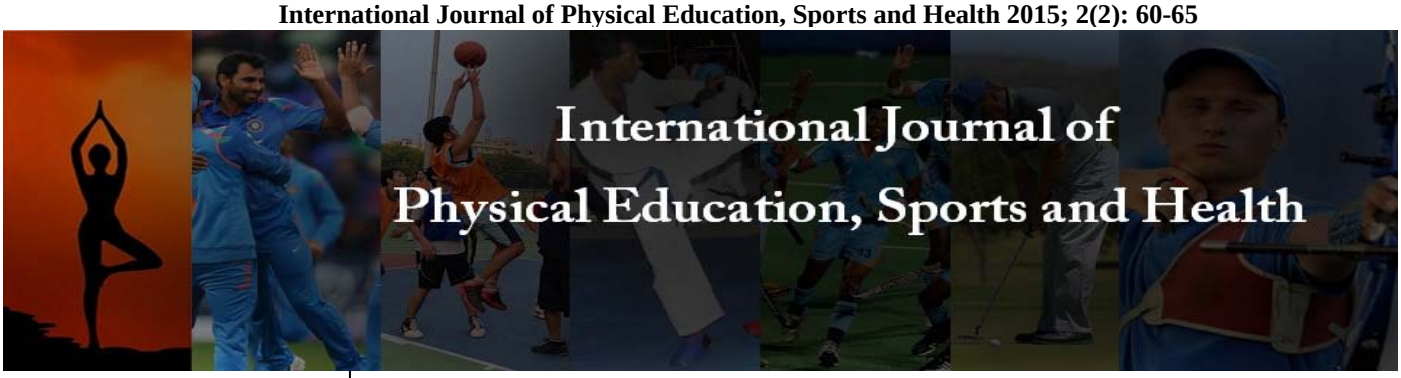

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Comparison of recovery cardiovascular responses of young physically active and sedentary Nigerian undergraduates following exercise testing

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Abstract
Purpose
The purpose of this study was to compare the recovery heart rate (HR) and blood pressure (BP) responses of sedentary (physically inactive) and physically active young subjects following a submaximal exercise test on a bicycle ergometer.
Methods
Apparently healthy sedentary university students who were matched for age with their physically active counterparts (N=102; mean age 24.84 ± 3. 215 years) participated in this study. All subjects performed exercise testing on a bicycle ergometer, and their HR and BP were measured before exercise, at peak-exercise, and at first, third and fifth minutes post exercise.
Results
The recovery HR drop at first, third and fifth minutes minutes post-exercise were significantly higher among the physically active participants than in their sedentary counterparts. Although the recovery systolic BP drop at the first and third minutes post-exercise were comparable for the groups, it was higher in the PA group than in the sedentary group five minutes into recovery.
Conclusion
Overall, the study affirms quicker return to hemodynamic equilibrium consistent with adaptations in physically active subjects, compared to their sedentary counterparts.

Keywords: Cardiovascular response, exercise, physically active, sedentary

Introduction
There is consensus that regular physical activity confers increased cardiac vagal tone [1-4] and that the speed at which heart rate (HR) and blood pressure (BP) return to resting level is faster in aerobically fit individuals than in sedentary individuals [4-7]. It is also the consensus that HR and BP changes during and immediately upon cessation of exercise are important indices of cardiovascular and autonomic nervous system's response to physical stress [8-11]
The rate at which the body respond to exercise is dependent on the cardiorespiratory fitness, cardiac autonomic nervous system modulation, hormonal level changes, baroreflex sensitivity and exercise intensity [4, 12]. Unlike in physically active state, sedentariness may cause a physiological state characterized by a shift towards the sympathetic side in a sympathovagal continuum [4, 13]. A delayed fall in HR and blood pressure following cessation of exercise has been hypothesized to be an important prognostic marker and a powerful and independent predictor of risk of death within one year [10, 14].
Recovery systolic blood pressure (SBP) has also been shown to be a useful clinical tool for diagnosing cardiovascular abnormalities [9, 13, 14], and there is consensus that aerobic capacity, can influence the rate at which the cardiovascular parameters return to resting level or hemodynamic equilibrium following a training stimulus [6, 13, 16]. A physically active individual is therefore expected to recover faster compared to a sedentary individual who perform a similar or comparable exercise.
Accessible studies on recovery responses following exercises and even nomograms on anthropometric indices such as BMI in the literature were on subjects in other parts of the world especially in Europe, North America and Asia [6, 7, 9, 10, 17] and there is paucity of reports from the Sahel region of Africa. The purpose of this study was to compare the recovery HR (RHR), systolic BP (SBP) and diastolic BP (DBP) responses to bicycle ergometer in sedentary

