ORIGINAL RESEARCH

Systolic Blood Pressure Responses in Relation to Cardiorespiratory Fitness of Young Adults

Dimkpa Uchechukwu, PhD[1], Okoye Chinelo Blessing, BSc[1], Stephen O. Maduka, PhD[1], Uchefuna Roy Chinweuba, MSc[1], Njoku-Oji Nancy Njideka, PhD[1], Uneze Bright, PhD[1]

ABSTRACT

Background: We aimed to assess systolic blood pressure (SBP) responses in relation to the cardiorespiratory fitness (CRF) levels of apparently healthy, young Nigerian adults during and after a submaximal-effort exercise test.
Methods: One hundred and twelve young adults (62 males and 50 females) participated in the study and were grouped according to their CRF levels—low, moderate, and high. The participants performed submaximal ergometer exercise tests to elicit exercise and postexercise blood pressure responses.
Results: Males and females with high CRF indicated significantly ($P < 0.05$) higher change of exercise SBP at peak exercise ($\Delta Ex \cdot SBP_{peak}$), and post-SBP decline compared with the other CRF groups. In addition, higher ($P < 0.05$) $\Delta Ex \cdot SBP_{2min}$ and faster SBP recovery time were observed in the high CRF group compared to low CRF group. Females with high CRF had a significantly ($P < 0.05$) higher peak oxygen pulse and energy expenditure compared with the lower CRF groups. There was a very low incidence of abnormal SBP responses among the study population.
Conclusion: Greater exercise SBP responses, an indication of higher cardiac output due to greater metabolic demand, and faster SBP recovery were observed in participants with a high CRF compared with the other CRF groups. These findings suggest that regular exercise which maintains a higher CRF in young Nigerian adults may be related to a healthy SBP exercise response. *Journal of Clinical Exercise Physiology*. 2019;8(2):55–63.

Keywords: submaximal exercise, ergometer, young adults, postexercise recovery, peak VO_2

INTRODUCTION

Cardiorespiratory fitness (CRF) is defined as the ability of the circulatory, respiratory, and muscular systems to supply oxygen during sustained physical activity (1). It is a health-related component of physical fitness and considered to be a strong predictor of cardiovascular diseases, cancer-specific mortality, and all-cause mortality, as well as various chronic diseases (2,3). Improving exercise capacity and CRF is therefore a very important target to reduce cardiovascular events across all age strata.

During exercise in normotensive, nondiseased individuals, systolic blood pressure (SBP) is expected to rise due to increase in cardiac output (4). Systolic blood pressure reaches a plateau at peak exercise and declines rapidly and uniformly throughout the recovery phase (5). Both exercise and postexercise SBP responses represent important indexes of cardiovascular and autonomic nervous system response to physical stress as well as clinical tools applied toward predicting cardiovascular abnormalities. For example, an exercise-induced excessive rise in SBP has been found to be a predictor of future hypertension, myocardial infarction, stroke, and cardiovascular mortality in apparently healthy people (6–8). Similarly, a blunted decline in SBP after exercise is associated with an increased risk of stroke, coronary heart disease, and hypertension (8–10).

[1]Physiology Department, Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Nnewi Campus, Nnewi, Anambra State, Nigeria

Address for correspondence: Dimkpa Uchechukwu, Physiology Department, Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Nnewi Campus, P.M.B. 5025, Anambra State, Nigeria; +234-07037362106; e-mail: positivedoings@yahoo.com.

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Limited studies exist relating SPB responses with CRF. The few available studies in the literature demonstrate that increased CRF levels result in lower BP responses; however, the underlying mechanisms have not been fully elucidated. In addition, most previous studies have focused on older adults and used maximal exercise tests as the gold standard for assessing maximal aerobic capacity. Cardiovascular disease (CVD) is a progressive disease that has its roots in the early years of life (11), and there is a growing global concern over sedentary lifestyle and lack of physical activity among young adults, which places them at risk for CVD. Furthermore, maximal exercise testing is considered very challenging, since it is labor intensive, requires higher levels of motivation by the individual, requires additional monitoring equipment and trained staff (12,13), and is difficult for people whose performance may be limited because of pain, fatigue, abnormal gait, or impaired balance (14). Submaximal exercise testing thus may be preferred as the method of choice for the majority of individuals seen by clinical exercise professionals, since it overcomes many of the limitations of maximal exercise testing.

