ORIGINAL ARTICLE

Effects of low intensity interval training on physiological variables of university students

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Abstract

Background and Study Aim This study was to investigate the effects of low-intensity interval training on the physiological variables of university students.

Material and Methods Forty male sports science students aged 18-25 years were randomly assigned to the Experimental group (n=20) and the Control group (n=20). The Experimental group underwent low-intensity interval training for eight weeks, whereas the Control group did not. Measurements of physiological variables such as resting heart rate, respiratory rate, recovery heart rate, breath-hold time, maximal oxygen uptake, and blood pressure were obtained for all subjects before and after the intervention. To compare the mean physiological variables between the experimental and control groups, an independent samples t-test was used.

Results Statistical significance was set at p 0.05. After the training intervention, the experimental group showed significantly better improvements than the control group in resting heart rate, respiratory rate, recovery heart rate, breath-holding time, maximal oxygen uptake, and blood pressure (p 0.05). Post intervention maximum oxygen uptake was statistically significant with t (38) = 3.086, p value 0.004. Post experiment systolic blood pressure was statistically significant with t (38) = -2.405, p value 0.021 for low intensity interval training and control group. Post experiment diastolic blood pressure was statistically highly significant with t (38) = 0.569, p value 0.001 for low intensity interval training and control group. The result of the study showed that there was a significant difference in post rest heart rate, respiratory rate, recovery heart rate, systolic blood pressure, diastolic blood pressure, breath holding and maximal oxygen uptake between the low intensity interval training and the control group (p 0.05).

Conclusions: Thus, it was concluded that eight weeks of low-intensity interval training show significant improvement in physiological variables of university students.

Keywords: blood pressure, breathe holding time, maximal oxygen uptake, resting heart rate, recovery rate.

Introduction

Interval training refers to the basic concept of alternating periods of relatively intense exercise with periods of lower-intensity or complete rest for recovery. Low-volume interval training refers to sessions that involve a relatively small amount of exercise [1]. Low-intensity interval training (LIIT) is the minimum exercise intensity threshold for improving aerobic capacity at a minimum 40 - 45% maximal oxygen uptake (Vo2max) [2-5]. Low-intensity resistance exercise provides successful results when performed with circulatory occlusion, even for a short duration of training [6].

Low-volume high-intensity interval training seems to be an efficient and practical way to develop physical fitness [7]. Low-intensity training consisted of treadmill running 3 days/week, 55 min/day, for 15 weeks, beginning and started 2 months post banding (≈10 months old) with gradually increasing intensity, as tolerated, until finally consisting of: 1) 5-min warm-up at 2 mph; 2) six 5-min sessions at 3 mph with five 3-min intervals at 4 mph in between; and 3) 5-min cool down at 2 mph [8-10].

Low-intensity interval training preserved normal coronary vascular function and smooth muscle cell Ca2 -sensitive IK+, illustrating a potential mechanism underlying coronary vascular dysfunction in a large-animal model of Left ventricular(LV) hypertrophy. Low-intensity interval training attenuated increased fibrosis, collagen deposition, and mitochondrial dysfunction. Low-intensity interval training preserved normal coronary vascular function in vivo and maintained coronary smooth muscle cell Ca2 -sensitive IK in miniature swine with LV hypertrophy [8].

The low-intensity exercise-induced decreases of resting heart rate (RHR) was positively related with the pre-interventional RHR and negatively with the average age of the participants. The exercise-especially endurance training and yoga-decreases RHR. This effect may contribute to a reduction in all-cause mortality due to regular exercise or sports [11]. The aerobic fitness was associated with RHR in both sexes, indicating that lower aerobic fitness values were associated with higher RHR values [12].

Low-intensity exercise training applied during chronic Doxorubicin treatment protects against cardiac dysfunction following treatment, possibly by enhancing antioxidant defenses and inhibiting apoptosis [13]. Low-intensity norm duration training significantly improved peak aerobic and sprint power output, efficiency and physical strain in able-bodied untrained individuals. Training at 30% recovery heart rate (HRR) (3- 6/week, 30

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min/session) may be appropriate in untrained individuals, such as novice wheelchair users at the start of their rehabilitation, to prevent early fatigue and overuse and enhance motivation [14].

Data suggest that high-intensity interval training was equally effective as endurance training in decreasing mean arterial pressure, Systolic blood pressure (SBP), diastolic blood pressure (DBP), and circulating C-reactive protein. High-intensity interval training was equally as effective as endurance training in improving V̇O2max. Importantly, these effects seen with high-intensity interval training occurred with substantially less total exercise time and volume than endurance training [15-17].

