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# Determination of Systolic Blood Pressure Recovery Time after Exercise in Apparently Healthy, Normotensive, Nonathletic Adults and the Effects of Age, Gender and Exercise Intensity

UCHECHUKWU DIMPKA <sup>†1</sup>, ANDREW C. UGWU <sup>‡2</sup>,

<sup>1</sup>Department of Physiology, Faculty of Basic Medical Sciences, Ebonyi State University, Abakiliki, Ebonyi State, Nigeria; <sup>2</sup>Department of Physiology, School of Medical Sciences, University of Benin, Benin City, Edo State, Nigeria

<sup>†</sup>Denotes graduate student author, <sup>‡</sup>denotes professional author

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## ABSTRACT

*Int J Exerc Sci* 2(2): 115-130, 2009. The aim of this study was to determine in statistical terms, the systolic blood pressure recovery time (SBPRT) and the effects of age, gender and exercise intensity in a large sample of apparently healthy non-athletic adults (n=597, aged 18-68). Subjects performed mild, moderate, and severe ergometer exercise tests. Blood pressure was measured before exercise (after 10 and 15 minutes of rest), during exercise (at 2-minute intervals) and at every minute of post-exercise recovery until systolic blood pressure (SBP) returned to baseline. The present findings indicate that the average values of SBPRT were between 5 and 7 minutes regardless of age, gender or exercise intensity. Systolic blood pressure recovery time increased with each age group ( $p < 0.001$ ) in all the exercise intensities. Young and middle-aged men indicated higher SBPRT than females ( $p < 0.001$ ) in mild and moderate exercise regimens. In men, SBPRT appeared to decrease with increase in exercise intensity ( $p < 0.001$ ) but indicated no significant differences amongst the exercise intensities in women. The present study therefore indicated mean SBPRT values that were consistent with previously reported values and which indicated age and gender effects following three exercise intensities of cycle ergometer. The reported data will help clinicians to define post-exercise SBP responses in statistical terms stratified by age, gender and exercise intensity in future investigations and during clinical assessment of individuals.

**KEY WORDS:** Recovery time, exercise intensity, cycle ergometer, systolic blood pressure.

## INTRODUCTION

Systolic blood pressure recovery after exercise represents an important index of cardiovascular and autonomic nervous system response to physical stress and has been shown to be a clinical tool applied toward diagnosing cardiovascular abnormalities (11, 14, 15, 17, 21). After exercise, systolic blood pressure (SBP) is

expected to decline rapidly and uniformly from peak exercise level to baseline (23). The time it takes blood pressure to recover to resting position after physical stress has been reported to be an index of autonomic function (24). A delay in the return of SBP to normal is therefore said to represent an abnormal response (23). These literatures suggest that blood pressure recovery time

may be a potential clinical tool for interpreting blood pressure responses.

Apart from two previous reports (9, 23), limited studies exist on the average time it takes SBP to decline from peak to pre-exercise levels. The above reviews reported that SBP may generally reach pre-exercise levels within an average time of five to six minutes following exercise. However, these literatures failed to provide adequate information to elucidate their reports. For example, Fletcher et al. (9) could not cite any reference to support their report on systolic blood pressure recovery time (SBPRT), while the reference (1) cited by Taylor and Beller (23), failed to indicate any data relating to the reported time of recovery of SBP. Similarly, we could not find any previously published statistical data or methodologies to back up and elucidate these facts. Furthermore, studies (3, 4) have previously reported differences of age and gender on SBP responses to exercise but not SBPRT. No previous study has also statistically stratified SBPRT by age, and gender following three exercise intensities of cycle ergometry. The novel aspect of the present study therefore would be the quantification and stratification of SBPRT by age, and gender following three exercise intensities of cycle ergometry.

In the present study therefore, we aimed to determine statistically, the time it takes SBP to recover from peak exercise level to pre-exercise level. We carried out exercise tests involving apparently healthy men and women of different age groups, who underwent ergometer exercise tests of different intensities. We further investigated whether the systolic blood pressure recovery time is influenced by age,

gender and exercise intensity. We therefore hypothesized that average SBPRT values may differ from previously reported values and will show age, gender and exercise intensity effects.