and physically active apparently healthy young adult undergraduates in a Nigerian university located in a Sahel region of the country. It was hypothesised that the HR and SBP drops one minute post exercise will be larger in the physically active group compared to their non-physically active, sedentary counterparts.

Materials and Methods

Participants

This pre-and post-test design study conveniently sampled 102 apparently healthy male participants who were available and willing to participate in the study. Sedentary young adult male students (n=51) of age 18-35 years, and their age matched self-described physically active male students who reportedly engages in regular exercises and physical activity (moderate-to-vigorous intensity aerobic activity for a minimum of 150 minutes per week) as per the current American College of Sports Medicine and WHO guidelines [18, 19] were recruited for the study. Subjects with history of hypertension or any cardiac disease, or those with smoking history, alcohol abuse, on medication for cardiac condition, those who are unable to walk or who have leg length discrepancy or any orthopaedic condition such as knee pain, ankle sprain or strain were excluded from participation.

Instruments

A physical characteristics and socio-demographic form was used to collect information about the subjects' height, weight, age, health history, and physical activity history. An adapted version of the International Physical Activity Questionnaire Short Form (IPAQ-SF) was used to collect information about the physical activity level of the participants [20]. A test-retest reliability co-efficient of 0.80 and criterion validity score of 0.39 have been documented for the IPAQ-SF, and it is considered to have acceptable measurement properties comparable to other self-reports measures of physical activity [21].

A digital electronic device (Life Source, Model UB-512) was used for the measurement of the participant's BP and HR. Bicycle ergometer (Kettler: HKS-selection ergometer EX1, Germany, Din. EN 957 Art. Nr: 0783-700, max Betastuy 110kg) was used for the submaximal exercise test. A floor type weighing scale attached with calibrated height meter (Hospibrand, model ZT 160, Great Britain) and calibrated from 1-160kg was used to measure the weights of the participants to the nearest 1.0 kilogram. The attached height meter is calibrated from 0 – 190cm with a headpiece on top and it was used to measure the height of each participant to the nearest 0.1cm. A Stop watch (Blackberry bold 2, 9700 model) was used for timing during testing and a Borg's Perceived Exertion Scale [22] was used for measurement of the Rated Perceive Exertion (RPE) of the participants.

The adapted IPAQ-SF assesses the time spent being physically active in the last seven days and measures vigorous-intensity activity (very hard intensity), moderate intensity activity (hard intensity), walking activity and sitting in terms of frequency (day/week) and duration (minute/day) and was used to estimate the participants' physical activity levels [20]. The activity category was first treated separately to obtain the physical activity behavior patterns among the participants, and the separate activity category was multiplied by their estimated values in metabolic equivalents (METs). The MET values for vigorous, moderate and walking were 8.0, 4.0 and 3.3 respectively [23].

