

Heart Rate and Blood Pressure Responses to Exercise Testing in Relation to Age in Healthy Men

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ABSTRACT:

BACKGROUND:

There are many circulatory changes that occur during exercise including the stimulatory effects on the circulation by the mass sympathetic discharge, the increased arterial pressure and cardiac output.

OBJECTIVE:

To investigate the effect of aging process on the heart rate and blood pressure responses during exercise in normal Iraqi male subjects.

METHODS:

The subjects involved in the study were normal healthy people, their total number was 80 persons all of them were males. They were grouped into three age groups; $20 \leq 29$ years, $30 \leq 39$ years and $40 \leq 50$ years. Each subject performed the exercise on motor driven treadmill device. Testing was conducted at The Medical City Teaching Hospital-Treadmill and Echo unit. Blood pressure was measured indirectly by auscultation. The heart rate was determined by ECG.

RESULT:

There was a significant differences in heart rate after the exercise between the three age groups, a significant differences in systolic blood pressure after the exercise between group2 and group3 was also noted, a non significant decrease in diastolic blood pressure among the three age groups and there was a significant increase in mean blood pressure between group2 and group3.

CONCLUSION:

There was a negative linear correlation between heart rate after the exercise and increasing age, while a positive linear correlation between systolic blood pressure and increasing age was found and there was a positive linear correlation between age and the mean blood pressure after the exercise.

KEY WORDS: age, exercise, heart rate, blood pressure.

INTRODUCTION:

The ability to impact the environment is dependent on our capacity for physical activity and movement represent more than just a convenience, it is fundamental for our evolutionary development not less important than the complexities of intellect and emotion⁽¹⁾.

Moreover, there are no other normal stresses to which the body is exposed that even nearly approach the extreme stresses of heavy exercise. In fact, some of the exercises were continued for prolonged periods, they might be lethal⁽²⁾.

There are many circulatory changes that occur during exercise to supply the tremendous blood flow required by the muscles including the stimulatory effects on the circulation by the mass sympathetic discharge, the increased arterial pressure and cardiac output. These cardiovascular responses could vary between children, adults, and elderly normal people due to the age related effects on the heart, as well as, on the circulatory system⁽³⁾.

The most common modes of exercise stress testing include multistage bicycle and treadmill tests, the test graded for exercise intensity, includes submaximal levels of three to four minutes duration each, progressing up to a self imposed level, for safety reasons, the test need not to be maximal, instead, the person exercises to at least 85% of age predicted maximum heart rate. The resting ECG usually proceeds the test and provides an important baseline measure to establish that the person can engage safely in the test⁽¹⁾.

An age associated diminution in the effectiveness of sympathetic modulation of the cardiovascular response to exercise could contribute to many of the changes identified in the cardiovascular response to exercise in healthy older humans, including the decline in maximum heart rate, the increases in left ventricular end- diastolic and end-systolic volume indices, and decreased ejection fraction and left ventricular contractility⁽⁴⁾.

SUBJECTS AND METHODS:

The subjects involved in the study were normal healthy people, their total number was 80 persons all of them were males (friends,relatives and medical staff working in the hospital). They were

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grouped into three age groups: Group 1 (20≤ 29years), Group 2 (30≤ 39years) and Group 3 (40≤ 50years).

A complete medical history was taken from each subject and any subject having the following exclusion criteria was excluded from the study: (1) Previous history of any symptoms suggesting coronary heart disease like chest pain or chest tightness or dyspnea on exertion. (2) Asthma. (3) Smoking. (4) History of neurological or musculoskeletal disorders. All subjects were examined by specialist physician in the outpatient clinic including measuring of the body temperature, heart rate and blood pressure. Testing was conducted at The Medical City Teaching Hospital-Treadmill and Echo unit. Using motor driven treadmill device (Exercise testing system, Marquette 2000, Marquette Electronics, USA) in the upright position, the measurement of the maximal exercise capacity was done and, in this study, we applied the Bruce (modified) Protocol for treadmill testing. Blood pressure was measured indirectly by auscultation (listening to sounds) described in 1902 by Russian physician N.S.Korotkoff, using a stethoscope and sphygmomanometer (SK-MINIATUR300B-Germany) consisting of a blood pressure cuff and a mercury column pressure gauge. Both systolic and diastolic blood pressure was recorded in mmHg before and immediately after the test in the recovery period. Also the mean blood pressure was calculated using the following formula: Mean BP. = Diastolic BP. + 1/3 Pulse pressure. Pulse pressure = Systolic BP. – Diastolic BP. Heart rate was determined by ECG using the standard R-R method; the R-R interval indicate the time between successive R waves, an approximate heart rate in beats per minute can be determined by dividing 1500(60 sec*25 mm/sec) by the number of mm between adjacent R-waves.