## METHOD

### *Subjects*

Five hundred and ninety seven apparently healthy, normotensive subjects between the ages of 18 to 68 years, selected from students and staff of Igbinedion University, Okada and residents of Okada town in Edo state Nigeria, participated in the study between 2004 and 2007. The number of study participants according to age, gender and exercise regimen is as indicated in Figure 1. Subjects were randomly selected based on the results of a structured health and lifestyle screening questionnaire, physical examination, morphometric measurements and medical history. Criteria for inclusion in the study were as follows: (a) subjects should be non-athletic but who should occasionally participate in recreational activities such as soccer, table tennis, lawn tennis, badminton, basketball, cycling and others; physical activity history of the subjects consisted of the subjects' yes or no responses to the question "Do you participate in recreational and sports activities for at least three times in a week" (subjects were also asked to mention types of recreational activities they participate in) (b) ability of a subject to at least perform a mild exercise intensity (50% of age-predicted maximum HR) (c) no prior history of unstable cardiovascular, peripheral vascular and respiratory disease, malignancy, and orthopedic or musculoskeletal lesions (d) subjects should be non-smokers, non-alcoholics, non-obese,

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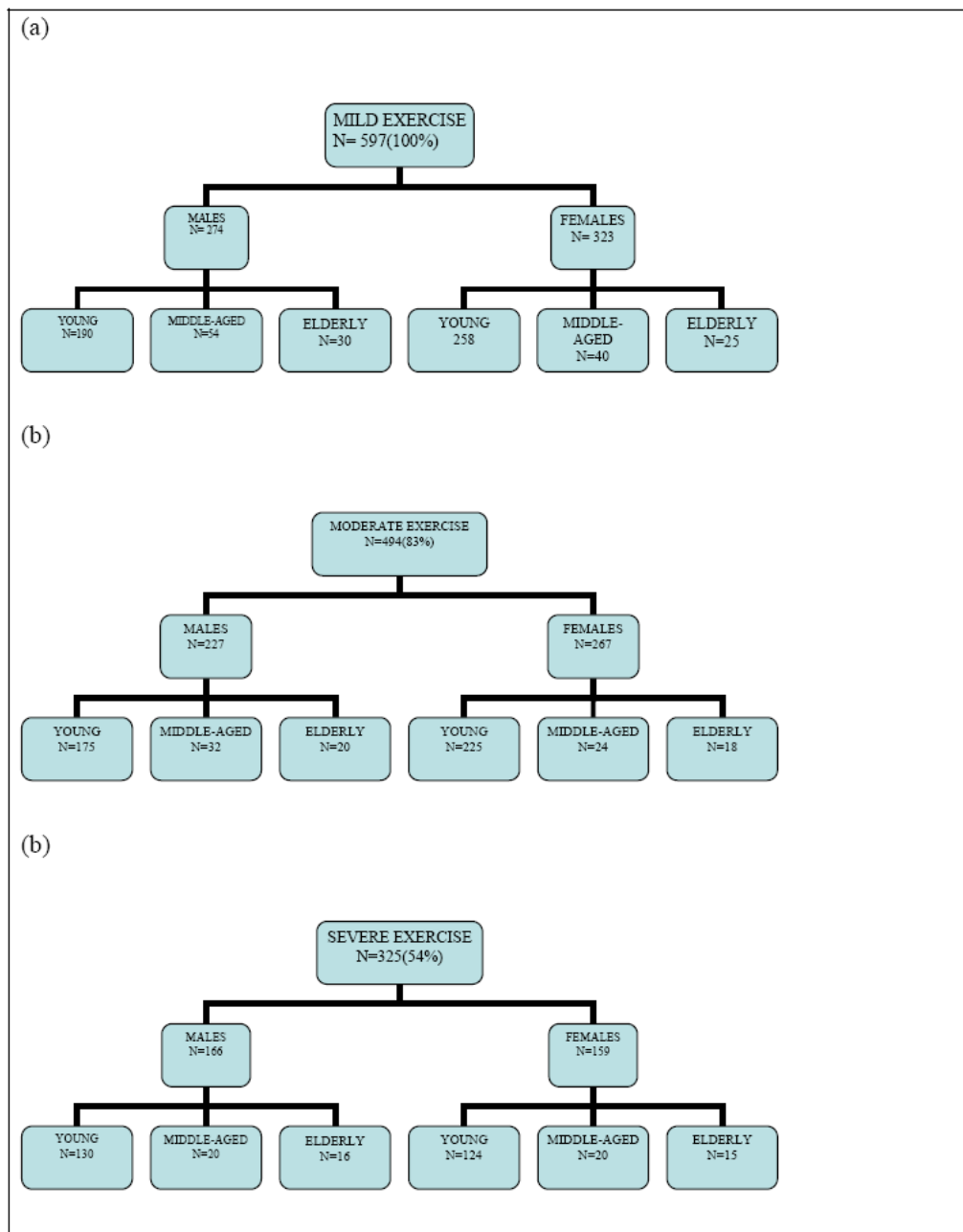