In the present study, therefore, we used a wide range of hemodynamic variables to assess SBP responses in an apparently healthy young adult population who underwent a submaximal-effort exercise test in relation to their CRF levels. In addition, we determined the incidence of abnormal SBP responses among the study population. We also were interested in determining possible mechanisms behind differences in SBP responses among the different CRF groups. It is believed that understanding the relationship between SBP responses and CRF and the underlying mechanisms would be of interest to clinical exercise physiologists who develop exercise prescriptions for disease prevention in apparently healthy young adults and exercise training strategies for competitive athletes.

METHODOLOGY

Participants

One hundred and twelve young adults (62 males and 50 females; aged 18–30 years) selected from the College of Health Sciences, Nnamdi Azikiwe University, Nnewi campus, participated in the study. A structured pre-exercise health and lifestyle screening questionnaire was administered to the participants prior to the exercise tests. Physical examinations and morphometric measurements were performed by experienced personnel, and the participants' ability to complete a submaximal cycle ergometer exercise test at intensity of 60–85% of predicted maximum heart rate (HR) was considered as criteria for inclusion in the study. Exclusion criteria were: hypertension (SBP $\geq$ 140 mmHg and/or diastolic blood pressure $\geq$ 90 mmHg); history of unstable cardiovascular, peripheral vascular, or respiratory disease; a malignancy, orthopaedic or musculoskeletal lesions; a history of smoking or alcoholism, obesity (body mass index $\geq$ 30 kg·m^{-2}), diabetes, and taking medication affecting cardiovascular function. Oral and written consent was obtained from each participant before data collection. The participants' CRF levels were determined using indirect prediction of VO_2max using the HR ratio method (15) and classified using sex-specific tertiles. VO_2max within the first tertile (i.e., <41 mL·kg^{-1}·min^{-1} for males and <37 mL·kg^{-1}·min^{-1} for females) were classified as low CRF; the group between the first and second tertile (i.e., 41–46 mL·kg^{-1}·min^{-1} for males and 37–40 mL·kg^{-1}·min^{-1} for females) as moderate CRF; and VO_2max equal and above the second tertile (i.e., ≥47 mL·kg^{-1}·min^{-1} for males and ≥41 mL·kg^{-1}·min^{-1} for females) were classified as high CRF. The Experiments and Ethics Committee of the Faculty of Basic Medical Sciences of the University approved the study. All aspects of this investigation conformed to the Code of Ethics of the World Medical Association.

Anthropometric Measurements

Each participant's height was measured with the use of standiometer (SECA, Hamburg, Germany) with the shoulders in a relaxed position and the arms hanging freely. Weight was measured with the participant in light clothing without shoes using a standard scale. Body mass index was calculated as weight (kg) divided by the square of the height (m^2).

Exercise Test Procedure

The exercise tests were carried out the same time of the day (9:00 AM to 12:00 PM) to standardize climatic conditions, in a well-ventilated room, using a mechanically braked magnetic ergometer bicycle. Participants were instructed not to consume beverages containing alcohol or caffeine, not to eat a heavy meal, and not to participate in any vigorous physical activity 24 h before the test. The nature, purpose, and procedure of the exercise test were explained to each participant, and there was a demonstration on how to use the cycle ergometer before each participant began to exercise.

The exercise protocol comprised an initial 2 min warmup at a work load of 20 watts, followed by a linear increase of 20 watts every 2 min to elicit 65% of the individual's age-predicted maximum HR (HRmax). Once this targeted percentage HRmax was achieved, the participant was asked to cycle at a constant rate to maintain the work load until a steady-state HR was achieved. Heart rate was considered steady state when consecutive HRs between 2 min intervals remained constant (12). The predicted HRmax was determined as [HRmax = 208 minus (0.7 × age)] (16). The rating of perceived exertion (RPE) of exercise was obtained using the Borg's scale 0–10 (17) immediately after the exercise protocol. An experienced clinical exercise physiologist supervised each exercise test.