Statistical analysis:

The arithmetic mean and standard deviation of distribution of each set of the data were calculated. The paired student (t) test was used to compare variables in the same group and the unpaired t-test was used to compare variables of different groups. The level of statistical significance was defined as

P value <0.05, which was obtained by comparing the calculated t-value to the tabulated t-value at 95% confidence interval. Regression analysis was chosen as a statistical tool to investigate the effect of age on the measured parameters and to find the correlation. Simple linear regression was used and the correlation coefficient (r) was calculated. Analysis of variance (ANOVA) was done to test the variation significance for each parameter between the different age groups. The post Hoc tests procedure (LSD) was used for multiple comparisons among means.

RESULT:

The mean heart rate (HR) results are presented in table (1) showing significant statistical differences in the mean heart rate after the exercise (HR-A) between group 1 & 2, and between group 1 & 3 (P< 0.05).

The negative linear correlation between age in years and the heart rate after the exercise (HR-A) is shown in figure (1).

The mean systolic blood pressure results are shown in table (2). The mean systolic blood pressure after the exercise (SBP-A) shows a significant statistical difference between group 2 and group 3 (p< 0.05).

A positive linear correlation between age in years and systolic blood pressure after the exercise (SBP-A) is shown in figure (2).

The mean diastolic blood pressure results are shown in table (3), which shows that there is a decrease in the mean diastolic blood pressure after the exercise (mean DBP-A) from the mean diastolic blood pressure before the exercise (mean DBP-B) in all the three groups, but without significant statistical difference among them.

We have calculated the mean blood pressure for each subject and the findings are shown in table (4) represented by the mean ± SD for each group. There was a significant statistical difference in the mean of blood pressure means before the exercise (mean mBP-B) between group 2 and group 3. Also there was a significant statistical difference in the mean of blood pressure means after the exercise (mean mBP-A) between group 2 and group 3. There is a positive linear correlation between age in years and mean blood pressure after the exercise (mBP-A) shown in figure (3).

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Table (1) : Mean Heart Rate Measurements

	Group 1 (N= 25)	Group 2 (N=26)	Group 3 (N=29)	Overall P value	Post hoc G1VS G2	G1VS G3	G2VS G3
Mean HR-B Beat/min	82.81 SD±11.7	83.32 SD±11.9	80.69 SD±10.4	0.633	0.542	0.73	0.646
Mean HR-A Beat/min	132.19* SD±20.7	121.21* SD±22.3	118.57* SD±28.8	0.002*	0.001*	0.004*	0.481

*Significant HR-A between group1 & group2, between group1 & group3 (P<0.05).

HR-B: Heart rate before exercise.

HR-A: Heart rate after exercise.

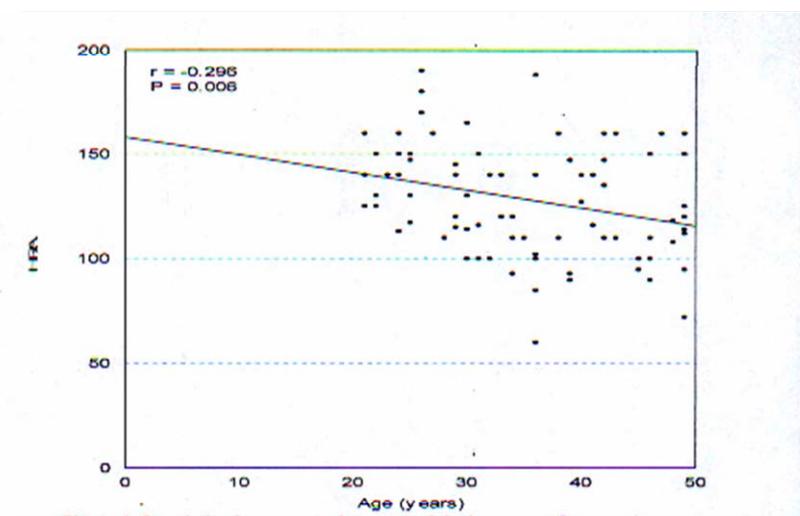


Figure 1: Correlation between age (years) and heart rate after exercise (HR-A).

Table (2): Mean systolic blood pressure (SBP) measurements.

	Group 1 (N= 25)	Group 2 (N=26)	Group 3 (N=29)	Overall P value	Post hoc G1VS G2	G1VS G3	G2VS G3
Mean SBP-B mmHg	123.98 SD± 17.5	127.29 SD± 13.7	132.25 SD± 12.6	0.082	0.068	0.072	0.12
Mean SBP-A mmHg	139.81 SD± 22.9	148.25* SD± 17.0	158.275* SD± 15.9	0.002*	0.105	0.061	0.0001*

* Significant SBP-A between group 2&3(P<0.05).