Figure 1. Flow diagram showing subjects participation by gender and age for each exercise regimen (a) mild exercise (b) moderate exercise (c) severe exercise. N=number of subjects.

and non-diabetics (e) not taking medications that could affect cardiovascular functions (f) not menstruating at the time of test if female. Subjects were informed (written and oral) of the experimental procedures and their

consents were obtained before participation. The Experiments and Ethics Committee of the College of Health Sciences of the Igbinedion University Okada, Edo state approved the study.

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Table 1: Basal characteristics of the study population by age and gender. Data are means  $\pm$  SD. \* = significant age effect in both gender groups, ? = significant age effect among the male age groups only, ? = significant age effect among the female age groups only.

Characteristics	MALES			FEMALES		
	Young	Middle-aged	Elderly	Young	Middle-aged	Elderly
Participation	190	54	30	258	40	25
Age (yrs) *	22 $\pm$ 3.06	42 $\pm$ 5.42	63 $\pm$ 2.40	20 $\pm$ 1.70	46 $\pm$ 6.34	62 $\pm$ 1.95
Height (m) $\vee$	1.76 $\pm$ 0.06	1.73 $\pm$ 0.09	1.66 $\pm$ 0.07	1.65 $\pm$ 0.06	1.67 $\pm$ 0.05	1.66 $\pm$ 0.09
Weight (kg) $\wedge$	68.3 $\pm$ 7.69	69.5 $\pm$ 7.51	70.7 $\pm$ 7.36	60.3 $\pm$ 7.80	63.5 $\pm$ 8.44	68.8 $\pm$ 7.0
Body Mass Index(kg/m <sup>2</sup> )*	22 $\pm$ 2.10	23.1 $\pm$ 1.84	25.4 $\pm$ 1.04	22 $\pm$ 2.27	22.5 $\pm$ 2.18	24.8 $\pm$ 0.80
Waist Circumference (cm) *	78.8 $\pm$ 5.75	87.6 $\pm$ 5.40	85.5 $\pm$ 3.74	75.2 $\pm$ 2.76	78 $\pm$ 2.49	75.1 $\pm$ 2.20
Resting SBP (mmHg) *	120 $\pm$ 8.29	124 $\pm$ 6.31	129 $\pm$ 4.22	118 $\pm$ 11.8	123 $\pm$ 3.22	125 $\pm$ 2.50
Resting DBP (mmHg) *	76 $\pm$ 6.58	80 $\pm$ 5.86	83 $\pm$ 2.75	75 $\pm$ 7.76	77 $\pm$ 6.35	81 $\pm$ 2.45
Resting HR (bpm) $\wedge$	73 $\pm$ 5.26	73 $\pm$ 3.62	72 $\pm$ 3.00	75 $\pm$ 4.12	73 $\pm$ 2.64	72 $\pm$ 3.66

### Exercise test

Each subject performed an exercise test involving three different exercise intensities, (mild, moderate, and severe). Each of the exercise intensity tests was performed on a separate day starting with mild, moderate, and then severe. The exercise tests were carried out between 8.00 AM and 11.00 AM in a well-ventilated room, using a mechanically braked cycle ergometer (Homeware Ltd, North York, Ontario, Canada). With the ergometer cycling protocol, it is easy to obtain reliable blood pressure measurements especially during recovery period. The cycle ergometer usually consists of progressive incremental workloads that may have minor effects on SBPs achieved during the exercise test (14). Participants were instructed not to consume beverages

containing alcohol or coffee, not to eat a heavy meal, or participate in any vigorous physical activity 24 hours before the test. They were also properly instructed on how to perform the exercise test with demonstrations. The testing protocol was comprised of an initial two-minute warm up of exercise at a work load of 20 Watts, followed by a linear increase in workload by 20 Watts every minute until the subject reached a targeted percentage of age-predicted maximum heart rate for each exercise intensity (mild, 50%; moderate, 70%; severe, 80%). The age-predicted maximum HR (HR<sub>max</sub>) was determined as [HR<sub>max</sub> = 208 minus (0.7  $\times$  age)], (22). The rating of perceived exertion (RPE) to exercise (2) was obtained through an oral questionnaire for the subjects immediately after the exercise protocol. The RPE of

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Table 2. Exercise test characteristics of subjects by gender and age. Data are means  $\pm$  SD. \* = significant age effect (in both gender groups), ? = significant age effect (among the female age groups only), † = significant gender effect.

