EFFECT OF AEROBIC TRAINING ON ENDURANCE CAPACITY OF THE SEDENTARY SOUTH INDIAN MALES

Subarna Ghosh[1], Chandana Bera[2], Mohammad Monis Khan[3]

[1]Assistant Professor, Department of Physiology, N. C. Medical College and Hospital, Israna, Panipat.
[2]Assistant Professor, Department of Physiology, N. C. Medical College and Hospital, Israna, Panipat.
[3]Assistant Professor, DDU Kaushal Kendra, CPRS, Jamia Millia Islamia, New Delhi.

ABSTRACT

BACKGROUND

Nowadays the efficiency of doing work in respect of endurance capacity is a great question, especially in sedentary males. Aerobic type of exercise training can improve that endurance capacity through its effective inputs, mainly on Cardiovascular and Respiratory system of body.

The aim of the present study was to investigate whether regular aerobic exercise for 21 days can increase the endurance capacity of the sedentary Telugu males.

MATERIALS AND METHODS

100 Telugu subjects were divided into 50 “Experimental” and 50 “Control” subjects. Both were asked to exercise in bicycle ergometer with 2 kg workloads for 30 mins and their BP and HR were measured before and after exercise. The experimental group was allowed to get regular exercise training for 21 days. After 21 days, again the same parameters were studied in the same manner.

Statistical Analysis - The statistical analysis of the subject was done by SPSS (Statistical Package of Social Sciences), Version 16.0.

RESULTS

Due to 3 weeks endurance training, the mean resting SBP of trained subjects significantly ($p = 0.0001$) decreases to 108.32 ± 7.45 mmHg than their untrained counterpart as 116.84 ± 8.53 mmHg. However, no significant ($p = 0.269$) difference observed between them regarding resting DBP. The resting Heart Rate (HR) of the trained subjects also significantly ($p = 0.0001$) decreases to 67.82 ± 4.93 beats/min than their untrained counterpart as 72.68 ± 5.01 beats/min. On the other hand, the endurance capacity of the trained subjects significantly ($p = 0.0001$) increases than the untrained.

CONCLUSION

We concluded that regular aerobic exercise training for 3 weeks significantly reduces the resting HR and SBP with no significant change in DBP, thus it significantly increases the endurance capacity.

KEYWORDS

Exercise and Training, Training and Cardiopulmonary Fitness, Training and Heart Rate, Training and Blood Pressure.

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BACKGROUND

Training to the body tissues is provided by the different sets of exercise regimens, among which aerobic exercise produces the cardiovascular conditioning apart from its conditioning effects on other body systems.

Athletic training increases the vagal tone that helps the trained athletes to have low resting heart rate. During exercise, it increases the range through which the heart rate can increase without any change in the maximal heart rate.[1,2] The aerobic athletic training also leads to cardiac hypertrophy and increase in end diastolic volume, which increase the resting stroke volume.[1]

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Corresponding Author:
Subarna Ghosh,
Assistant Professor,
Department of Physiology,
N. C. Medical College and Hospital,
Israna, Panipat- 132107.
E-mail: gbubai@rocketmail.com
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Because of the low resting heart rate and higher resting stroke volume, a trained athlete can achieve much larger cardiac output during exercise than an untrained individual. Training reduces the sympathetic activity, thus decreases the peripheral resistance to blood flow, which in turn decreases systolic and the diastolic blood pressure[3,4] with the regular aerobic exercise for many previously sedentary men and women, regardless of age both at rest and during exercise.[5,6,7] The maximum oxygen consumption (VO_2max) increases by athletic training because of increased cardiac output and arteriovenous oxygen difference.[8] In addition to that athletic training allows more increase in diffusion capacity of lungs for oxygen, because by training the pulmonary capillary density increases.