Low volume high-intensity interval exercise can considerably improve aerobic fitness, body composition, and cardio metabolic health in a variety of populations [18-20]. Low-intensity exercise training significantly delays the onset of heart failure and improves survival in female hypertensive heart failure rats without eliciting sustained improvements in blood pressure, cardiac function, or expression of several myocardial proteins associated with the cardiovascular benefits of exercise [21]. Chronic low-intensity interval training attenuates diastolic impairment by promoting compliant extracellular matrix fibrotic components and pre- serving extracellular matrix regulatory mechanisms preserve myocardial oxygen balance and promote a physiological molecular hypertrophic signalling the phenotype in a large animal model resembling heart failure with preserved ejection fraction [10].

Daily physical activity level was correlated with systolic blood pressure during resistance exercise at 20% and 40% 1 RM, and that systolic blood pressure during resistance exercise decreased after 6 wks of aerobic exercise training. These results suggest that habitual exercise decreases systolic blood pressure during low-intensity resistance exercise [22].

Children and adolescents are recommended to undertake at least 60 min of daily moderate to vigorous exercise [23]. However, studies with objective assessment of physical activity show a significant decline in physical activity in childhood and adolescence [24] and that few children and adolescents meet the recommended daily dose of physical activity [25, 26]. The goals of physical training are to increase the physiological potential of the athlete and to develop bio-motor skills at the highest level [27]. University students represent the future of families, communities, and countries. They are exposed to pressures as they try to achieve their academic goals and are likely to become future leaders in their society, whether in business, education, or politics. It has been argued that health is an important factor in academic success in school and higher education.

According to the above results on low-intensity interval training has a positive effect on physiological variables. The result of this study may be important to physical education teachers, fitness instructors, and coaches who should incorporate a variety of low-intensity interval training methods for physiological variables to improve the physical fitness level of their trainees.

Materials and Methods

Participants

There are currently 103 male sports science students in the study area. Out of them 40 sample students were selected using simple random sampling technique.

To achieve the purpose of the study, the untrained male sports science students were selected from those who were not in any playing or sports team or training program and also free from deformities and ailments. They were randomly divided into two groups, low-intensity interval training (LIIT) group (n=20) and control (C) group (n=20). The experimental (E) group was trained with LIIT and the control group received no training.

A true experimental design was used in this study. According to Guetterman et al., and Bryman, such design helps to generalize and predict from a sample population so that inferences can be made about the outcome of the study population [28, 29].

Therefore, the present study was conducted to investigate the effect of low-intensity interval training on selected physiological variables of Dilla University male sport science students.

The requirements of the project were explained to all subjects and all voluntarily agreed to undergo the testing and training program. A thorough orientation on the requirements of the experimental testing procedure as well as the exercise protocol was well explained to all participants to calm uneasiness and written informed consent was obtained from them.

Research Design

Blood pressure was recorded while students in are in a comfortable sitting position with the right arm fully exposed and resting on a supportive surface at the heart level; a mercury sphygmomanometer was used with an appropriately sized cuff. At the same time, three resting heart rate measurements (radial pulse) were taken after 5, 10, and 15 minutes of being in a sitting position, and the mean was calculated. Resting heart rate was recorded by a physician over a 1-min period [30].

Wash hands with soap and water to Gain the students in a comfortable position. Maintain a constant temperature remove bulky clothing and observing depth, symmetry, and pattern of breathing. If the students are sitting, their feet must be flat on the floor. Allow the students to rest, if possible, for 20 minutes before taking the measurement. When measuring respiratory rate the students were blinded to the specific aims of the study and the simulated students not specifically advised when the respiratory rate was being measured. Using a stopwatch with a second hand, count breaths (number of times the chest moves up and down) for a full minute. This length of time is needed as changes can occur in the respiratory pattern and rate. Record the respiratory rate on the recording paper [31, 32].

To measure breath-holding time primarily fill the plastic bag. With a nose clip in place, have the students take a large breath of room air and then exhale into a previously empty plastic bag, closing the bag so that it stays full. Once the bag is full of expired air, have the students resume normal breathing in and out of the closed bag. Have the time recorder start the stopwatch when the participant begins to rebreathe. The participant should continue to rebreathe until their depth of breathing causes the bag to collapse or until the students reach their limit of tolerance. The observer should terminate the test if the participant exhibits any signs or symptoms of discomfort or dizziness. In our experience, rebreathing should be limited to no longer than 2 min. The duration of rebreathing should be recorded in the data collection sheet, along with any observations of changes in rate and depth of breathing [33, 34].