Characteristics	MALES			FEMALES		
	Young	Middle-age	Elderly	Young	Middle-age	Elderly
<b>Mild Exercise</b>						
Peak exercise SBP(mmHg)*†	143 $\pm$ 7.96	148 $\pm$ 8.53	155 $\pm$ 7.78	137 $\pm$ 11.07	143 $\pm$ 2.34	147 $\pm$ 5.8
Peak exercise DBP(mmHg)*†	79 $\pm$ 6.21	82 $\pm$ 5.78	85 $\pm$ 2.66	76 $\pm$ 7.69	79 $\pm$ 6.24	83 $\pm$ 2.10
Peak exercise HR (bpm) *†	96 $\pm$ 1.07	89 $\pm$ 1.90	82 $\pm$ 0.84	97 $\pm$ 0.59	88 $\pm$ 2.22	82 $\pm$ 0.68
Exercise duration*†	5.94 $\pm$ 0.22	5.22 $\pm$ 0.76	4.63 $\pm$ 0.49	5.59 $\pm$ 0.49	5.02 $\pm$ 0.69	4.60 $\pm$ 0.50
Rating of perceived exertion	11.0 $\pm$ 0.96	11.5 $\pm$ 0.75	11.7 $\pm$ 0.47	10.97 $\pm$ 0.83	11.07 $\pm$ 0.76	11.56 $\pm$ 0.51
<b>Moderate Exercise</b>						
Peak exercise SBP(mmHg)*†	166 $\pm$ 11.42	168 $\pm$ 9.42	173 $\pm$ 7.33	159 $\pm$ 13.79	166 $\pm$ 6.0	171 $\pm$ 6.67
Peak exercise DBP(mmHg)*†	80 $\pm$ 5.60	81 $\pm$ 5.69	84 $\pm$ 2.48	77 $\pm$ 7.61	81 $\pm$ 6.92	84 $\pm$ 2.22
Peak exercise HR (bpm) *†	135 $\pm$ 1.51	126 $\pm$ 2.30	115 $\pm$ 1.06	136 $\pm$ 0.86	120 $\pm$ 3.34	115 $\pm$ 1.03
Exercise duration*†	9.33 $\pm$ 0.75	9.06 $\pm$ 1.04	7.70 $\pm$ 0.47	8.51 $\pm$ 1.04	8.87 $\pm$ 1.03	7.27 $\pm$ 0.75
Rating of perceived exertion	13.3 $\pm$ 0.48	13.5 $\pm$ 0.51	13.8 $\pm$ 0.41	13.61 $\pm$ 0.48	13.3 $\pm$ 0.44	13.44 $\pm$ 0.51
<b>Severe Exercise</b>						
Peak exercise SBP (mmHg)*†	182 $\pm$ 10.5	186 $\pm$ 10.37	189 $\pm$ 7.32	179 $\pm$ 13.99	183 $\pm$ 6.83	186 $\pm$ 6.95
Peak exercise DBP (mmHg)*†	80 $\pm$ 6.13	81 $\pm$ 6.74	84 $\pm$ 2.36	74 $\pm$ 7.43	79 $\pm$ 6.59	83 $\pm$ 2.31
Peak exercise HR (bpm) *	155 $\pm$ 1.45	142 $\pm$ 3.59	131 $\pm$ 1.16	155 $\pm$ 0.99	137 $\pm$ 3.64	131 $\pm$ 1.25
Exercise duration*†	13.97 $\pm$ 1.00	12.35 $\pm$ 1.95	10.9 $\pm$ 0.88	13.48 $\pm$ 1.32	13.65 $\pm$ 1.08	10.73 $\pm$ 0.79
Rating of perceived exertion	18.7 $\pm$ 0.63	18.8 $\pm$ 0.69	19.4 $\pm$ 0.50	18.9 $\pm$ 0.71	18.6 $\pm$ 0.60	19.1 $\pm$ 0.64