Blood Pressure and Heart Rate Measurements

Pre-exercise BP and HR were measured in a quiet room using an electronic monitor (Omron Health Care, Inc., China), after the participant had been seated for 5–10 min. The procedure was repeated, and the average of the 2 measures was used. During the exercise protocols, BP and HR were measured at 2 min intervals and at peak of exercise after the participants had reached their targeted HR as well

TABLE 1. Demographic and baseline characteristics of male participants according to their CRF. Data are mean ± standard deviation.

Variables	CRF Groups	Males			Females		
		No.	Mean	SD	No.	Mean	SD
Age (years)	Low	17	22.2	2.9	16	19.9	1.7
	Moderate	22	22.9	2.6	16	20.1	1.4
	High	23	21.6	1.1	18	20.7	2.2
Weight (kg)	Low	17	63.7	7.7	16	61.1	7.7
	Moderate	22	66.6	6.7	16	60.0	6.0
	High	23	70.3	8.5*	18	65.7	4.5‡
Height (m)	Low	17	1.72	0.05	16	1.67	0.07
	Moderate	22	1.75	0.06	16	1.66	0.04
	High	23	1.73	0.06	18	1.69	0.04
Body mass index ($kg \cdot m^{-2}$)	Low	17	21.5	2.0	16	21.8	1.7
	Moderate	22	21.6	1.5	16	21.7	1.8
	High	23	23.3	3.4	18	22.9	1.5
Pre-exercise SBP (mmHg)	Low	17	119	8.9	16	112	8.0
	Moderate	22	117	7.6	16	113	9.6
	High	23	112	8.5*	18	104	7.9*‡
Pre-exercise DBP (mmHg)	Low	17	69	8.5	16	75	7.5
	Moderate	22	68	5.9	16	71	8.9
	High	23	62	9.8	18	73	5.7
Pre-exercise HR ($b \cdot min^{-1}$)	Low	17	82	3.9	16	91	9.4
	Moderate	22	69	5.7*	16	81	4.9*
	High	23	60	3.7*‡	18	68	8.6*‡
Predicted VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$)	Low	17	36.6	2.0	16	33.7	1.9
	Moderate	22	43.2	1.9*	16	38.2	1.1*
	High	23	50.5	2.7*‡	18	47.3	5.4*‡

Abbreviations: CRF, cardorespiratory fitness; DBP, diastolic blood pressure; HR, heart rate; SBP, systolic blood pressure; VO_2max, maximum oxygen uptake
*Significantly different from low CRF
‡Significantly different from moderate CRF

as steady state HR. The peak-exercise BP and HR were defined as the highest values achieved at the termination of the exercise. Systolic BP data at minutes 2, 4, and peak of exercise were used to assess SBP responses and were available for all the participants.

Normal SBP response during exercise was defined as an increase of at least 20 mmHg in SBP per 20 watt workload increase (18). Abnormal SBP responses during exercise were defined as (a) hypotensive response: if there is >20 mmHg fall in SBP when compared with peak SBP after an initial rise due to exercise (i.e., initial rise in SBP value − peak SBP = >20 mmHg) or a continuous fall of >20 mmHg in SBP throughout the duration of exercise; (b) flat response: if there is an increase of <20 mmHg from rest to peak exercise (i.e., peak SBP – resting SBP = <20 mmHg) (19); exaggerated response: peak SBP >210 mmHg in men and >190 mmHg in women (6,20).

During the postexercise BP measurement, participants were asked to remain in a sitting position, and BP was measured immediately after exercise (within the first minute of recovery) and subsequently at 2 min intervals until recovery to pre-exercise level (i.e., measurements were done at 1, 3, 5, 7, etc. min postexercise). Percentage decline of SBP during recovery was calculated as [peak SBP − postexercise SBP (at 1 or 3 min)/peak SBP × 100]. Third minute SBP ratio, an index of SBP recovery, was computed as postexercise SBP at 3 min divided by postexercise SBP at 1 min. An abnormal or delayed SBP recovery was defined as the ratio of the third minute SBP ratio >1.0 (9).