Increased muscle strength due to training results from increase in muscle mass,[9] which as a result of hypertrophy and not due to hyperplasia. Here is increased availability of cross bridges for generating force of muscle contraction by somatomedins mediated increase in actin- and myosin-like contractile protein formation.[10] Increase in capillary-to-muscle fibre ratio, number of mitochondria and its enzymes,[11] muscle glycogen stores and stored triglycerides of muscle enhances the capacity of the muscle to extract more oxygen and improves the ability of the muscle fibres to provide energy during prolonged exercise.[12]

Aerobic exercise training causes a shift toward the aerobic metabolism, which is more efficient than the anaerobic metabolism. It leads to less accumulation of lactic acid and smaller fall in the pH of the body fluids.[13] These changes facilitate the mobilisation of fatty acids, which shifts the metabolism toward the more utilisation of fats from fat stores which are virtually unlimited as compared to the extremely meagre glycogen store. So fat utilisation spares glycogen. As physical performance is a direct function of glycogen stores, therefore endurance of the individual increases.[11]

MATERIALS AND METHODS

1. **Selection of the Subject**
   100 healthy male students of paramedical courses of Alluri Sitarama Raju Academy of Medical Sciences (ASRAMS), A.P., of comparable socioeconomic and nutritional (food habit) status between the age group of 20 - 25 years were chosen.

Subject Exclusion Criteria

a) Having history of diseases.
b) Taking any drug or having addiction for any drug.
c) Alcoholics and non-smokers.
d) Presence of sign of any weakness or disability, which significantly limit activity.

Subject Inclusion Criteria

a) HR within the normal range, i.e. 70 - 80 beats/min.
b) Had not taken any prior exercise conditioning programme.

The study was conducted in the comfortable and well lightened work physiology laboratory in the Department of Physiology, having temperature of 27^{o} - 32^{o}C. The subjects were familiarised in the work physiology laboratory for 7 days to allay their apprehension and nervousness during the actual procedure.

2. **Apparatus Required**
   a) Bicycle ergometer (Fig. 1).
   b) Polar Heart Rate Monitor (Fig. 2).
   c) Sphygmomanometer and Stethoscope (Fig. 4).
   d) Weighing Machine (Fig. 5).
   e) Height measuring Scale (Fig. 5)
   f) Electronic Stop Watch (Fig. 5).

3. **Measurement of Blood Pressure**
   A mercurial sphygmomanometer was used to record the blood pressure.

The cuff was carefully applied on one inch above the cubital fossa and the left brachial artery was located out, the subject was allowed to take rest in supine position for 20 - 30 minutes in a quiet room.

After taking the rough systolic blood pressure by palpatory method, both systolic and diastolic blood pressure was taken by auscultatory method. The appearance of sound [phase - 1 of the Korotkoff] recorded as systolic blood pressure and disappearance of this sound [phase - 5 of Korotkoff sound] was recorded as diastolic blood pressure.[14]

4. **Measurement of Heart Rate**
   Polar HR monitor is used, having a transmitter attached with the chest belt that transmit the HR to the wrist watch receiver (Fig. 3).

5. **Experimental Procedure**

1st Phase

The subjects were asked to come to the laboratory within 8 - 9 a.m. Before experiment, the physical parameters i.e. height in centimetre, weight in kilogram of the selected subjects were noted down by using the Height Measuring Scale and Weighing Machine. The Body Surface Areas (BSA) were measured by using DuBois nomogram (Fig. 6). The subjects were allowed to take rest on the couch for 30 mins, during which they were informed about the experimental procedure. During the rest period, the pre-exercise HR and pre-exercise BP were noted down. Then, they were allowed to perform the endurance exercise in bicycle ergometer with 2 kg work load with maximum effort up to 3 mins. This 3 mins was noted down by using the electronic stop watch. After 3 mins, they were allowed to stop the exercise and peak HR were noted immediately after cessation of exercise and simultaneously recovery HR (1st min, 2nd min, 3rd min, 4th min, 5th min) were noted down. After exercise, the post exercise BP (both Systolic and Diastolic) were recorded. Environmental conditions were kept constant at room temperature at 27 - 32^{O}C.