subjects corresponded to the appropriate exercise intensity performed according to the Borg's scale. During the exercise tests, a total of 6 visits were made by subjects who were able to complete the three exercise

tests; a total of 4 visits for those who completed the moderate exercise test, and those who could not continue due to fatigue or other contra-medical indications. All the 597 subjects (100%) by age and

gender completed the mild exercise regimen (Figure 1); 494 (83%) subjects completed the moderate exercise; and 325 (54%) subjects completed the severe exercise regimen. This indicates that 103 and 272 subjects could not complete the moderate and severe exercise phases respectively and their data were not included in the data analysis of both exercise tests. All those who could not complete the moderate exercise test were excluded from participating in the severe exercise test. The most common reasons why some subjects could not complete the exercise tests (moderate or severe) were, leg fatigue, exhaustion, breathlessness and dizziness irrespective of age or gender. The average duration of each of the exercise intensity tests according to age and gender is presented in Table 2.

Heart rate (HR) was measured twice immediately before exercise (after 10 min and 15 min of rest) using the Omron electronic monitor (HEM-712C, Omron Health Care Inc., Vernon Hills, Illinois). The mean of the values was used as the pre-exercise HR. During the exercise test, HR was measured at 2-minute intervals until the subjects reached their age adjusted, predicted maximum HR for the particular exercise intensity. The peak exercise HR was the highest value achieved at the termination of each of the exercise tests, after the subject has reached his predetermined HR. An experienced physician supervised the entire exercise test.

### *Blood Pressure Measurements*

Resting blood pressure was measured one week prior to the exercise test, and after 10 and 15 minutes of rest in a seated position

in a quiet room using both cuff-stethoscope (manual) and electronic (HEM-712C, Health Care Inc., Vernon Hills, Illinois) methods. The mean values of the two methods correlated ( $p < 0.001$ ) with each other, and showed no significant differences. We however used the mean of the electronic method as the resting blood pressure. The resting blood pressure measurement was used to ascertain whether a subject was normotensive or not. Prior to each day's exercise test, subject's pre-exercise blood pressure was also measured twice (after 10 and 15 minutes of rest) when sitting on the cycle ergometer, using the electronic method. There was no significant difference observed between the pre-exercise SBP and the earlier obtained resting blood pressure values in all cases. During the exercise, blood pressure was measured at two-minute intervals (with the same electronic method), until the termination of exercise, when the subject has reached his or her predicted maximum HR for the particular exercise intensity. The peak exercise SBP was defined as the highest value achieved during the test. Systolic blood pressure after exercise was measured every minute until recovery to pre-exercise level. During the post-exercise SBP measurement, subjects were asked to be in a sitting position on the bicycle without pedaling while the research personnel were blinded to the SBP test results at baseline and during exercise. These measurements were repeated for the subjects, under the same experimental conditions, on a separate day and the mean of the values obtained from the two days' tests was used as the experimental value. This was done in order to reduce errors that may arise from the measurement of BP and HR using electronic method.

*Statistical Analyses*

Descriptive data are presented as means  $\pm$  SD. Test of normal distribution of data was analyzed using Kolmogorov-Smirnov test. Data analysis between two study groups was compared using the independent sample t-test. One-way analysis of variance (ANOVA) was used to compare variables in three groups. Pearson's bivariate correlation test was used to test the relationship between age and SBPRT. BMI-adjusted association between SBPRT and age was analyzed using Pearson's partial correlation tests. All statistics were done using SPSS for Windows (Version 16.0). Statistical significance was set at  $p < 0.05$  for the independent sample t-test and ANOVA test, and  $p < 0.01$  for correlation tests.

**RESULTS**

Among the study population, 448 were young adults (190 males and 258 females aged 18-30 yrs), 94 were middle-aged (54 males and 40 females aged 36-59 yrs), and 55 were elderly adults (30 males and 25 females aged 60-68 yrs). General characteristics of subjects (by age and gender) are shown in Table 1. Young males indicated significantly higher resting DBP ( $p < 0.05$ ); lower HR ( $p < 0.001$ ) and higher waist circumference ( $p < 0.001$ ) than females. There were no significant differences in resting SBP and BMI between the young males and females. Middle aged males indicated higher waist circumference ( $p < 0.001$ ), and higher DBP ( $p < 0.05$ ). BMI, resting SBP and resting HR indicated no significant differences between the two groups. Elderly males presented higher BMI ( $p < 0.05$ ) and waist circumference ( $p < 0.001$ ), higher resting SBP ( $p < 0.005$ ), and DBP ( $p < 0.05$ ) than the elderly females. Resting HR indicated no significant

differences between the two groups. ANOVA analysis revealed that BMI, waist circumference, resting SBP, and resting DBP indicated age effects ( $p < 0.001$ ) in male and female groups respectively. Resting HR showed age effect ( $p < 0.001$ ) only in females but not in males.