Measurement and Determination of Exercise Performance and Metabolic Parameters

Oxygen uptake (VO_2): In this study, VO_2 values were estimated from prediction models. The prediction models are

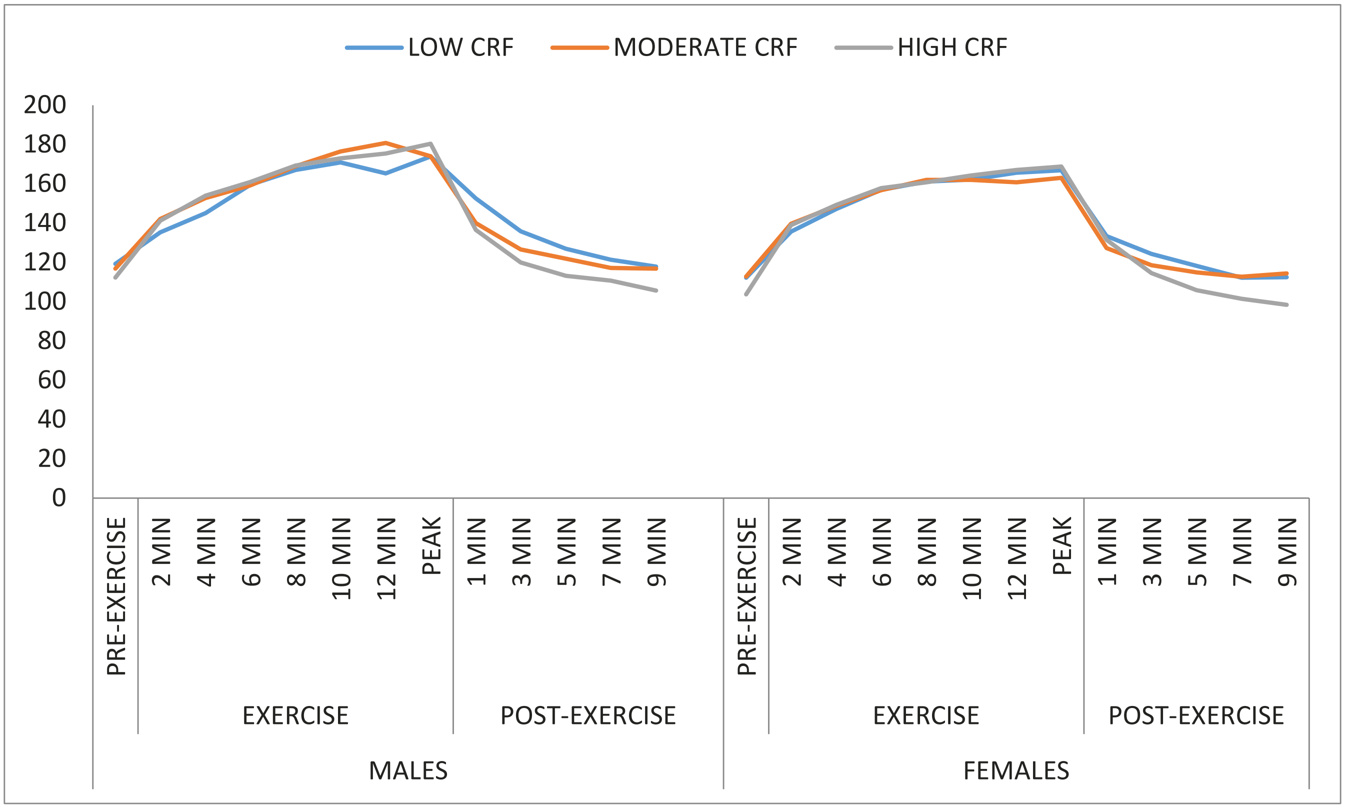

FIGURE 1. Changes in systolic blood pressure from pre-exercise to peak exercise and during recovery according to CRF statuses of participants.