Using the above values, three continuous scores comprising walking, moderate and vigorous activities were summed for a total MET to indicate physical activity level [21, 23]: Walking MET-minutes/week at work = 3.3 x walking minutes x walking days at work; Moderate MET-minutes/week at work = 4.0 x moderate-intensity activity minutes x moderate-intensity days at work; Vigorous MET-minutes/week at work = 8.0 x vigorous-intensity activity minutes x vigorous-intensity days at work; Total Work MET-minutes/week = sum of Walking + Moderate + Vigorous MET-minutes/week scores at work. The test-retest reliability (ICC= 0.33- 0.73) and concurrent validity (r=0.78-0.92) of the adapted IPAQ SF among adults in Nigeria are good and acceptable[21].

Procedure

This study was conducted in the University of Maiduguri Teaching Hospital (UMTH), Physiotherapy gymnasium. The Research and Ethical Committee of University of the UMTH approved the protocol of the study. An introductory letter from the Department of Medical Rehabilitation (Physiotherapy), University of Maiduguri explaining the purpose of the research was presented to the participants. A pilot study was conducted on two volunteer participants; one physically active and the other sedentary, to provide an idea on possible responses to be anticipated and to give an estimate of the possible exercise time that may be tolerable by the participants.

On first encounter, the purpose of the research was fully explained to each of the participants. Prospective participants were advised not to take *kola nut* (a local fruit considered to be stimulant), cigarette or heavy meal less than one hour prior to the next encounter during which their cardiovascular parameters and recovery responses were assessed. Participants completed the IPAQ-SF in their hostels, with the researcher (P.E) in attendance to ensure independent responding and assist participants who had questions about the survey. The questionnaire was used to first classify participants into the physically active or inactive groups.

Participants who engage in any of 3 or more days of hard intensity activity of at least 20 minutes per day, or 5 or more days of hard intensity of at least 30 minutes per day, or 5 or more days of any combination of walking, hard intensity or very hard intensity activities achieving a minimum total physical activity of at least 600 MET- minutes/week were classified as PA. Male students who report no or irregular physical activity enough to meet the above criteria for physical activity were classified as physically inactive (PI) or sedentary. Participants with more than 450 minutes per day of sitting time were considered as sedentary. The mean time spent in sedentary activities among male Nigeria students has previously been reported as 7 hours 30 minutes per day [24].

On second encounter which took place at least 24 hours after the first encounter, the physical and socio-demographic form was completed. All the participants were seated in a wellventilated room for at least 30 minutes prior to the exercise test. The participants were properly instructed on how to perform the test. The pre-exercise HR and blood pressure were measured using a digital electronic device attached to their wrist (Life Source, Model UB-512) at least five (5) minutes upon assuming resting sitting position on a chair.

The test was carried out at early hours of the morning and from mid-day up to about 8 pm in the evening each day as convenient for participants, at a room temperature maintained at 20-25 ^{o}C. The testing protocol comprised an initial 2 minutes warm up exercise at a work load of 25 Watts maintained at 50-60 rotation per minute (RPM), followed by a linear increase in workload every two minutes until a point

where participants can no longer continue to exercise or 2 minutes upon attainment of 70% of age-predicted HR_{max}. Those participants who attained 70% of their age predicted HR_{max} were encouraged to continue the exercises for at least 2 more minutes. The age-predicted HR_{max} was determined using the formula [HR_{max} = 208 - (0.7 x age)] by Tanaka *et al* [26].

The peak-exercise HR was the highest value achieved at the termination of exercise test, after the participant can no longer continue to exercise or 2 minutes after a participant had reached his predetermined HR of 70% of maximum HR (HR_{max}). The post-exercise HR was obtained 1 minute, and then subsequently at 2 minutes interval after the first measurement, up to 5 minutes after cessation of exercise. The peak-exercise SBP and DBP were also recorded within 2 minutes on attaining 70% age predicted HR_{max} and also 1 minute, and then at 2 minutes interval after the first measurement up to 5 minutes into recovery. The absolute and relative decrease in HR and BP at the first minute, and at 2 minutes intervals after the first measurement up to 5 minutes into recovery were determined.