Students consumed a light breakfast 2-3 hours before the test and refrained from any vigorous physical activity during this period. The students had no history of serious diseases and did not perform any physical conditioning program except for some recreational sports. The maximal oxygen uptake of each subject was determined by indirect methods. Subjects were asked to rest for at least half an hour before exercise. Subjects ran on a 400-meter track for a total duration of 12 min. They were highly motivated to run as many laps as possible. The total number of laps was counted and the finish point was marked. The total distance (in meters) covered in 12 min was calculated by multiplying the number of complete laps by 400 plus the distance (in meters) covered in the last incomplete lap. The distance in meters was converted to km and the following equation was used to predict VO2max.

$$VO_2max\ (ml \cdot kg^{-1} \cdot min^{-1}) = (22.351 \times \text{distance covered in kilometres}) - 11.288\ [34, 35].$$

Heart rate was measured in a supine, standing, during each minute of exercise, at maximum exercise, and in recovery at 1, 2, 3, and 5 min. Heart rate recovery was defined as (maximum heart rate — heart rate at a specified time period after exercise) and represented the drop in heart rate during that time interval [36, 37].

Statistical Analysis-

The data collected on the selected physiological variables in pre and post-test were analyzed, interpreted, and tabulated into a meaningful way by using IBM-SPSS version 20 (IBM, Armonk, NY, United States of America) and analysis of independent sample t-test was used. Mean difference and standard deviation was used in order to compare components of the variable levels among the experimental and control groups. For the study, the significance level for all data was $p < 0.05$.

Results

The demographic characteristics of the participants were explained in Table 1. The mean age, body mass, height and body mass index of the experimental groups were 21.15 years, 62.93 kg, 1.69 m and 22.34 respectively, while the control groups were 20.95 years, 62.45 kg, 1.69 m and 21.81 m tall respectively. Thus, the groups were well matched at entry. Various research findings suggest that body mass index is a useful tool to study the general population to determine health risks and recommended body mass. The acceptable body mass index for the general population ranges from 18.5 to 24.99 kg/m2 appearance her

After the Intervention between Group Comparisons

After eight weeks of the intervention, the effects of the mean physiological variables are described in Table 2. The result of the study shows that the mean of resting heart rate, respiratory rate, recovery rate, breath holding, Vo2max, systolic blood pressure and diastolic blood pressure had positive effects on both health and performance.

The mean RHR for LIIT was 63±6.88, while it was 74.1±7.09 in the control group. The respiratory rate was M= 17.65 for LIIT while it was M= 21.90 for the control group. The recovery rate for LIIT was M= 17.70, while for control group M= 38.50. The LIIT after intervention for breath holding was M= 45.41, while for control group 33.13. After exercise, the Vo2max for LIIT was M= 47.44, while for control group M= 39.64. The LIIT for systolic blood pressure and diastolic blood pressure was M= 114, 69, while for control group 120.5 and 78, respectively.

Results of between-group comparisons were explained in table 3. The result of the study showed that there was a significant difference in post-resting heart rate, respiratory rate (RR), recovery heart rate, systolic, diastolic blood pressure, breath-hold (BHT), vo2-max between LIIT and Control group ($p<0.05$).

Low-intensity interval training and control group of students resting heart rate has a statistically significant difference with $t(38) = -5.023$, p-value < 0.001. This indicates that LIIT had a lower resting heart rate after the intervention. Whereas after intervention respiratory rate there was a statistically significant difference between LIIT and control group of students with, $t(38) = -4.643$, p-value < 0.000. The recovery rate for LIIT and control group after exercising was statistically significant with, $t(38) = -6.286$, p-value < 0.000. Breath-hold for LIIT

Table 1. Participants demographic characteristics

Variables	N	Minimum		Maximum		Mean		Std. Deviation	
		Experimental group	Control group	Experimental group	Control group	Experimental group	Control group	Experimental group	Control group
Age	20	19	19	25	24	21.15	20.95	1.872	1.669
Body mass	20	61.00	61.60	68.00	64.00	62.9300	62.4500	1.87311	.77832
Height	20	1.60	1.59	1.76	1.78	1.6800	1.6940	.04542	.04773
Body mass index	20	20.62	20.01	26.23	24.41	22.3375	21.8060	1.30126	1.15423

Table 2. The mean value between low-intensity interval training and control group within 8 weeks of follow-up.