low cost, time effective, and can be used in large population studies (21). They have also been reported to be accurate and may be better than widely accepted submaximal exercise procedures for predicting aerobic fitness (22). The predicted VO_2max used in categorizing the participants into their CRF groups was determined using the HR ratio method estimated from the equations of Uth et al. (15.3 × [age predicted HRmax/resting HR]) (15). The peak oxygen uptake (peak VO_2) of participants was estimated from the standardized VO_2 equation: $\%VO_2$ = (%HRmax/0.64) − 37 (23), and expressed in relative VO_2 unit (mL·kg^{-1}·min^{-1}). Note that $\%VO_2$ achieved at peak exercise is also expressed as [peak VO_2/predicted VO_{2max}] × 100. Substituting for $\%VO_2$ (peak), the standardized equation is expressed as (peak VO_2/predicted VO_{2max}) × 100 = (%HRmax/0.64) − 37. Peak VO_2 therefore is expressed as [predicted VO_{2max} × (%HRmax/0.64) − 37]/100. The relative VO_2 (mL·kg^{-1}·min^{-1}) values were converted to absolute values (L·min^{-1}) using the formula (relative VO_2 × body weight)/1000.

Peak oxygen pulse, a physiological term for oxygen uptake per heart beat at peak of exercise (24), was calculated as peak absolute VO_2 (L·min^{-1}) × 1000/peak HR (b·min^{-1}) and expressed as mL·b^{-1}. It is recognized as an indicator of maximal stroke volume (25). The percentage HRmax attained by participants was expressed as (peak HR/age-predicted HRmax) × 100.The work load or power output (kpm·min^{-1}) was computed with the formula kpm·min^{-1} = (pedal rate [rpm]) × (ergometer resistance [kp]) × (6 m·rev^{-1}) and then converted to watts (1 W = 6.12 kpm·min^{-1}). The workload at which a steady-state HR occurred was recorded. Peak exercise rate pressure product, which is a reflection of the myocardial oxygen demand and myocardial workload at peak of exercise (26), was calculated as peak HR × peak SBP. Energy expended in calories was obtained from the value on the electronic monitor connected to the ergometer bicycle. Duration of exercise was recorded as the total time spent from the start of exercise to the point of termination by each participant.

Data Analysis

Descriptive data were expressed as mean and standard deviation. Comparative analysis among the various groups was done using one-way analysis of variance using the Bonferroni post hoc multiple comparison test. Statistical significance was set at $P < 0.05$. All statistics were performed using SPSS for windows (version 20.0).

RESULTS

The demographic and baseline characteristics of male and female participants are summarized in Table 1. Age, height, body mass index, and pre-exercise DBP did not differ among the CRF groups of both males and females. In both males and females, pre-exercise SBP was significantly ($P < 0.05$) lower in the high CRF group compared with the low CRF group. There was a significantly ($P < 0.001$) lower HR in the higher CRF levels of both male and female participants (Table 1).

TABLE 2. Exercise characteristics of male and female participants according to their CRF statuses. Data are mean ± standard deviation.

Variables	CRF Groups	Males			Females		
		No.	Mean	SD	No.	Mean	SD
Exercise SBP_{2min} (mmHg)	Low	17	135	10.3	16	136	10.5
	Moderate	22	142	13.1	16	140	10.2
	High	23	141	12.5	18	139	10.0
Exercise SBP_{4min} (mmHg)	Low	17	145	11.3	16	147	9.9
	Moderate	22	152	13.1	16	149	11.5
	High	23	154	17.8	18	149	11.3
Peak Ex•SBP (mmHg)	Low	17	174	14.1	16	167	10.6
	Moderate	22	174	16.0	16	163	13.4
	High	23	180	14.8	18	169	13.2
Peak Ex•HR (bpm)	Low	17	130	10.3	16	143	21.4
	Moderate	22	135	17.8	16	134	19.3
	High	23	134	14.0	18	140	30.1
Δ peak HR (bpm)	Low	17	49	11.1	16	61	26.0
	Moderate	22	66*	18.0	16	54	20.0
	High	23	75*	15.6	18	72	32.5
Target HR reached (%)	Low	17	68	5.4	16	73	11.2
	Moderate	22	70	9.2	16	69	9.8
	High	23	69	7.3	18	72	15.4
Exercise duration (min)	Low	17	10.5	1.5	16	8.8	1.3
	Moderate	22	10.8	2.3	16	8.3	1.1
	High	23	12.7*‡	1.6	18	12.0*‡	1.9
Rating of perceived exertion	Low	17	3.23	1.0	16	3.4	0.9
	Moderate	22	3.31	0.8	16	3.1	0.6
	High	23	3.56	1.3	18	3.5	0.7
Recovery SBP_{1min} (mmHg)	Low	17	152	11.0	16	133	10.2
	Moderate	22	140*	10.9	16	127	10.8
	High	23	136*	9.2	18	131	11.1
Recovery SBP_{3min} (mmHg)	Low	17	136	7.7	16	124	8.8
	Moderate	22	127*	10.0	16	119	10.0
	High	23	120*‡	7.3	18	114*‡	9.2