The number and percentage of subjects who participated in each of the exercise intensity tests is as presented in the flow chart in figure 1 and table 2 shows the exercise test characteristics of subjects by age group, gender and according to exercise intensities. The ANOVA analysis revealed that in mild exercise, peak exercise SBP, and peak exercise DBP, significantly increased with each age group ( $p < 0.001$ ) for all genders; peak exercise HR declined with each age group for all genders ( $p < 0.001$ ). During moderate exercise, males indicated significant age effects ( $p < 0.05$ ;  $p < 0.01$ ;  $p < 0.001$ ) for peak exercise SBP, and peak exercise DBP and peak exercise HR respectively. The same trend was also observed in females ( $p < 0.001$  for all effects). During severe exercise, there were significant age effects for peak exercise SBP ( $p < 0.05$ ), and peak exercise HR ( $p < 0.001$ ), in males and females respectively. Significant increase in peak DBP with age was also observed in females ( $p < 0.001$ ) but not in males ( $p > 0.05$ ). A t-test analysis revealed that men indicated significantly higher peak exercise DBP ( $p < 0.001$  for all effects) and higher peak exercise SBP ( $p < 0.001$ ;  $p < 0.01$ ;  $p < 0.001$ ) than females, during mild, moderate, and severe exercise regimens respectively. Higher peak exercise HR was also observed in males than females in mild ( $p < 0.001$ ) and moderate ( $p < 0.05$ ) exercise intensities but not in the severe exercise ( $p > 0.05$ ).

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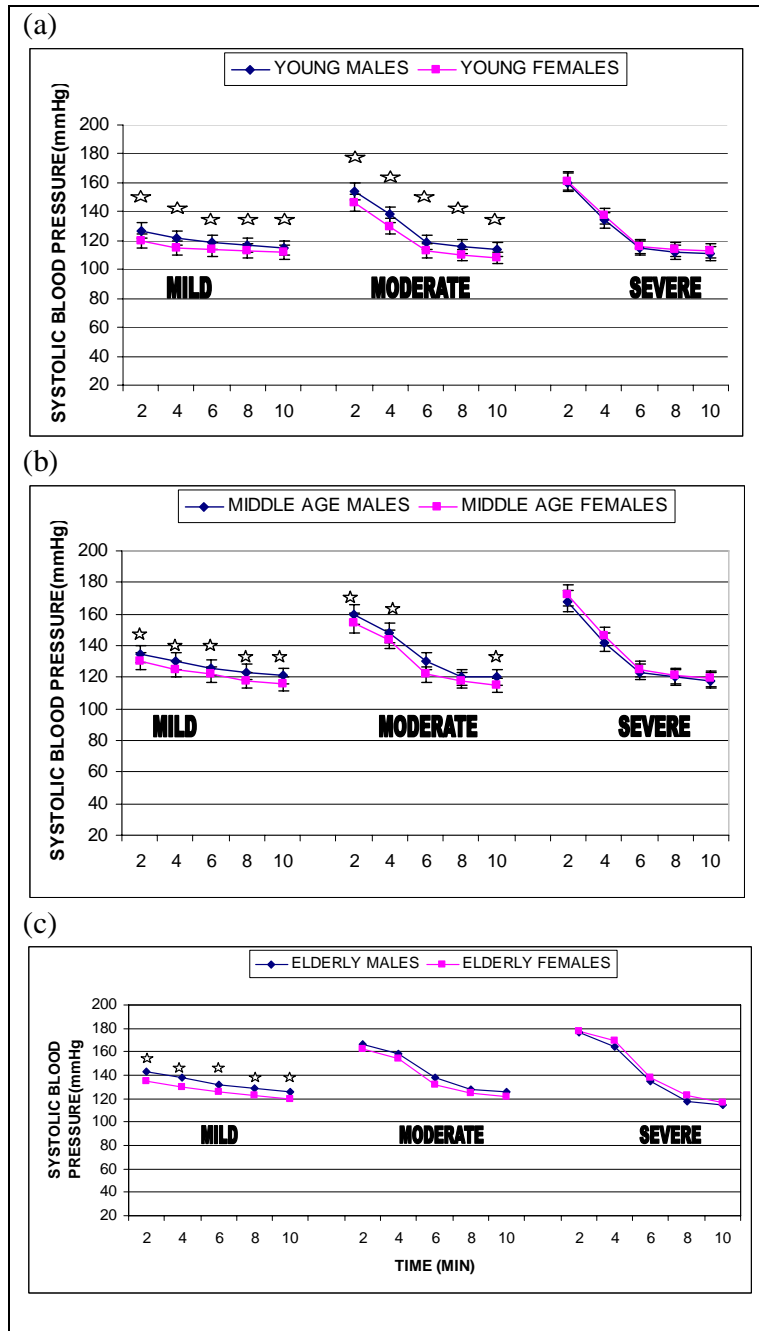