Group Statistics					
Variables	**Group**	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Resting heart rate	Low	20	63.00	6.882	1.539
	control	20	74.10	7.093	1.586
Respiratory rate	Low	20	17.65	3.014	.674
	control	20	21.90	2.770	.619
Recovery rate	Low	20	17.70	9.229	2.064
	control	20	38.50	11.569	2.587
Breath hold	Low	20	45.4145	16.24769	3.63309
	control	20	33.1335	14.35613	3.21013
Vo2max	Low	20	47.4400	6.78393	1.51693
	control	20	39.6350	9.05139	2.02395
Systolic blood pressure	Low	20	114.00	8.208	1.835
	control	20	120.50	8.870	1.983
Diastolic blood pressure	Low	20	69.50	6.863	1.535
	Control	20	78.00	8.335	1.864

Table 3. Changes in outcome between the intervention group doing Low-intensity interval training and the control group within 8 weeks of follow-up.

Independent Samples T Test of Male students' physiological variable test with Experimental and control group

Variables	**Levene's Test for Equality of Variances**			**t-test for Equality of Means**		
	Md.	**F**	**Sig.**	**T**	**Df**	**Sig.(2t)**
Resting heart rate	-11.10	0.007	0.934	-5.020	38	0.001
Respiratory rate	-4.25	0.049	0.827	-4.643	38	0.001
Recovery rate	-20.80	4.124	0.075	-6.286	38	0.001
Breath hold	12.281	0.330	0.569	2.533	38	0.016
Vo2max	7.805	0.556	0.460	3.086	38	0.004
SBP	-6.500	0.383	0.540	-2.405	38	0.021
DBP	-8.500	0.569	0.455	-3.521	38	0.001

t-Test, df- degree of freedom, sig- significant, MD- mean difference

and control group after the intervention was statistically significant with, t (38) = 2.533, p-value < 0.016. This indicates that the low-intensity exercises group were lower respiratory, recovery rate, breath-hold than the control group. Vo_2max after the intervention was again statistically significant with, t (38) = 3.086, p-value < 0.004. This also indicates that students who exercise low-intensity training were higher Vo_2max than the control group. After the experiment for LIIT and control group Systolic blood pressure was statistically significant with, t (38) = -2.405, p-value < 0.021. Diastolic blood pressure for LIIT and control group after exercising it was statistically highly significant with, t (38) = 0.569, p-value < 0.001. This implies that low-intensity the exercising group had lower SBP and DBP than the control group.

Discussions

The purpose of this study was to evaluate the effects of LIIT on physiological variables of university students. The results of the present study show that there was a significant difference in resting heart rate, respiratory rate, recovery heart rate, breath-hold, vo2-max, and systolic and diastolic blood pressure between LIIT and the control group.

The decrease in resting heart rate subsequent to endurance training may be attributed to a decrease in intrinsic rate augmented blood volume, enhance left ventricular ejection fraction, an increase in cardiac parasympathetic efferent activity, and a decrease in cardiac sympathetic efferent activity [38]. In agreement with previous reports the RHR significantly decreased more in the exercising group compared to the control group (all studies: −4.7% and −3.3 bpm resp., females only: −4.8% and −3.4 bpm, resp., males only: −6.4% and −4.3 bpm, resp., studies including both females and males: −3.6% and −2.6 bpm, resp.) [11].

Previous studies on resting heart rate reported that LIIT changes, resting heart rate [32]. This change may occur due to the effect of the training improved cardiovascular and performance capacity related to an increased stroke volume and cardiac output. The mechanisms also enhanced diastolic filling parameters at the highest heart rates associated with maximal exercise. There is also a component of peripheral blood flow adjustment to training that contributes to the enhanced exercise capacity post-training. A modest increase in the ability to extract oxygen as assessed by arteriovenous oxygen difference. These findings are similar to the current study. This is likely due to changes in the ability to preferentially re-route blood flow to active muscle tissues, a greater capillarization of active skeletal muscle beds, and the enhanced oxygen extraction capability of the trained muscle cells with greater numbers of mitochondria and oxidative enzymes. Therefore, increasing the efficiency of heart rate muscles, ventricular cavity size, and stroke volume, or neural adaptation to decrease sympathetic tone to the sinoatrial node and increase parasympathetic tone which plays a role in reducing the resting heart rate [32].

Similarly, this study illustrated a significant difference in respiratory rate between LIIT groups and the control groups following the eight-week intervention. This finding is in agreement with Low-intensity interval training may constitute an effective training protocol for improving VO2 max and cardiovascular endurance [39].