SBP-B: Systolic blood pressure before exercise.

SBP-A: Systolic blood pressure after exercise.

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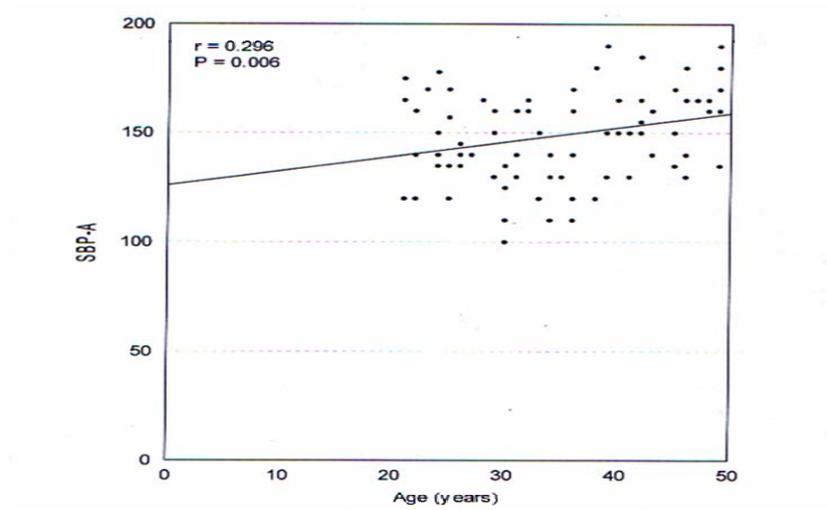


Figure 2: Correlation between age (years) and systolic blood pressure after exercise (SBP-A)

Table (3): Mean Diastolic Blood Pressure Measurements (DBP).

	Group 1 (N= 25)	Group 2 (N=26)	Group 3 (N=29)	Overall P value	Post hoc G1VS G2	G1VS G3	G2VS G3
Mean DBP-B mmHg	78.78 SD± 7.1	76.53 SD± 7.9	80.83 SD± 5.9	0.08	0.16	0.07	0.062
Mean DBP-A mmHg	73.63 SD±11.0	72.23 SD±11.3	76.81 SD± 8.1	0.242	0.21	0.08	0.14

DBP-B: Diastolic blood pressure before exercise.

DBP-A: Diastolic blood pressure after exercise.

Table (4): Mean mean Blood Pressure Measurements (mBP).

	Group 1 (N= 25)	Group 2 (N=26)	Group 3 (N=29)	Overall P value	Post hoc G1VS G2	G1VS G3	G2VS G3
Mean mBP- B /mmHg	95.83 SD± 9.9	92.28 * SD± 10.5	98.02 * SD± 6.8	0.049*	0.162	0.342	0.015*
Mean mBP- A /mmHg	98.47 SD± 11.1	94.76 • SD± 14.6	104.01• SD± 9.9	0.014•	0.259	0.094	0.004°

* Significant mBP- B between group 2& 3.

• Significant mBP- A between group 2& 3.

mBP- B: mean blood pressure before exercise.

mBP- A: mean blood pressure after exercise.

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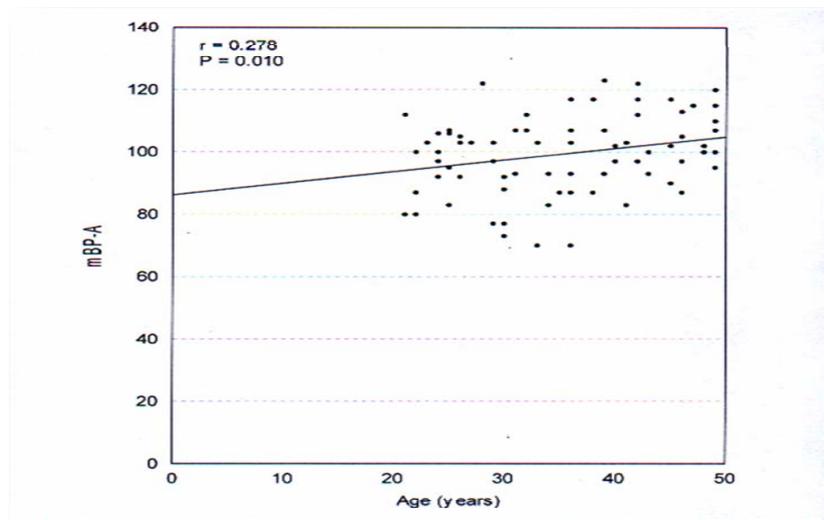


Figure 3: Correlation between age (years) and mean blood pressure after exercise (mBP-A).

