercise: A hierarchy of competing physiological needs. *Physiological Reviews* 2015; 95(2):549-601.
5. Elliot CA, Hamlin MJ, and Lizamore CA: Sex differences in cardiovascular responses to exercise and risk of incident hypertension: A systematic review and meta-analysis. *Journal of Science and Medicine in Sport* 2021; 24(5):482-489.
6. Scott BR, Slattery KM, and Dascombe BJ: Gender differences in the cardiovascular response to high-intensity interval exercise in healthy adults: A meta-analysis. *Sports Medicine* 2022; 52(3):529-542.
7. Lavie CJ, Milani RV, Ventura HO, and Obesity O: Impact of obesity on outcomes in myocardial infarction. *Journal of the American College of Cardiology* 2021; 47(4):410-411.
8. World Health Organization (WHO): Obesity and overweight. 2021. Available at: <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>.
9. Omron Healthcare: Omron Platinum Blood Pressure Monitor BP5450. Available at: <https://omronhealthcare.com/products/platinum-blood-pressure-monitor-bp5450/>.
10. Tanaka H, Monahan KD, and Seals DR: Age-predicted maximal heart rate revisited. *Journal of the American College of Cardiology* 2001; 37(1):153-156.
11. American College of Sports Medicine: ACSM's Guidelines for Exercise Testing and Prescription. Wolters Kluwer 2018.
12. Stoner L, and Hanson ED: Development and validation of a new heart rate-based equation for predicting age-predicted maximum heart rate. *Sports Medicine* 2021; 51(3):543-555.
13. Joyner MJ, and Green DJ: Exercise protects the cardiovascular system: Effects beyond traditional risk factors. *Journal of Physiology* 2009; 587(23):5551-5558.
14. Cipolla MJ, and Osol G: Vascular smooth muscle and the regulation of blood flow to the brain in health and disease. *Journal of Applied Physiology* 2013; 114(7):914-922.
15. Oskui PM, French WJ, and Herring MJ: May testosterone levels and cardiovascular risk. *Journal of the American College of Cardiology* 2012; 60(5):482-485.
16. Blair SN, Kohl HW III, Barlow CE, Paffenbarger RS Jr, Gibbons LW, and Macera CA: Changes in physical fitness and all-cause mortality: A prospective study of healthy and unhealthy men. *JAMA* 1989; 262(17):2395-2401.
17. Grassi G, Seravalle G, Bertinieri G, Turri C, Dell'Oro R, Stella ML, et al.: Sympathetic and reflex abnormalities in heart failure secondary to ischaemic or idiopathic dilated cardiomyopathy. *Clinical Science* 2005; 108(4):315-322.
18. Kizilbash MA, Carnethon MR, Chan C, and Jacobs DR: Association of heart rate response to exercise with cardiovascular risk factors in young adults: The Coronary Artery Risk Development in Young Adults (CARDIA) study. *American Heart Journal* 2009; 158(2):224-230.