Abbreviations: CRF, cardiorespiratory fitness; HR, heart rate; SBP, systolic blood pressure
*Significantly different from low CRF
‡Significantly different from moderate CRF

Figure 1 indicates changes of SBP from rest to peak exercise and from the first to the ninth minute of recovery in both males and females. Systolic blood pressure indicated steady increase from pre-exercise position until it plateaus at peak of exercise. At postexercise, SBP had an initial rapid decline followed by slower recovery from peak exercise toward baseline.

Table 2 shows the exercise characteristics of male and female participants according to their CRF levels. Compared among the CRF groups, data indicated no significant differences in second minute exercise SBP, fourth minute exercise SBP, peak exercise SBP, peak exercise HR, % targeted HR reached, and RPE in males and females, respectively. Similarly, no significant difference was observed in first minute SBP recovery among the females. In contrast, significantly ($P < 0.05$) higher exercise duration and a lower SBP at the third minute of recovery were observed in the high CRF group for both males and females. Among the males, a lower first minute SBP recovery and a higher Δ peak HR were observed in the high ($P < 0.001$) and moderate ($P < 0.01$) CRF groups compared with lower CRF group.

TABLE 3. Systolic blood pressure responses in male and female participants according to CRF statuses. Data are mean ± standard deviation.

Variables	CRF Groups	Males			Females		
		No.	Mean	SD	No.	Mean	SD
$\Delta Ex \bullet SBP_{2min\ (mmHg)}$	Low	17	16.1	8.8	16	23.4	11.5
	Moderate	22	25.3	12.9	16	26.7	13.3
	High	23	28.9*	16.3	18	35.3*	15.5
$\Delta Ex \bullet SBP_{4min\ (mmHg)}$	Low	17	25.9	11.1	16	36.3	12.2
	Moderate	22	35.9	14.3	16	36.0	13.5
	High	23	41.6*	20.1	18	45.5	13.9
$\Delta Ex \bullet SBP_{peak\ (mmHg)}$	Low	17	54.8	16.9	16	54.7	13.3
	Moderate	22	57.1	15.8	16	50.3	14.4
	High	23	68.1*‡	14.4	18	65.0*‡	11.8
% 1 min post-SBP decline	Low	17	12.6	5.3	16	20.5	7.2
	Moderate	22	19.1*	7.1	16	19.8	8.5
	High	23	23.8*	8.5	18	21.9	6.7
% 3 min post-SBP decline	Low	17	21.9	6.7	16	25.8	6.9
	Moderate	22	26.8	7.0	16	25.3	8.3
	High	23	33.2*‡	6.0	18	31.8*‡	6.9
$SBPR_3$	Low	17	0.89	0.04	16	0.93	0.03
	Moderate	22	0.90	0.04	16	0.93	0.04
	High	23	0.88	0.05	18	0.87*‡	0.06
SBPRT (min)	Low	17	7.7	3.3	16	8.0	1.9
	Moderate	22	6.2	1.8	16	5.8*	2.9
	High	23	4.8*	2.0	18	5.0*	1.4