2nd Phase

Subjects (n = 100) are divided into two groups - Control Group (n = 50), Experimental Group (n = 50). Control group subjects were asked to come for the experimental procedure after 3 weeks and the same data were collected for them after 3 weeks. Experimental group were asked to come into the laboratory for 3 weeks every day in between 8 to 9 a.m. for exercise training. The experimental group subjects were allowed to take severe training by the bicycle ergometer unless their calculated maximum HR will be reached. After 3 weeks, the same data were collected to compare the cardiac fitness before and after the exercise training.

Statistical Analysis

The statistical analysis of the subject was done by SPSS (Statistical Package of Social Sciences), Version 16.0, designed by the TISS (Tata Institute of Social Studies).

RESULTS

In this study, no significant difference has been observed in the resting SBP, DBP and HR in control subjects before and after 3 weeks with P values respectively as 0.944, 0.968 and 0.985. On the contrary, in the experimental subjects highly significant difference was observed in resting SBP and HR with the P value of 0.0001, whereas there is no significant difference in resting DBP with the P value of 0.252 before and after 3 weeks (Table 1).

After 3 weeks, the trained or experimental subjects showed significantly low resting SBP and HR than their untrained or control counterpart (P value - 0.0001), but there was no significant difference observed in resting DBP (P value - 0.269) (Table 2).

No significant change in increase of SBP and HR and decrease in DBP due to exercise has been observed in control subject before and after 3 weeks with the p-value respectively - 0.874, 0.995, 0.708. On the contrary, increase of SBP and HR due to exercise decreases significantly in experimental subjects, after 3 weeks with the p-value of 0.0001 in each, but there is no significant change in decrease of DBP due to exercise, p-value of 0.0918 (Table 1).

There is no significant (P = 0.854) difference observed in the peak HR of control subjects before and after 3 weeks, whereas highly significant (P = 0.0001) difference observed in peak HR in experimental subjects before and after 3 weeks (Table 1).

No significant difference in recovery HRs for 5 minutes after exercise observed in control subjects before and after 3 weeks with the p value respectively of 0.938, 0.909, 0.880 and 0.985. On the contrary, a significant difference in recovery HR for 5 minutes after exercise was observed in experimental subjects before and after 3 weeks with the P value respectively of 0.0001 in each (Table 1).

There is no significant change (P = 0.936) in endurance capacity has been observed in controls, whereas significantly (P = 0.0001) increases in experimental subjects before and after 3 weeks (Table 1). Therefore, after 3 weeks the experimental subjects show significantly higher endurance capacity (0.0001) than their control counterparts (Table 2).

