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Effect of physical exercise on resting cardiovascular and cardiovascular autonomic response parameters

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Abstract
The current study was designed to assess the effect of physical exercise on resting cardiovascular and cardiovascular autonomic response parameters. 100 healthy volunteers (M68:F32) from age group (17-26) years were included in the study. They practiced some slow walk, calisthenic & stretching exercises daily 1 hour for 3 months. Resting cardiovascular parameters measured were resting HR, SBP, DBP, RPP & DoP. The autonomic function tests to measure the parasympathetic reactivity were deep breathing test (DBT), lying to standing test (LST) and valsalva ratio (VR). For sympathetic reactivity hand grip test (HGT) and cold pressure test (CPT) were performed. All parameters were recorded at start & end of the study. Result showed decreasing trend in all resting cardiovascular parameters ($P>0.05$). After physical exercise training no significant difference was observed in E: I ratio, 30:15 ratio and valsalva ratio ($P>0.05$). In Isometric handgrip test (IHG test) rise in diastolic BP in response to the test was significantly decreased from 18.44±6.15 mmHg to 15.66±4.98 mm Hg ($P<0.01$).The present data provide more evidence to support the beneficial effect of physical exercise training on cardiovascular and autonomic function variables in healthy volunteers.

Keywords: physical exercise, cardiovascular autonomic functions, DBT, E: I ratio, VR, HGT, CPT

1. Introduction
In the resting state the cardiovascular system is influenced by both the divisions of the Autonomic Nervous System and interaction of sympathetic and parasympathetic nervous system is important in cardiovascular regulation [1].
The sympathetic system controls energy expenditure in stressful conditions whereas parasympathetic system conserves energy through relaxation at rest. The control of cardiovascular system via Autonomic Nervous System (ANS) varies from one individual to another and is also affected by many diseases. Regular physical exercise affects the cardiovascular status of the person and the ANS is the mediator of this response. Regular physical training causes a decrease in sympathetic tone an increase in parasympathetic tone [2, 3, 4].
Cardiovascular autonomic functions are quantified by changes in the heart rate and blood pressure in response to some of the physiological stimuli.
In view of these facts present study evaluated the effect of physical exercise on resting cardiovascular and cardiovascular autonomic function test in normal healthy volunteers.

2. Materials and Methods
This study was conducted on 100 healthy students and volunteers between age of 17-26 years of either sex (M68:F32) from Dr. S.N. Medical College, Jodhpur and other academic colleges.
Subjects included in the study were non-alcoholic, non-smokers, not taking any type of medication and were having similar dietary habits. Subjects involved in heavy physical exercise and previous experience of yoga training, history of any major medical illness and major surgery were not included in the present study.
Subjects were allocated to practice physical exercise for 3 months. The volunteers and students were briefed about the outcome of study and a written consent was obtained from them.
Subjects were given physical exercise training for 1 hour under the guidance of physical exercise instructor. This 1 hour session was divided into 4 stages: warm up (10 min.) calisthenics (30 min.) cool down (5min.) & stretching (15 min.).
In warm up stage – subjects performed stretching & low energetic demand aerobic exercise such as slow walk & brisk walk followed by jogging & running (somewhat hard intensity). Warm up followed by calisthenics exercise – like jumping jacks, lunges, sit-ups, crunches, push-ups, squat, flutter kick, mule kick.
Cool down stage (5 min.) includes slow jogging & walking for 5 min. (to decrease body temp. / sweating).
Lastly stretching exercise was done for 15 minutes. These include- neck stretch, upper back stretch, triceps stretch, chest & biceps stretch, quadriceps stretch, calf stretch, butterfly stretch, hamstring stretch, lower back stretch, back extension stretch.

Parameters
First anthropometric characteristics (body weight, height, and BMI) were evaluated using an anthropometric scale. (Table-1) Then before starting Physical training & after end of 3 months following parameters were measured.

Resting cardiovascular parameters
After 10 minutes of supine rest, arterial blood pressure (BP) was recorded using a standard mercury column sphygmomanometer and stethoscope.

Resting Heart rate (HR) was measured using an electrocardiograph (ECG) rhythm strip on limb lead II and calculated by dividing 1500 by the number of small squares between two R waves in the ECG tracing.

Rate pressure product [RPP = (HR × SBP)/100] and double product (Do P = HR × MP/100) were calculated for each recording. Three BP and HR recordings at 2-minute intervals were taken and the lowest of these values was included for the present study.

Cardiovascular Autonomic function test

To measure the parasympathetic activity deep breathing test (DBT), lying to standing test (LST), valsalva ratio (VR) and for sympathetic activity hand grip test (HGT) and cold pressure test (CPT) were performed following the procedures described by Banister and Mathias (5). All these test employed in the study were simple, reliable and non-invasive.

i) Deep breathing test (DBT): The test was performed in supine position. Subject was asked to lie down comfortably with ECG leads attached to ECG machine till his heart rate was stabilized. Then he was asked to breathe deeply at a rate of 6 breaths per minute, allowing 5 sec each for inspiration and expiration, by counting "IN-2-3-4-5-OUT-2-3-4-5" hand signal were also given to maintain the rate and timing of the breathing. Along with deep breathing ECG recording was also done in IInd limb lead. It was explained that breathing should be smooth, slow and deep.
   The parasympathetic activity (heart responses to deep breathing) was measured by calculating E: I (Expiration: Inspiration) ratio.
   E: I ratio = average of maximum R-R interval during expiration / average of minimum R-R interval during inspiration.

ii) Lying to standing test (LST): Before the test was performed, the subject was allowed to lie down for 5 min in supine position. ECG leads were connected for recording of lead II ECG. The subject was instructed to stand within 3 seconds from lying position.
   30:15 R-R ratio was calculated as the ratio of longest R-R interval around 30th beat and shortest R-R interval around 15th beat from the ECG recording.

iii) Valsalva ratio (VR): For valsalva maneuver subject was allowed to sit in erect posture in a chair with a rubber clip over the nose. ECG leads were connected and he was asked to blow out or to expire forcefully in rubber tube of mercury manometer and to create a pressure of 40 mm Hg and maintain it for 15 sec. Simultaneously an ECG was recorded during VM and 30 sec after finishing it in limb lead II. From the ECG recording, Valsalva ratio was calculated using the formula -

Valsalva ratio = longest R-R interval after maneuver / shortest R-R interval during maneuver.