Abbreviations: CRF, cardiorespiratory fitness; ΔEx·SBP, increase in exercise systolic blood pressure; $SBPR_3$, third minute SBP ratio; SBPRT, SBP recovery time

*Significantly different from low CRF

‡Significantly different from moderate CRF

Table 3 shows the SBP responses in male and female participants according to their CRF levels. In both males and females, significantly higher ($P < 0.05$) change of SBP during exercise at 2 min ($\Delta Ex \cdot SBP_{2min}$), $\Delta Ex \cdot SBP_{peak}$, and lower SBP recovery time were observed in the high CRF group compared with the low CRF group. There was significant ($P < 0.05$) increase in percentage third minute post-SBP decline with increase in CRF levels of both males and females. Males, but not females, with high CRF had a significantly ($P < 0.05$) higher $\Delta Ex \cdot SBP_{4min}$ compared with the low CRF group. Similarly, males but not females had a higher ($P < 0.05$) first minute post-SBP decline in the high and moderate CRF groups compared with the low CRF group. Females, but not males, with high CRF had a significantly ($P < 0.01$) lower third minute SBP ratio compared with the moderate and low CRF groups.

The workload attained by the high CRF group was greater ($P < 0.05$) compared with the low and moderate groups in both males and females (Table 4). In addition, estimate absolute VO_2 was greater ($P < 0.05$) in the high CRF group compared with the low CRF group in both sexes. In females, but not males, relative peak VO_2, peak oxygen pulse, and energy expended were significantly ($P < 0.05$) higher in the high CRF group compared with the low and moderate groups, respectively.

It is noteworthy that none of the male CRF groups had an abnormal exercise (hypotensive, flat, or exaggerated) or postexercise SBP responses. One female (2%) in the moderate CRF group had a flat SBP response. In addition, one female (2%) in the low CRF group had an abnormal SBP response during recovery.

DISCUSSION

This present study demonstrated higher exercise SBP responses in participants with higher CRF compared with a lower CRF. This result is in contrast with previous studies which demonstrated that low CRF is associated with higher BP responses during submaximal exercise (27,28). However, the methodology used in these other studies differed from ours as they used the modified Bruce protocol using a

TABLE 4. Metabolic responses of participants during exercise. Data are mean ± standard deviation.

Variables	CRF Groups	Males			Females		
		No.	Mean	SD	No.	Mean	SD
Workload (watts)	Low	17	54.11	7.12	16	45.00	6.32
	Moderate	22	55.00	10.57	16	42.50	5.77
	High	23	64.34*‡	7.27	18	61.11*‡	10.22
Peak relative VO_2 ($mL{\bullet}kg^{-1}{\bullet}min^{-1}$)	Low	17	23.0	4.64	16	25.1	6.3
	Moderate	22	25.0	7.52	16	25.9	5.6
	High	23	26.6	4.98	18	34.6*‡	12.0
Peak absolute VO_2 ($L{\bullet}min^{-1}$)	Low	17	1.46	0.31	16	1.53	0.43
	Moderate	22	1.66	0.52	16	1.56	0.39
	High	23	1.85*	0.35	18	2.26*‡	0.77
Peak RPP ($\times 10^4$)	Low	17	2.28	0.27	16	2.38	0.41
	Moderate	22	2.34	0.39	16	2.20	0.45
	High	23	2.41	0.34	18	2.36	0.60
Peak oxygen pulse ($mL{\bullet}beat^{-1}$)	Low	17	11.3	1.91	16	10.6	1.7
	Moderate	22	12.22	2.70	16	11.5	1.7
	High	23	13.78	1.61*	18	16.0*‡	2.9
Energy expended (kJ)	Low	17	41.75	14.1	16	22.17	9.7
	Moderate	22	44.32	12.6	16	22.43	5.2
	High	23	46.58	12.1	18	31.09*‡	6.6

Abbreviations: CRF, cardiorespiratory fitness; RPP, rate pressure product; VO_2, oxygen uptake
*Significantly different from low CRF
‡Significatly different from moderate CRF

treadmill, while our participants performed submaximal cycle ergometer exercise test at a linear incremental workload until steady HR was achieved.