The relative decrease in HR and BP immediately after exercise were calculated as a percentage of peak-HR: (peak-HR–post-HR) / peak-HR x 100^6 and peak-BP: (peak-BP – post-BP) / peak-BP x100 [12, 26]. The RPE was measured using the Borg's scale which ranges from 6-20, where 6 mean "no exertion at all" and 20 means "maximal exertion". Two (one sedentary and one physically active) participants who reported dizziness after the end of the exercise-test were immediately positioned in sitting and the supine and their blood pressure and HR were monitored. Two minutes upon placement in the supine position, their HR and blood pressure were observed to be within safe limit and they were then placed back into sitting position. After 5 minutes into sitting position, no symptoms were reported but they were advised to see their doctors.

Data Analysis

Descriptive statistics of mean and standard deviation, percent, and frequency, were used to summarize the physical characteristics and the recovery HR and BP responses of the subjects. Student t-test was used to determine the difference in the recovery HR and BP of sedentary and physically active apparently healthy young adult male students. Analysis of Covariance (ANCOVA) test (adjusting for pre-exercise differences in HR and DBP) was conducted to determine the difference in recovery HR and DBP between the physically active and sedentary groups. The level of significance was set at $p < 0.05$.

Results

The physical characteristics, physical activity levels and cardiovascular characteristics of the participants are reported in table 1. The mean age and BMI of the participants were 24.84 ± 3.19 and 21.85 ± 3.02 kg/m^2 respectively. Majority of the participants (n=77, 75.5%) were of normal weight. There was no significant difference in BMI, Pre-exercise RPE and Predicted HR_{max} between the physically active (PA) group and physically inactive (PI) or sedentary groups. Significant differences were found for physical activity levels and peak-exercise RPE, with the PA group having higher physical activity levels (3326.50 MET-Min/wk vs 388.90 MET-Min/wk; p<0.001) but lower peak-exercise RPE (16.35 vs 17.35, p=0.01) compared to the PI group. Also the PA subjects achieved significantly higher peak power or exercises intensity (150.98±23.43 vs 113.78 ±24.69) and exercise time duration (11.31±1.77 vs 8.55±2.10) compared to their sedentary counterparts.

Heart rate responses

Table 2 shows the pre-exercise, peak exercises and post exercise heart rate, systolic and diastolic blood pressure responses of the participants. The mean values for the pre-exercise HR of the sedentary and physically active subjects were 78.56 ± 9.56 and 67.37 ± 7.81 respectively. The mean peak-exercise HR of the sedentary and physically active participants, were 113.55 ± 16.56 and 123.82 ±17.52 respectively, while the mean HR reserve for the sedentary and physically active participants were 34.99 ± 15.63 and 56.45 ± 14.27 respectively. Pre-exercise HR (p<0.001) were significantly lower in the PA group compared to the PI group, and higher HR reserve were observed for physically active participants than in their sedentary counterparts.

Table 1: Physical characteristics, physical Activity level, predicted maximum heart, RPE, power and exercise time duration of the participants

Parameters	Sedentary (n = 51)	Physically active (n = 51)	Statistical value	p-value
Pre exercise HR	78.56 ± 9.56	67.37 ± 7.81	6.47	0.00**
Peak-exercise HR	113.55 ± 16.56	123.82 ±17.52	-20.75	0.00**
Post-exercise HR1	96.59 ± 14.35	92.22 ±16.55	19.07	0.00**
Post-exercise HR2	93.08 ± 11.24	87.78 ± 13.60	29.73	0.00**
Post-exercise HR3	89.88 ± 11.21	83.18 ± 12.43	32.84	0.00**
HR reserve	34.99 ± 15.63	56.45 ± 14.27	-7.24	0.00**
Pre- exercise SBP	111.18 ±12.15	115.63 ± 10.08	-2.02	0.05 NS
Peak-exercise SBP	122.84 ± 16.69	134.10 ± 17.89	-3.29	0.00**
Post-exercise SBP1	113.86 ± 15.94	121.27 ±13.36	-2.54	0.00**
Post-exercise SBP2	109.75 ± 15.08	115.90 ± 12.61	-2.33	0.03**
Post-exercise SBP3	107.67 ± 10.99	113.14 ±10.81	-2.53	0.01**
Pre exercise DBP	70.31 ± 9.05	74.05 ± 8.09	-2.20	0.03*
Peak-exercise DBP	74.67±12.82	78.76 ± 10.39	14.86	0.00**
Post-exercise DBP1	71.27 ±11.91	74.33 ± 9.84	20.23	0.00**
Post-exercise DBP2	66.94 ± 11.47	70.45 ± 8.56	20.28	0.00**
Post-exercise DBP3	66.94 ± 9.33	70.12 ± 10.01	20.43	0.00**