DISCUSSION:

The ability of older persons to function independently is dependent largely on the maintenance of sufficient aerobic capacity and strength to perform daily activities. Whereby, peak aerobic capacity is widely recognized to decline with age⁽⁵⁾. There is therefore, a need to establish normal data for cardiovascular function in children, adult and elderly in order to differentiate age related changes from disease related alterations in cardiovascular function⁽⁶⁾. The results of this study showed that mean heart rate increased significantly post exercise in each age group (table 1), by the increased release of norepinephrine from the sympathetic nerve endings as a result of increased sympathetic outflow during exercise, the resultant alpha- receptor activation leads to constriction of both systemic and capacitance vessels outside the active muscles and the beta – receptor activation leads to an increase in heart rate and enhancement of myocardial contractility⁽⁷⁾. At exercise onset, central command increases heart rate by vagal withdrawal and resets the baroreflex to a higher blood pressure⁽⁸⁾ similar results reported by Turley and Wilmore 1997⁽³⁾, Alonso et al., 1998⁽¹⁶⁾, and Lenk et al., 1998⁽¹⁷⁾.

There was a negative linear correlation between the age and the heart rate post exercise (figure 1), the elevated levels of catecholamines contribute to desensitization to noradrenergic stimulation, and this is associated with an age-related decline in maximum achievable heart rate⁽⁹⁾ these results were in agreement with Oberman et al., 2000⁽¹⁸⁾, and Gajek et al., 2003⁽¹⁹⁾. Reductions in intrinsic

heart rate and chronotropic responsiveness to beta-adrenergic stimulation largely explain decreases in maximum heart rate with aging, with the reduction in intrinsic heart rate playing by far the greatest role⁽¹⁰⁾.

There was a significant increase in mean systolic blood pressure post exercise in each age group in this study (table 2). Wijnen et al., 1995⁽²⁰⁾, Sasaki et al., 1996⁽²¹⁾ and Finnoff et al., 2003⁽²²⁾ reported similar findings. Dynamic exercise causes an increase in arterial blood pressure due to combination of an increase in cardiac output and in total systemic vascular resistance as a consequence of increased sympathetic outflow and mechanical compression of the vessels in the active muscles and the arterial baroreceptors are reset so that they operate normally around higher blood pressure⁽⁸⁾.

This study showed that the increment in systolic blood pressure post exercise was positively correlated with age (figure 2). This result was reported also by Bjerregaard et al., 2003⁽²³⁾, O'Sullivan et al., 2003⁽²⁴⁾, Wasilewska et al., 2003⁽²⁵⁾, and Sausom et al., 2004⁽²⁶⁾ With aging, repetitive pulsations (some 30 million/year) cause fatigue and fracture of elastin lamellae of central arteries, causing them to stiffen (and dilate), so that reflections return earlier to the heart; in consequence, aortic systolic pressure rises, diastolic pressure falls⁽¹¹⁾. The primary aging change which occurs in all societies, and is represented by stiffening and dilation of the

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proximal aorta, Aortic stiffening with age is principally due to fatigue and fracture of elastin lamellae, with transfer of stress to stiffer collagenous components. Stiffening increases left ventricular load and myocardial blood requirement, but limits the capacity for blood supply during diastole⁽¹²⁾.

In this study, it has been found that diastolic blood pressure values post exercise were lower than those measured pre-exercise (table 3). Peripheral resistance at rest and comparable workloads is increased with age and may explain the diminished fall in diastolic pressure induced by age⁽¹³⁾. However O'Sullivan et al., 2003⁽²⁴⁾ showed that there was no correlation between age and diastolic blood pressure. While Yamamoto et al., 2002⁽²⁷⁾ reported that the mean diastolic pressure decrease with aging.

This study showed that the mean of blood pressure means post exercise was significantly greater than that pre exercise in each age group (table 4) and that the mean blood pressure post exercise was positively correlated with age (figure 3). These findings were in agreement with Convertino 2003⁽²⁸⁾, and Finnoff et al., 2003⁽²²⁾ Aging is associated with an absence of central autonomic interaction in the control of blood pressure regardless of physical fitness⁽¹⁴⁾. The increase in mean arterial pressure from rest to exercise was greater in the older subjects, because of age-related reductions in carotid-cardiac control manifest at rest⁽¹⁵⁾.

CONCLUSION:

- 1- The heart rate post-exercise decreased significantly with increasing age.
- 2- The systolic blood pressure increased significantly post-exercise in all subjects, and there was a positive linear correlation with increasing age.
- 3- A non significant decrease in diastolic blood pressure post-exercise, older age group had higher diastolic blood pressure than younger age.
- 4- The mean blood pressure increased post-exercise and there was a significant positive linear correlation with increasing age.

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