Previous studies indicate that Low-intensity interval training has positive improvement in respiratory rate [40-42]. This may be due to the effect of the training on improving ventilation pre-and post-training, at rest, and during low-intensity exercise and changes in tidal volume, respiratory rate, and ventilator volume of maximal aerobic exercise. Maximal respiratory rate and maximal tidal volume increase post-training for a profound effect upon maximal ventilator volume [43-45].

Based on different study findings, the effect of high-intensity interval training on recovery heart rate shows better efficiency on students' physiology. Longer recovery intervals resulted in a lower average heart rate and Maximum oxygen uptake over the training session [46-50].

In Sprint interval training protocols, similar beneficial performance outcomes were reported across a multitude of exercise modalities when recovery duration was increased between work intervals [51-54]. The main metabolic processes that take place during recovery from intense exercise, bouts are the repletion of phosphocreatine stores, the removal of hydrogen ions, and restitution of the acid-base balance of the exercising muscles. These processes proceed at different rates, with phosphocreatine having a much faster half- life (~30 s) and achieving complete restoration (~3 min), compared with blood lactate [BLa] and pH recovery (6-10 min) [55-57].

Thus, heart rate recovery contributed positively to the results for two reasons. First, the short recovery time would have meant that the anaerobic energy production systems would not have had sufficient time to fully recover. With each subsequent repetition, the aerobic system would have been required to make a greater contribution to energy production. If enough repetitions of this form of exercise are performed, energy production from the aerobic metabolism will be challenged regularly enough for a training effect to occur. Second, passive recovery has been found to be a more effective strategy when performing supramaximal high-intensity interval training.

For both participants, it was possible to maintain exercise intensity and perform larger workloads per effort using a passive rather than an active recovery strategy. Due to the high energy demands of supramaximal interval training, the oxygen demand for each subsequent interval is too high for oxygen to be consumed at all during the shorter recovery period. It can be postulated that the recovery strategy used in the current study contributed to the improvement in aerobic performance because, in theory, more oxygen was available to the subjects to maintain the required intensity. The shorter recovery time would have progressively required a significant contribution from the aerobic system to meet the energy demand [57, 58].

After the breath-holding test, the research data showed that high breath-holding capacity and significant improvement were observed in the LIIT group compared to the control group. This could be due to the improvement of respiratory muscle efficiency, which increases tidal volume and increases the number, size and metabolic capacity of mitochondria to increase the oxygen consumption of cells accordingly [44, 59].

The current literature has shown that a regular practice of yoga/breathing exercises can be useful in improving ventilator function. However, a short practice of deep breathing exercises can improve breath holding time [60]. The information described in the literature indicates that intermittent breath holding during moderate-intensity exercise provokes consistent changes in muscle oxygenation, leading to lower tissue oxygenation. The data also indicate that exercise with intermittent breath holding induces higher blood lactate concentration [61].

Much of the available literature demonstrates that better improvement in VO2 max was seen in the LIIT group when compared with the control group. This may be due to the intensity exercises enhances the activity of the cardiovascular system as well as the developed oxidative capacity of the skeletal muscles which leads to an increase in the delivery of oxygen to the working muscles. The above result was also confined to the study of [62-65].

The effect of the training on the vascularity of blood vessels or decreasing stiffness of arteries. The decreased resting blood pressure makes it easier for the left ventricle to pump blood because it must develop less force to eject blood into the peripheral circulation. A reduction in both systolic and diastolic blood pressure

(BP) may be due to the reduced sympathetic nervous activity as well as an increased nitric oxide-mediated vasodilation from exercise. It has been postulated that the mechanism involved in lowering blood pressure from undertaking aerobic exercise specifically, maybe be due to the hormone's norepinephrine and epinephrine, as regular exercise has been shown to reduce the level of norepinephrine, limiting vasoconstriction of the arteriole enabling reduced blood pressure. Furthermore, this reduction in the sympathetic neural activity that may help to reduce the blood pressure from undertaking aerobic exercise [47, 66-70].

Evidence supports the idea that physiological performance can be improved when individuals include LIIT in their training plan [39, 71].

The present study recommended that physical education teachers, fitness instructors, and coaches should incorporate a variety of low-intensity interval training methods to improve the performance of their trainees. Similar studies can be conducted involving female students by including other variables for better performance enhancement in selected physiological variables.

Conclusions

In conclusion, the study results show that eight weeks of low intensity interval training showed a positive effect on physiological variables, namely: resting heart rate, respiratory rate, breathe hold, vo2 max, diastolic and systolic blood pressure compared to the control group.

Conflict of interest

The author declare that there is no conflict of interest regarding the publication of this article.

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