All values are mean ±SD (standard deviation); n= number of the participants. BMI = body mass index. Power = the mean intensity in watts at which participants in both groups stopped the exercise test. Time = the mean time in minutes at which the participants in the groups stopped the exercise.

NS p>0.05= not significant,

Table 2: cardiovascular responses at rest, at peak exercise and during recovery

Parameters	Sedentary	Physically active	Statistical	p-value
	(n = 51)	(n = 51)	value	
Pre exercise HR	78.56 ± 9.56	67.37 ± 7.81	6.47	0.00**
Peak-exercise HR	113.55 ± 16.56	123.82 ±17.52	-20.75	0.00**
Post-exercise HR1	96.59 ± 14.35	92.22 ±16.55	19.07	0.00**
Post-exercise HR2	93.08 ± 11.24	87.78 ± 13.60	29.73	0.00**
Post-exercise HR3	89.88 ± 11.21	83.18 ± 12.43	32.84	0.00**
HR reserve	34.99 ± 15.63	56.45 ± 14.27	-7.24	0.00**
Pre- exercise SBP	111.18 ±12.15	115.63 ± 10.08	-2.02	0.05 NS
Peak-exercise SBP	122.84 ± 16.69	134.10 ± 17.89	-3.29	0.00**
Post-exercise SBP1	113.86 ± 15.94	121.27 ±13.36	-2.54	0.00**
Post-exercise SBP2	109.75 ± 15.08	115.90 ± 12.61	-2.33	0.03**
Post-exercise SBP3	107.67 ± 10.99	113.14 ±10.81	-2.53	0.01**
Pre exercise DBP	70.31 ± 9.05	74.05 ± 8.09	-2.20	0.03*
Peak-exercise DBP	74.67±12.82	78.76 ± 10.39	14.86	0.00**
Post-exercise DBP1	71.27 ±11.91	74.33 ± 9.84	20.23	0.00**
Post-exercise DBP2	66.94 ± 11.47	70.45 ± 8.56	20.28	0.00**
Post-exercise DBP3	66.94 ± 9.33	70.12 ± 10.01	20.43	0.00**

All values are mean ±SD (standard deviation) in mmHg; n= number of the participants. SBP=Systolic blood pressure, DBP= diastolic blood pressure; When recovery variables are followed by numerals it denotes value of the variable during recovery. For example Post exercise SBP1, -2, -3 denotes recovery systolic blood pressure at 1 minute, 3 minutes and at 5 minutes into recovery respectively; HRR = heart rate reserve (peak-exercise HR - HR_{rest}). $^{NS}p > 0.05$; not significant; $^{*}p<0.05$; significant, $^{**}p<0.01$; highly significant. Statistical values for peak exercise and post exercise HR and DBP are from Analysis of Covariance test while all other cardiovascular values are from t-test.

Systolic blood pressure responses

The mean pre-exercise SBP of sedentary and physically active participants were 111.18 ±12.15 and 115.63 ± 10.08 respectively. There was no significant difference in the pre-exercise SBP between the groups (p = 0.05). The mean peak-exercise SBP values of the PI and PA groups were 122.84 ± 16.69 and 134.10 ± 17.89 respectively. The mean value of the difference between the peak and pre-exercise SBP for the PI and PA participants were 12.71 ± 12.38 and 16.93 ± 16.56 respectively. Significantly higher (p <0.001) mean peak-exercise SBP were observed for the PA group compared to the PI group.