Figure 2. Systolic blood pressure during recovery by age and gender and at different exercise intensities. \*= significant gender difference.

# SYSTOLIC BLOOD PRESSURE RECOVERY TIME

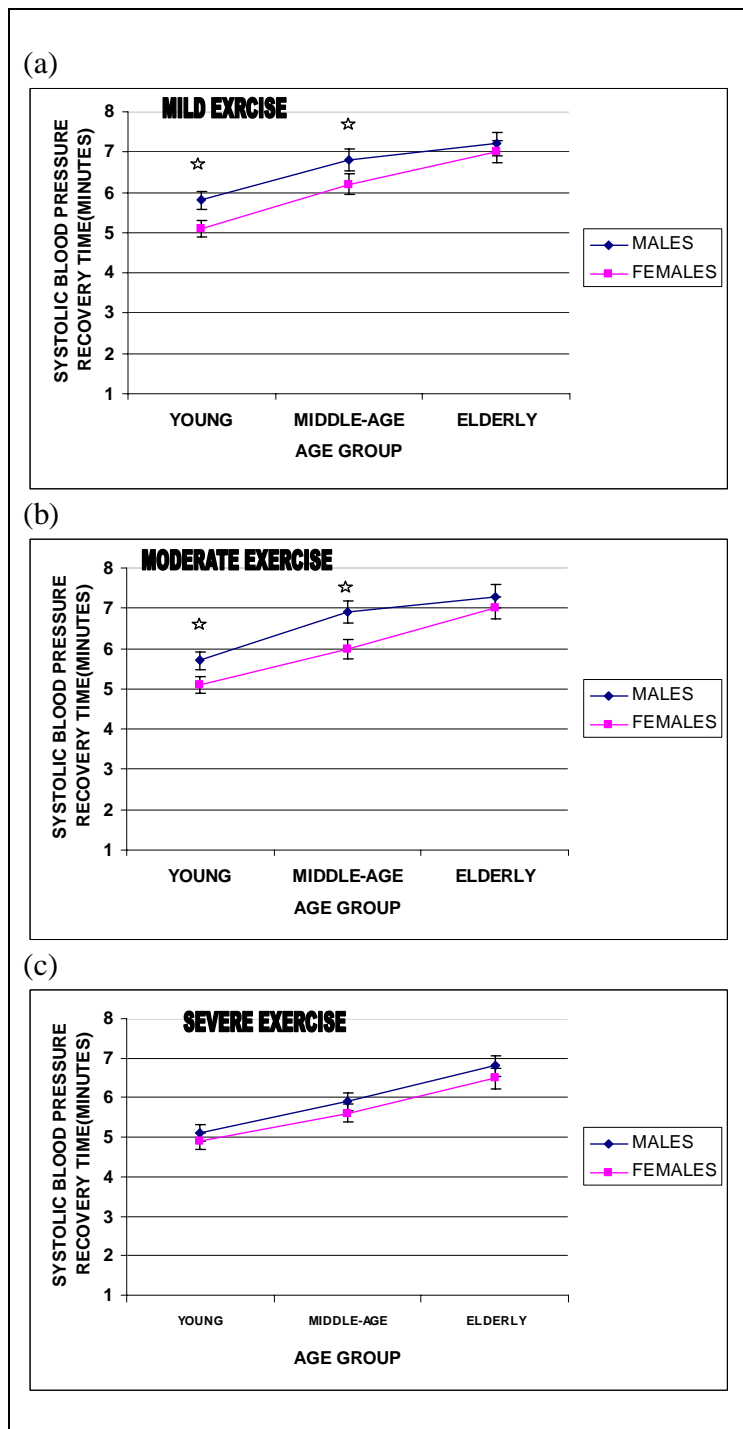


Figure 3. Systolic blood pressure recovery time by age group and gender in large referral study population for different exercise intensities (a) mild (b) moderate (c) severe. \*= significant gender difference.

# SYSTOLIC BLOOD PRESSURE RECOVERY TIME

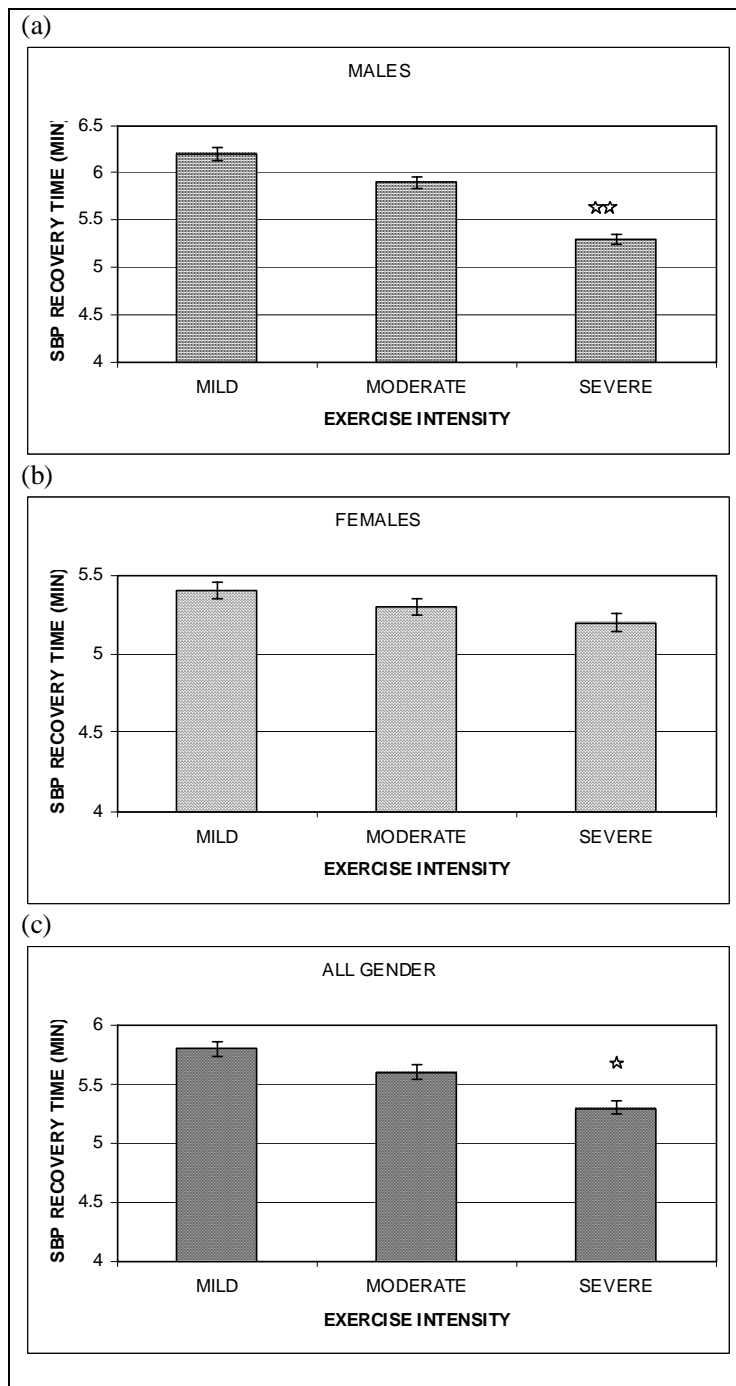


Figure 4. Systolic blood pressure time by exercise intensity in (a) all male (b) all female and (c) all gender study groups. \*= $p < 0.005$  exercise intensity effect; \*\*= $p < 0.001$  exercise intensity effect.











