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Maximum Heart Rate and Blood Pressure in Exercise-Trained and Sedentary Healthy Males in Ilorin, Nigeria

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Abstract: The effect of exercise-training on heart rate and blood pressure both at rest and after an all out effort on a bicycle ergometer was studied in 87 healthy Nigerian males. The age groups of the subjects are 15-19, 20-24, 25-29 and 30-34 years. Results showed that exercise-trained individuals have a significantly lower resting rate ($p<0.05$) and a significantly lower maximum heart rate ($p<0.05$) than sedentary individuals in all the age groups. However, no significant difference was recorded in the blood pressure (both systole and diastole) between exercise-trained and sedentary individuals in all the age groups. Endurance training, through improvement of heart efficiency may improve cardiac autonomic balance; increasing parasympathetic while decreasing sympathetic stimulation of the heart. Exercise training results in markedly lower heart rate readings in exercise-trained individuals compared with sedentary individuals.

Key words: Exercise-trained, resting heart rate, maximum heart rate, blood pressure, sedentary, individuals

INTRODUCTION

Heart rate is a relative accurate indicator of cardiovascular work intensity; most exercise prescriptions use heart rate as a preferred measure of exercise intensity (George and Kukielka, 2007). The influence of endurance training on heart rate is one of the most commonly used and easily understood standards for measuring the intensity and effort of physical exercise. The theoretical basis behind this is that at low to moderate exercise intensity there is linear relationship between exercise intensity and the observed heart rate response. But this does not hold true once the activity level becomes very intense. The actual point at which heart rate and exercise intensity fail to increase in a linear fashion is termed the heart rate deflection point. Physiologically, this point represents an important transitional event where the subject shifts from aerobic to anaerobic energy supply (Whyte *et al*., 2008). The heart rate corresponding to this point is called the maximum heart rate. The phenomenon by which there is an increase in heart rate during exercise over time is termed cardiac drift and the maximum heart rate is the level at which there is no further increase in heart rate with exercise (Wilmore and Costill, 2005).

Various factors affect heart rate, among which are circulating levels of different hormones, temperature, altitude, posture and drugs. Nonetheless, heart rate is still maintained at a level consistent with pumping of enough blood to meet the tissue demand. Regular physical activity is an important factor in the prevention and treatment of cardiovascular diseases. Large clinical studies demonstrated a reduction of morbidity and mortality among physically active individuals as compared to sedentary controls in both health and cardiovascular disease (Nylen *et al*., 2010). As for primary prevention, daily walking of 2 miles reduced the mortality of non-smoking retired men as did brisk walking for at least 2.5 h week^{-1} in postmenopausal women (Hakim *et al*., 1998). In the presence of coronary artery disease, hypertension and heart failure, exercise training as secondary prevention or adjunctive therapy was associated with a significant reduction of morbidity and mortality (Georg and Hambrecht, 2005).

Exercise-training leads to a variety of changes in cardiovascular function including reduced heart rate, reduced blood pressure, increased maximal myocardial oxygen uptake, increased vascular expression of endothelial Nitric Oxide Synthase (eNOS) and adaptations involving skeletal muscle, cardiac muscle, circulating blood volume and various metabolic modifications (Jouven *et al*., 2005). Exercise-training has also been reported to have antioxidative effects, mediated via mechanisms including upregulation of Superoxide Dismutases (SOD1, SOD3) and downregulation of NADPH oxidase which likely blunts the effects of oxidative stress. Of these beneficial training effects,

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reduction of blood pressure and inhibition of atherogenesis are mainly mediated by changes of vascular biology (Georg and Hambrecht, 2005). Although, health benefits of routine exercise has been heavily exploited, there is dearth of information on the cardiovascular effects of exercise training in apparently healthy Nigerian males while the reports of reduced blood pressure observed after exercise training were conducted mostly in the elderly (60-81 years old) or aged hypertensive patients (Ohkubo *et al*., 2001). The purpose of the present study is to examine the significance of exercise training on cardiovascular function of presumed healthy Nigerian males.

MATERIALS AND METHODS

Subject selection criteria: Exercise trained subjects were recruited from sports men in the university stadium, University of Ilorin while sedentary individuals were recruited amongst students.

Vital signs were checked and 67 of initial 87 subjects were screened for this study. Inclusion criteria were age between 15 and ≤35 years, no previous history of any heart disease or chronic systematic disease, not presently on any medication, no history of drug addiction or smoking habit. Excluded were individuals with high blood pressure (systole ≤140 mmHg and diastole ≤90 mmHg), obese individuals (BMI ≤30), asthmatic patients and diabetic patients.

Exercised-trained individuals were recruited from athletes and footballers while students who live an average life without any form of exercise or endurance work were classified as sedentary individuals. All willing subject gave written informed consent and experiment was conducted between 7 and 10 a.m.

Measurement of heart rate and blood pressure: Blood pressure was measured with the HEM 705CP (Omron Life Science Kyoto, Japan), a fully automatic device, based on the Cuff-oscillometric Method that generates a digital display of systolic BP, diastolic BP and HR. This device has been validated previously and meets the criteria of the Association for the Advancement of Medical Instrumentation and the British Hypertension Society (O`Brien *et al*., 1996).

Experimental procedure: Subjects were allowed to rest in a relaxed sitting position for 20 min. Thereafter, resting heart rate and blood pressure were measured for about 3 times or until values were constant. Body weight and height measurement were taken without shoes using a standard weight and height scale, respectively. Also, ages as provided by the subjects were taken to the nearest birthday. Maximum heart rate and blood pressure were measured immediately after an all out effort during pedaling of a bicycle ergometer, lasting not >4 min.