Diastolic blood pressure responses

The mean values for pre-exercise DBP of the sedentary and physically active participants were 70.31 ± 9.05 and 74.05 ± 8.09 respectively. The mean values of peak-exercise DBP of the sedentary and physically active participants are 74.67 ± 12.82 and 78.76 ± 10.39 respectively. The mean values of the one minute post-exercise DBP of the PI group and PA group were 71.27 ± 11.91 and 74.33 ± 9.84 respectively. Significantly higher (p = 0.03) pre-exercise DBP was observed for the PA group compared to the PI group.

Recovery heart rate and blood pressure responses

Recovery cardiovascular responses drop of subjects (absolute values and percentages) were presented in Table 3. The mean HR drop at one minute post-exercise for the sedentary and physically active participants were 16.96± 6.86 and 31.61± 6.29 respectively and the corresponding percent values ware 14.79 ± 5.93 and 25.88 ± 5.83 respectively. Significantly higher (p<0.01) absolute and percent drop in recovery HR at 1 minute, 3 minutes and 5 minutes post-exercise were observed for PI participants than in their PI counterparts.

The mean SBP drop one minute post-exercise for the sedentary and physically active participants were 8.98 ± 8.77; 12.82± 15.91 respectively, while the corresponding percent values were 7.13 ± 7.58 and 8.83 ±10.22 respectively. There was however no significant between group differences in the absolute and percentage drop in SBP at 1 or 3 minutes into recovery. Significantly higher drop (p< 0.001) in SBP 5 minutes into recovery were observed for the PA group compared to the PI group. The mean DBP drop at one minute post-exercise of the PI and PA participants were 3.39± 7.84 and 4.43± 9.81 respectively while the corresponding percent values were 3.43 ± 14.39 and 4.84 ± 12.95 respectively. There was also no significant between group difference in the absolute and percent DBP drop at any of the recovery times.

Table 3: Comparison of recovery heart rate and blood pressure drops among the two groups

Parameters	Sedentary	Physically active	t-value	p- value
	(n = 51)	(n = 51)		
Rec HR 1	16.96± 6.86	31.61± 6.29	-11.23	0.00**
% Rec HR1	14.79 ± 5.93	25.88 ± 5.83	-9.52	0.00**
Rec HR 2	20.47 ± 9.38	36.04± 8.49	-8.79	0.00**
% Rec HR2	17.44 ± 7.14	29.08 ± 5.35	-9.31	0.00**
Rec HR 3	23.67± 9.33	40.65± 9.28	-9.22	0.00**
% Rec HR3	20.30 ± 6.89	32.74 ± 5.24	-10.27	0.00**
Rec SBP1	8.98± 8.77	12.82± 15.91	-1.51	0.14NS
% Rec SBP1	7.13 ± 7.58	8.83 ±10.22	-0.95	0.34 NS
Rec SBP 2	13.09± 11.36	18.19± 16.53	-1.82	0.07NS
% Rec SBP2	10.29 ± 9.25	12.68 ± 10.96	-1.19	0.24 NS
Rec SBP 3	15.18± 12.75	20.96± 15.01	-2.10	0. 04*

% Rec SBP3	11.52 ± 10.01	14.73 ± 9.95	-1.63	0.11 ^{NS}
Rec DBP 1	3.39± 7.84	4.43± 9.81	-0.59	0. 56^{NS}
% Rec DBP1	3.43 ± 14.39	4.84 ± 12.95	-0.52	0.60 ^{NS}
Rec DBP 2	7.73± 8.73	8.31± 12.46	-0.28	0. 78^{NS}
% Rec DBP2	9.31 ± 14.07	9.09 ± 16.13	0.07	0.94 ^{NS}
Rec DBP 3	7.73± 8.79	8.65± 12.03	-0.44	0. 66^{NS}
% Rec DBP3	8.99 ± 12.31	9.92 ± 14.63	-0.35	0.73 ^{NS}