Variables	Control (n=50)				Experimental (n=50)			
	Before 3 weeks (Mean±SD)	After 3 weeks (Mean±SD)	P-Value	Inference	Before 3 weeks (Mean±SD)	After 3 weeks (Mean±SD)	P-Value	Inference
SBPr (mmHg)	116.72±8.550	116.84±8.534	0.944	Not Significant	116.72±8.550	108.32±7.454	0.0001	Highly Significant
DBPr (mmHg)	79.12±9.956	79.04±9.949	0.968	Not Significant	79.12±9.956	76.92±9.100	0.252	Not Significant
HRr (beats/min)	72.70±5.388	72.68±5.012	0.985	Not Significant	72.70±5.388	67.82±4.935	0.0001	Highly Significant
SBPie (mmHg)	27.00±10.055	26.68±10.042	0.874	Not Significant	27.00±10.055	14.96±5.617	0.0001	Highly Significant
DBPde (mmHg)	1.88±2.228	1.72±2.021	0.708	Not Significant	1.88±2.228	1.92±1.614	0.918	Not Significant
HRie (beats/min)	56.64±16.43	56.66±15.973	0.995	Not Significant	56.64±16.043	40.54±9.813	0.0001	Highly Significant
PHR (beats/min)	128.74±16.479	128.14±16.031	0.854	Not Significant	126.60±15.312	108.32±11.557	0.0001	Highly Significant
HR1 (beats/min)	115.32±14.024	115.10±14.093	0.938	Not Significant	116.02±14.175	98.66±9.576	0.0001	Highly Significant
HR2 (beats/min)	104.36±12.340	104.20±12.344	0.948	Not Significant	104.06±12.514	90.40±7.877	0.0001	Highly Significant
HR3 (beats/min)	94.42±9.639	94.20±9.489	0.909	Not Significant	94.42±9.639	82.60±6.857	0.0001	Highly Significant
HR4 (beats/min)	83.82±7.328	83.60±7.180	0.880	Not Significant	84.08±7.303	75.90±5.373	0.0001	Highly Significant
HR5 (beats/min)	76.16±5.320	76.18±5.181	0.985	Not Significant	76.10±5.350	70.26±5.005	0.0001	Highly Significant
Distance (Km)	4.1240±0.768	4.1362±0.760	0.936	Not Significant	4.1298±0.771	5.3826±0.718	0.0001	Highly Significant

Table 1. Comparison of Cardiovascular and Endurance Profiles in Experimental and Control Subjects before and after 3 Weeks

SBPr = Resting SBP, DBPr = Resting DBP, HRr = Resting HR

SBPie = SBP Increases After Exercise, DBPde = DBP Decreases After Exercise

HRie = HR Increases After Exercise, PHR = Peak HR

HR1 = Recovery HR in 1st Minute, HR2 = Recovery HR in 2nd Minute

HR3 = Recovery HR in 3rd Minute HR4 = Recovery HR in 4th Minute

HR5 = Recovery HR in 5th Minute

Variable	After 3 Weeks		P-Value	Inference
	Control (Mean±SD)	Experimental (Mean±SD)		
SBPr (mmHg)	116.84±8.534	108.32±7.454	0.0001	Highly Significant
DBPr (mmHg)	79.04±9.949	76.92±9.100	0.269	Not Significant
HRr (beats/min)	72.68±5.012	67.82±4.935	0.0001	Highly Significant
Distance (Km)	4.1362±0.760	5.3826±0.718	0.0001	Highly Significant

Table 2. Comparison of Cardiovascular and Endurance Profiles in Experimental and Control Subjects after 3 Weeks

SBPr = Resting SBP.
DBPr = Resting DBP.
HRr = Resting HR.