The mechanism resulting in the observed higher SBP responses is not clear and was not tested in our study. We speculate that higher cardiac output, metabolic demand, central neural command, and baroreflex sensitivity may contribute to the greater SBP responses associated with higher CRF level. Systolic blood pressure normally rises with exercise as cardiac output increases during exercise in response to the increased metabolic demand from working muscles (29). In the current study, an increase in oxygen pulse (a surrogate for stroke volume), but not peak HR, was noted, implying that a greater cardiac output may have been the result of a higher stroke volume at peak exercise. A higher cardiac output is needed to match an increase in the metabolic demands of the exercising muscles. In the current study, those with higher CRF had a greater metabolic demand. For example, in both sexes, the highest CRF group presented with a greater estimated peak VO_2, attained greater peak workloads, and had a longer exercise duration. The high CRF group also had a higher peak oxygen pulse and expended more energy compared with lower CFR groups in females.

Central command plays an important role in the resetting of arterial baroreflex during exercise (30), and its magnitude is assessed using the RPE scale (31). In addition, changes in blood pressure are mediated by the baroreflex mechanism via HR changes (32). In the current study, the higher SBP response observed among those with higher CRF cannot be explained by the contribution of the central neural command since RPE did not differ among the CRF groups. However, this may be due to greater baroreflex sensitivity since changes in peak HR response increased with higher CRF levels (as observed in men).

The present study further indicated faster postexercise SBP recovery among participants with higher CRF. This finding is in agreement with a previous study (10) that associated a faster rate of SBP recovery with increase in aerobic capacity and fitness in middle-aged men. It was speculated that reduced sympathetic activity, increased vagal activation, reduced systemic vascular resistance, increased VO_2max and baroreflex sensitivity, and decreased metaboreflex sensitivity may be possible pathways by which higher CRF levels induce faster SBP recovery. For example, previous studies have associated delay in postexercise SBP recovery with an increase in systemic vascular resistance (8), and an increase in sympathetic activity and an attenuated parasympathetic reactivation (8,10), while a faster SBP recovery has been associated with increased VO_2max (10,33), a higher baroreflex sensitivity (34), and a decreased metaboreflex sensitivity (35).

Of all the aforementioned mechanisms, only the peak aerobic capacity (VO_2peak) of the participants was investigated in our study. Greater peak VO_2 was assumed among the higher CRF individuals. Based on longer tests, VO_2peak is considered the best measure of cardiovascular fitness and exercise capacity and can improve with regular physical exercise (36). Interestingly, regular physical exercise is associated with decreased sympathetic nervous system activity (37), decreased vascular resistance (38), greater vagal reactivation (39) and elevated parasympathetic tone (40), improved baroreflex sensitivity (41), and improved muscle and hemodynamic response to muscle metaboreflex activation (42,43).

We note that the incidence of abnormal (hypotensive, flat, or exaggerated) SBP response to exercise was very low in our study. A flat exercise BP response and a delayed postexercise SBP recovery were observed in one female from both moderate and low CRF groups, respectively. A flat response has been defined as a change in the SBP during effort less than 20 mmHg, compared with the resting SBP (20,44). A delayed SBP recovery is defined as value of the third minute SBP ratio relative to 1 min postexercise SBP that is >1.0 (9). Delayed SBP response has been linked with an increased risk of coronary heart disease, stroke, and emergence of hypertension (8–10). The low incidence of abnormal SBP responses in our study is likely because all participants were apparently healthy young adults, with no history of cardiovascular diseases.

CONCLUSION

This is, to the best of our knowledge, the first study to examine the relationships between CRF and exercise and postexercise SBP responses in healthy young Nigerian adult males and females. This is unique, as there is a paucity of research on CRF and blood pressure responses focusing on young Nigerians adults. In contrast to previous studies, the present study indicated greater SBP responses during exercise in those with a higher CRF level compared with those with lower fitness levels. These findings may suggest that regular exercise among young adults to ensure a higher CRF is associated with a healthy SBP response to physical exercise.

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