Exercise protocol: Exercise test to exhaustion was conducted on a bicycle ergometer. The subjects were made to stretch and warm-up before proceeding and were urged to give their best. The seat height of the ergometer was adjusted to conform to the length of the subject's leg with a very small angle in the knee when the foot was resting on the pedal and at the bottom of the pedal stroke. The subject was made comfortable before the experiment began. As the subject began pedaling, the resistance was set to 0.5 KPa. The subject was allowed to get accustomed to the cadence and thereafter, the timer was started to begin the experiment. After the 1st min, the heart rate was taken and recorded; the resistance was then increased to 1.5 KPa. Readings of the heart rate was taken after subsequent minutes by increasing the resistance by 0.5 KPa each minute. This was continued until the subject can no longer maintain the cadence or insist on stopping. Verbal encouragement was given throughout the exercise in an attempt to ensure that individual used maximum effort.

Statistical analysis: Data are expressed as mean±SEM and analyzed using the student's t-test and ANOVA where necessary. The $p<0.05$ was accepted as significant.

RESULTS

Eefect of exercise training on heart rate: In all age groups, exercise-trained subjects had a statistically significantly lower RHR than sedentary individuals ($p<0.05$). However, with the exception of age group 20-24 years where MHR is apparently but not statistically lower in the exercise-trained, all other age groups have a statistically significantly lower MHR when compared with the corresponding sedentary age group (Table 1).

Eefect of exercise training on blood pressure: There was no significant difference between the systolic blood pressure of the exercise-trained athletes when compared

Table 1: Resting Heart Rate (RHR) and Maximum Heart Rate (MHR) in exercise trained and sedentary individuals

Age group (years)	RHR (bpm)		MHR (bpm)	
	Sedentary	Exercise-trained	Sedentary	Exercise-trained
15-19	77.2±3.29	71.2±1.07	136.9±3.53	130.2±0.86
20-24	74.3±2.40	68.3±3.97	131.9±4.57	122.7±7.84
25-29	69.4±1.94	64.2±2.60	130.7±6.50	105.3±2.95
30-34	68.4±1.13	58.6±1.52	126.3±5.46	99.4±2.24

Table 2: Systolic blood pressure in exercise trained and sedentary individuals

Age group (years)	Systolic blood pressure (mmHg) Before exercise Sedentary	Before exercise Exercise trained	After exercise Sedentary	After exercise Exercise trained
15-19	121.7±2.28	122.0±1.92	142.9±3.20	141.2±2.35
20-24	124.1±2.55	123.8±2.27	151.0±5.26	147.0±5.93
25-29	130.2±4.80	129.2±3.52	146.4±4.54	145.5±4.86
30-34	134.6±2.80	128.7±3.69	157.9±4.80	156.0±3.80

Table 3: Diastolic blood pressure in exercise trained and sedentary individuals

Age group (years)	Diastolic blood pressure (mmHg) Before exercise Sedentary	Before exercise Exercise trained	After exercise Sedentary	After exercise Exercise trained
15-19	77.9±2.17	75.2±1.71	82.8±3.40	80.2±4.20
20-24	79.0±1.76	77.5±2.89	87.4±3.07	85.7±3.76
25-29	85.4±4.60	85.5±4.60	90.8±3.70	89.8±2.48
30-34	86.6±4.31	86.3±2.49	88.9±4.27	88.0±2.08

with that of the sedentary individuals in all the age groups studied both at rest and after maximal exercise (Table 2). The same holds true for the diastolic pressure (Table 3).

DISCUSSION

This study showed that exercise-trained subjects have a significantly lower resting heart rate than sedentary individuals in all the age groups studied and this is consistent with the research of Huang *et al*. (2005) who reported decrease in resting heart rate after endurance training in elderly subjects. Miguel Indurain (Big Mig who won the Tour de France in 5 successive years) had a resting heart rate of 28 bpm and Lance Amstrong (won Tour de France 7 consecutive times) also had a RHR as low as 30 bpm.

The mechanism by which exercise training reduces RHR remains to be elucidated but it is postulated that endurance training through improvement of heart and lung efficiency attenuates neural input to the heart, resulting in a markedly lower reading (Wilmore and Costill, 2005).

However, the maximum heart rate of the exercise trained was also found to be significantly lower than the sedentary individuals. The resting and maximum heart rate was however, found to decrease with age in both study groups. However, exercise training was shown to have no significant effect on the blood pressure both systolic and diastolic pressure both at rest and after exercise in healthy individuals.

Although, it is generally accepted that regular physical activity also reduces blood pressure and prevents hypertension there is still inconsistency among existing studies documenting these effects (Ohkubo *et al*., 2001). Cross sectional studies have shown that physically active individuals tend to have lower blood pressure than their sedentary counterparts but this association is not always observed for coronary risk factors.

Population-based Cohort studies suggest that being physically active is associated with a reduced incidence of hypertension. Likewise, intervention trials tend to demonstrate that exercise has a significant blood pressure lowering effect.

However, several meta-analyses have shown that many of these trials had major design limitations such as lack or an inadequacy of a control group or a small sample size. Furthermore, trials with a smaller number of subjects or with an inadequate control group tended to report a greater reduction in BP than did studies with a larger sample size or adequate control groups (Halbert *et al*., 1997). Older people have an increased incidence of short-term variations in BP and show a large white-coat effect.

Therefore, it is difficult to determine the true effect of exercise training on BP using the conventional type of BP measurement which is known to be influenced by several biases such as observer bias, regression dilution bias and the white-coat effect (Ohkubo *et al*., 2001).

CONCLUSION

This study reveals that Resting Heart Rate (RHR) and Maximum Heart Rate (MHR) are significantly lower in exercise-trained Nigerian males when compared with age matched sedentary counterparts. However, no difference in blood pressure was observed between the two groups. The mechanisms underlying these remain to be clearly defined.

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