Figure 1. Bicycle Ergometer

Figure 2. Polar Heart Rate Monitor

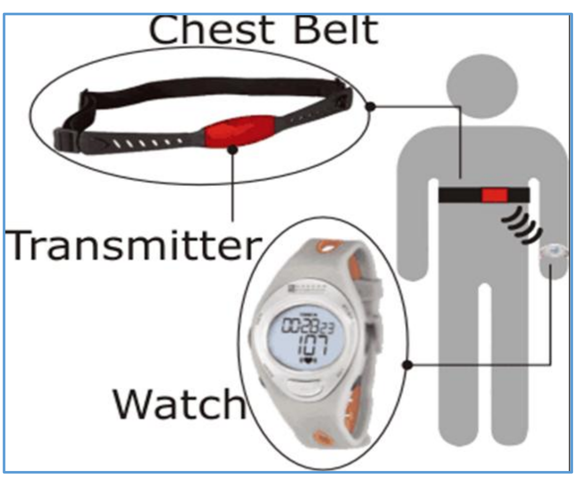


Figure 3. Mechanism of Working of Polar HR Monitor

Figure 4. Sphygmomanometer and Stethoscope

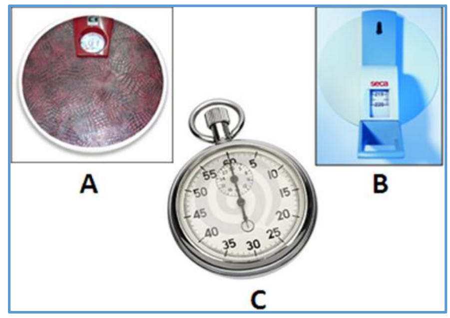


Figure 5A. Weighing Machine B. Height Measuring Scale. C. Electronic Stop Watch

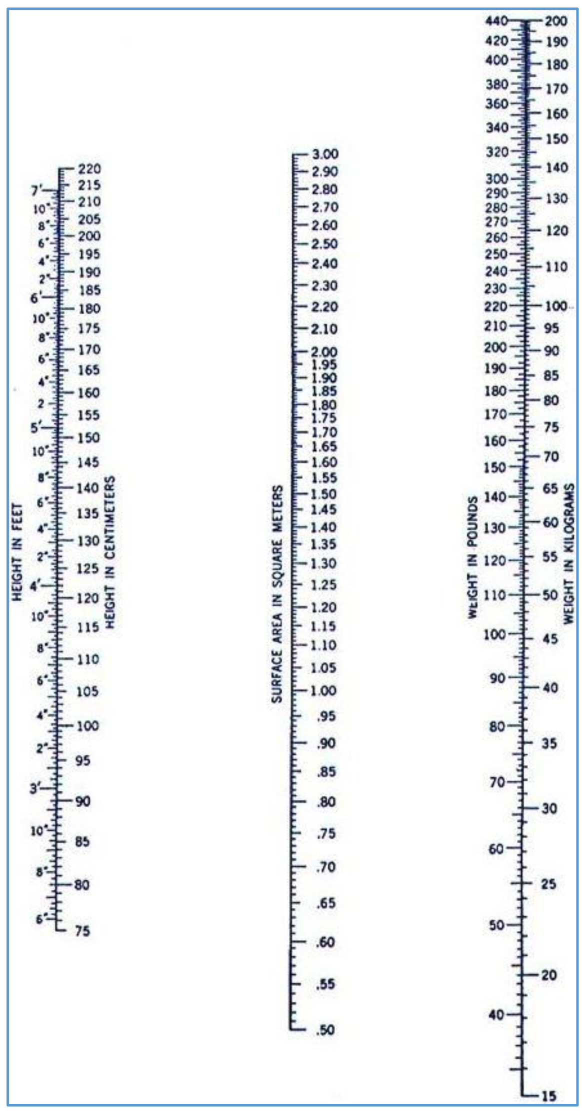


Figure 6. DuBois Nomogram

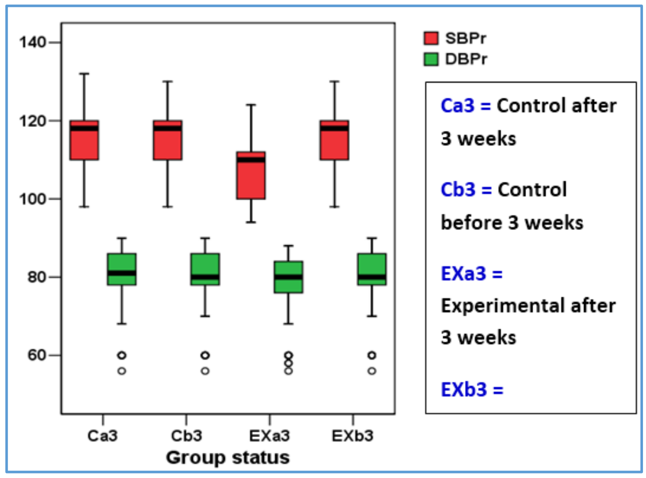
Figure 7. Subject is Cycling in Bicycle Ergometer