All values are mean ±SD; Blood pressures in mmHg; HR in beats per minute; SBP-systolic blood pressure, DBP= diastolic blood pressure; Rec preceding variable denotes recovery; Recovery variables followed by an Arabic numerals denotes drops in the value of the variable during recovery. For example Rec HR1, -2, -3 denotes recovery heart rate drop at 1 minute, 3 minutes and at 5 minutes into recovery post-exercise and %RecHR1,-2,-3 denotes percentage drop in heart rate at 1 minute, 3 minutes and at 5 minutes into recovery post-exercise when compared with peak exercise values.

^{NS} $p>0.05$= not significant, *= significant at $p<0.05$, ** =significant at $p<0.01$.

Discussion

Physical Characteristics and Resting Cardiovascular Parameters of Subjects

The physical characteristics of the subjects in both the PA and PI groups were similar as reflected in their heights, weight and BMI. The physical activity status of the subjects as reported on IPAQ was also validated by the subjects' time duration on exercise and power attained on the bicycle ergometer. This shows that any differences may be validly attributed to differences in the physical activity or aerobic fitness status between the groups.

Lower pre-exercise resting HR of the PA group compared to that of the PI group observed in the present study is consistent with the consensus in the literature [6-8], No significant difference in the pre-exercise SBP between the PA and PI participants was observed, consistent with a previous report by Haroonrashid *et al.* [6] However, unlike the study by Haroonrashid[6], our study shows a higher pre-exercise DBP for the PA participants ($p<0.05$) than that of the PI participants.

Comparison of peak and recovery heart rate

In the present study, it was observed that the peak-exercise HR of the physically active participants was significantly higher ($p<-.-1$) than that of the sedentary participants, similar to findings by Haroonrashid *et al.* [6] Peak values following submaximal exercise is a function of the response to exercises which is characterized by heightened deactivation of the vagal tone and activation of sympathetic tone in the PA subjects compared to the PI subjects. The absolute and percent heart rate drop for the PA participants was significantly higher than that of their PI participants at first, third and at fifth minutes post exercise, similar to findings in other studies [6, 7, 28].

Comparison of peak and recovery blood pressures

Significantly higher ($p<0.01$) peak-exercise SBP observed for the PA participants compared to those of their PI counterparts is consistent with findings in the study by Haroonrashid *et al.* [6] This can be attributed to increase in left ventricular mass due to training-induced augmentation of early diastolic filling at rest and during exercise in physically trained subjects [27]. Significantly higher ($p<0.05$) peak DBP observed in the PA group compared to the PI group was not reported in any previous study.

There was no significant difference in the recovery SBP drop between the groups at first and at the third minute post exercise, contrary to findings by Haroonrashid *et al* [6], which reported higher recovery SBP drop in the PA participants than in the PI group. At the fifth minutes post-exercise though, the recovery SBP drop was significantly higher ($p<0.05$) in the PA group than in the PI group, similar to finding by Manpreet and Aditya [7].

Conclusion

The present study shows the physically active subjects' response to exercise on bicycle ergometer is consistent with training adaptation when compared to their sedentary counterparts. The PA group also show higher HR drop one, three and five minutes post-exercise compared to the PI group. Although the recovery SBP dropped at the first and third minutes, post-exercise were comparable for the groups, it was higher in the PA participants than in the sedentary participants five minutes into recovery. Overall, the study affirms higher positive inotropic and chronotropic response to exercise and early return to hemodynamic equilibrium consistent with adaptations in physically active participants, compared to their sedentary counterparts.

Conflict of interest

Authors declare has no conflict of interest associated with this paper.

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