Figure 8. Measurement of BP

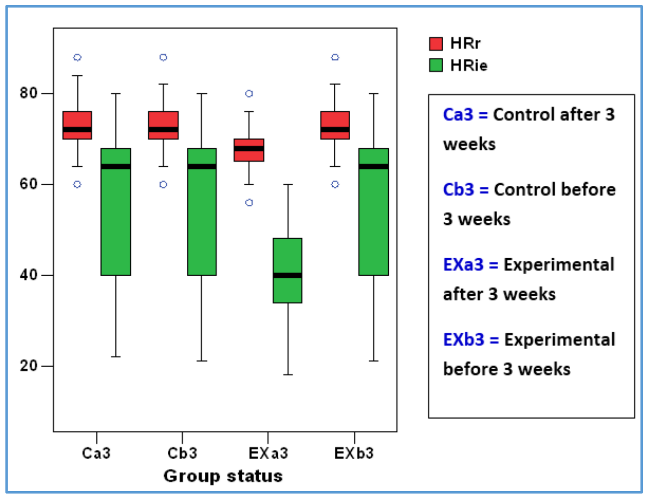
Figure 9. Noting of Reading of HR Monitor before and after Exercise

GRAPHS

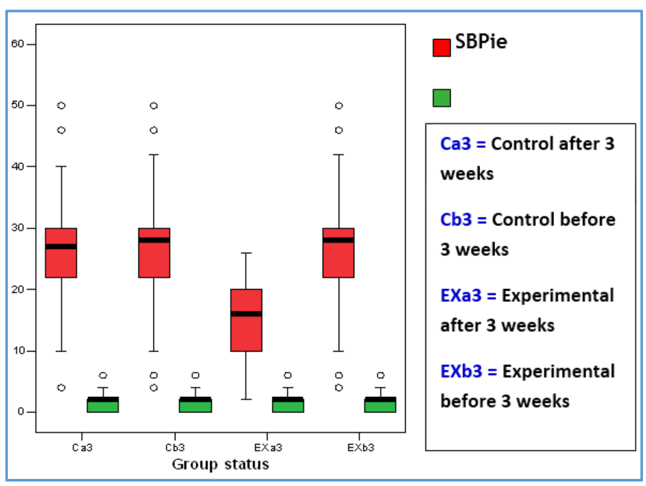
In Graphs: The colour rectangular box is the range of the variable in study population and the mid dark line inside the rectangle is the mean value of the variables. The "T" above the rectangle and the inverted "T" below the rectangle are respectively the upper and lower limit of the variable in the study population. The "O" below and above the rectangle denotes the data which are filtered by the software, which are not in the normal distribution. They are beyond the lower and upper limit of the observed population respectively.



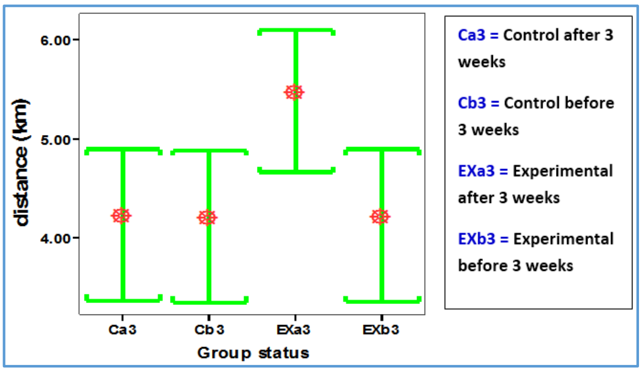
Graph 1. Graphical Representation of Blood Pressure Profile in the Study Population



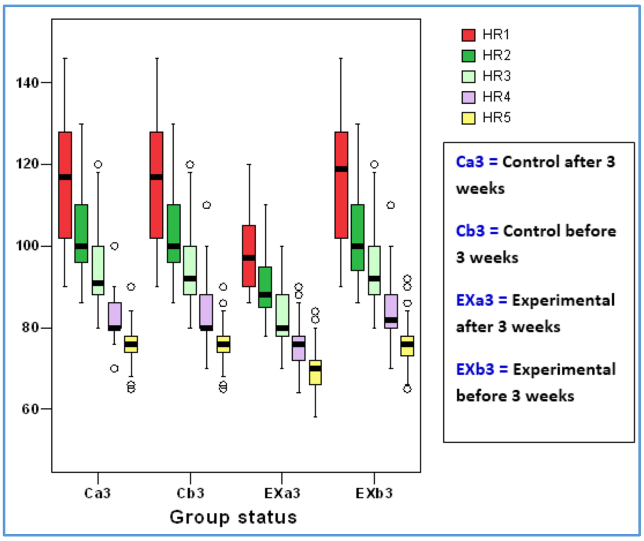
Graph 2. Graphical Representation of Heart Rate Profile in the Study Population



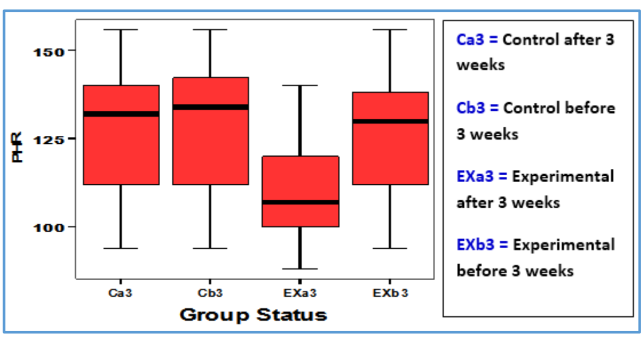
Graph 3. Graphical Representation of the Change in SBP and DBP in the Study Population



Graph 4. Graphical Representation of Distance Covered in Bicycle Ergometer by the Subjects



Graph 5. Graphical Representation of Changes in the Recovery HR at Various Time Intervals in the Study Populations



Graph 6. Graphical Representation of Peak Heart Rate in Various Sub-Groups of the Study Populations

DISCUSSION

Exercise combination program is helping the cardiorespiratory system to adapt quickly with the sudden increasing demand of oxygen and metabolism so nicely and systematically that after training program our body will show the delayed fatigability.

Appropriate training program promotes the exercise performances and impairs the fatigability. Training for aerobic exercise imparts the resistance to low frequency fatigue and therefore promotes the exercise endurance, especially when the moderate training enhances the performances and decreases the fatigability. Training effects are specific for the particular muscle group involved. Only aerobic exercise produces cardiovascular conditioning.

Exercise training can be considered as an useful tool for different body system, because training by the regular physical exercise is likely to slow the ageing process, helps to prevent several degenerative and metabolic diseases and thereby makes the life healthier and longer.[5,15] One of the clear-cut benefits of exercise regimen is psychological patients who exercise regularly and "feel better,"[16,17,18,19,20] such effect may also be attributed to release of endorphin during exercise. Endorphins are reported to relieve mental stress and induce a sense of wellbeing and even euphoria. Regular exercise is one of the most useful components of treatment of diabetes, because it reduces the insulin requirement by virtue of improvement in glucose tolerance.[12] Training program not only improves the cardiac disorder and diabetic patient's performance, but also improves the sedentary lifestyle, attitude and shows more cardiac fitness.

The attitude of the volunteers after exercise were also painful; they complained in few days of gastrocnemius muscle cramps and violent pain, but after some days when they had gone through the regular exercise program then only the subjects themselves were able to notice the change. Due to training the fatigability decreased abruptly and the interest for the exercise grew; so, we can discuss the observation results and the attitude as the effect of impact of exercise training. Before training, the bicycle ergometer was a stress to them and psychologically HR raised up to more than 80 beats/min, a rest for more than half an hour was needed for restoration of the basal HR, but training program by 21 days. The subjects were so nicely and quickly adapted that resting HR significantly became low than before training, i.e. vagal tone increases.[21,22,1,23,24,25] Increased vagal tone is useful during exercise, because it increases the range through which the HR can increase without any change in the maximal HR (HR_{max}). On the other hand, already it was discussed that the regular training improves the psychology of the individual and thus psychic stimuli to the vasomotor center and respiratory centers were reduced. Consequently, during exercise there are less increase in sympathetic activity and less decrease in parasympathetic activity.

The systolic and the diastolic BP can be lowered with the regular aerobic exercise for any sedentary persons.[26,6,27,28,5,29,30,7] The significant contributing factors included here are -

a) Reduced activity of sympathetic discharge causes decrease in peripheral resistance to blood flow and subsequent reduction of blood flow.[6]
b) An altered renal function to facilitate the elimination of sodium by the kidney to subsequently decrease the fluid volume and blood pressure.[6]

Therefore, nowadays the exercise training is thought to be a non-pharmacological strategy to reduce incidence of hypertension in susceptible individual.[31,28]

Endurance (aerobic) training increases the maximum minute ventilation that is achieved during exercise, but does not improve the maximum voluntary ventilation.[32] Specific respiratory muscle training allows one to increase the intensity and duration of exercise.[33]

During exercise the oxygen diffusing capacity increases in the sedentary individuals from a resting value of 23 - 48 mL/min/mmHg. Athletic training allows more increase in diffusing capacity of lungs for oxygen, because by training the pulmonary capillary density increases.

Due to the training, not only cardiorespiratory adaptation occurs, but the skeletal muscles involved in the particular type of exercise is[34] going to be changed. It causes hypertrophy of the skeletal muscle due to increase in the size of the skeletal muscle fibre, but not the hyperplasia, i.e. increase in the number of the muscle fibres. Proportionate increase in the strength of the muscle will be followed up.[35,9] Along with this the actin and myosin - contractile proteins will be more, which will increase the cross bridges available for generating force during muscle contraction.[10,36] On the other hand, it increases the efficiency of motor unit and the capillary network to the muscle will increase enormously. The mitochondrial enzymes will be more and automatically the oxidative metabolic rate will be enhanced.[37] Muscle glycogen storage will increase that can breakdown easily and can generate energy at the time of exercise[38] and the stored triglyceride will also increase.[39]

Training results in metabolic drift of both fast and slow twitch fibres toward the mitochondrial characteristics of slow muscle fibres, which are better studied for endurance events.

Metabolic adjustment during exercise is the result of increased energy stores and mitochondrial changes improves the ability of muscle to extract oxygen and there is a shift toward the aerobic metabolism, which is more efficient than the anaerobic metabolism.[5,39,37] Consequently, there is less accumulation of lactic acid and smaller fall in pH of the body fluids.[13,40] These changes facilitate the mobilisation of fatty acids from tissue stores into the blood. Shift in the metabolism toward the more utilisation of fats[41] is a very useful adaptation, because fat stores are virtually unlimited as compared to the extremely meagre glycogen store.[39] So fat utilisation spares glycogen. As physical performance is a direct function of glycogen stores, therefore the endurance of the individual increases.

Therefore, we consider that physical exercise is a common form of acute stress encountered during everyday life. On exposure to such an acute bout of stress, the body makes rapid and integrated adjustment in the functions of body organ system to meet the metabolic and thermal needs. Slower but nice adaptation occurs to physical exercise stress, which forms the basis of health improvement in any physical training.[42,34,43] Without exercise program the sedentary life is very much prone to the cardiovascular disorder,[18] metabolic disorder[44] and obesity.[17,41,45] Regular exercise can improve the quality of sedentary lifestyle.[24,46,47,48,49]

CONCLUSION

Exercise conditioning program (training) reduces the resting SBP. It also decreases the rate of increase of SBP due to exercise. But it does not alter the DBP significantly, in rest and after exercise. Training reduces the resting HR significantly and causes the early recovery of HR to resting level, thus decreases the early fatigability.

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