The following tests were done to assess sympathetic reactivity.

i) Hand grip test (HGT): The maximum voluntary contraction (average of three measurements) was obtained using a handgrip dynamometer then the subjects was asked to grip the dynamometer with their dominant hand at 30% of their maximum voluntary capacity for 5 minutes in sitting position. During the test procedure BP was recorded at every minute with the help of sphygmomanometer on the non- exercising arm. The rise in diastolic BP at the point just before the release of handgrip was taken as the index of response to HGT.

ii) Cold pressure test (CPT): The subject was asked to immerse his hand in cold water at 4-60C up to the wrist joint for 2 minutes. After 2 minutes subject was allowed to remove the hand. Simultaneously BP was recorded on other arm before starting of the test and towards the end of the test. Increase in systolic and diastolic blood pressure from the baseline value (average of two values) to maximal value, known as the range or response (Δ), was obtained.

Analysis of data

Paired t test was used to compare the data. P value <0.05 was considered significant.

3. Observation and result

Physical training results in reduction of resting heart rate (HR), blood pressure and other cardiovascular parameters but statistically no significant reduction was reported in above-mentioned cardiovascular parameters (P>0.05) after 3 months of physical training. (Table-2)

On comparing pre and post training data physical training shows insignificant change in E: I ratio, 30:15 ratio and valsalva ratio (P>0.05). Although increasing trend was observed in E: I ratio, 30:15 ratio but statically it was not significant. (Table-3).

Isometric handgrip test (IHG test) increased the blood pressure (BP). Rise in SBP (ΔSBP) was not significantly altered after training but the rise in diastolic BP in response to isometric handgrip was significantly decreased from 18.44±6.15 mmHg to 15.66±4.98 mm Hg (P<0.01).

Although rise in SBP (ΔSBP) and diastolic BP (ΔDBP) decreased in response to CPT after Physical training but result did not show any significant change in both ΔSBP and ΔDBP during cold pressor test (CPT) after three months of physical training. (Table-4)

Table 1: Anthropometric measurements before and after physical exercise training

Parameter	Pre	Post
Height (m)	1.69±0.09	1.69±.09
Weight (Kg)	59.36±5.96	58.3±5.69
BMI (Kg/m^2)	20.82±1.97	20.39±1.91

Table 2: Resting Cardiovascular function before and after physical exercise training

Parameter	Pre	Post
Heart Rate (beats/min)	76.89±6.89	75.48±6.3
SBP (mmHg)	125.83±8.7	123.77±8.7
DBP (mmHg)	77.5±8.62	76.26±6.19
RPP (units)	96.74±11.01	93.32±9.28
Do P (units)	71.92±7.97	69.43±6.28

Table 3: Parasympathetic activity before and after physical exercise training

Parameter	Pre	Post
E: I ratio (DBT)	1.4±0.15	1.42±0.15
30:15 ratio (LST)	1.51±0.19	1.53±0.2
VR	1.68±0.3	1.67±0.26

Table 4: Sympathetic activity before and after physical exercise training

Parameter	Pre	Post
ΔSBP (HGT)	21.16±6.24	20.18±6.54
ΔDBP (HGT)	18.44±6.15	15.66±4.98**
ΔSBP (CPT)	16.58±4.77	15.08±5.15
ΔDBP (CPT)	12.24±3.75	10.9±4.18

***P*<.01 on comparing pre and post**.**

5. Discussion

Although there were trends in reduction of resting heart rate (HR), blood pressure and other cardiovascular parameters but no significant reduction was reported in above-mentioned cardiovascular parameters (*P*>0.05) after 3 months of physical training.

It is known that resting heart rates among athletes is lower when compared to sedentary individuals [6]. However, the reduction in resting heart rate occurs only after a long period of intense training [7]. Our subjects had undergone training for 3 months. This period by comparison is inadequate to show any significant drop in the resting heart rate.

The result of the our study is in line with the results of Harinath K *et al* [8] who had observed insignificant difference in the mean HR, SBP, DBP, and MAP after 3 months of follow-up (*p* >0.05) in physical exercise group. Similar findings of resting cardiovascular parameters value after 3 months of physical training are presented by other authors [9, 10] who did not show any significant reduction in SBP and DBP.

Present study showed insignificant (*P*>.05) increase in heart rate response to deep breathing (E: I ratio) and to sudden standing from lying down position (30:15 ratio).

Rise in E: I ratio indicates an increase in vagal activity, as the change in heart rate during breathing is mainly due to the change in vagal activity [11].

30:15 ratio and valsalva ratio (VR) indicate intact baroreceptors mediated increase or decrease in heart rate in response to sudden standing from lying down position and Valsalva maneuver respectively so these tests are markers of parasympathetic reactivity and baroreflex function.

In our study the 30:15 ratio and valsalva ratio (VR) did not show any change after 3 months of training although increasing trend was observed in these parameters. This observation raises a question as how long a training schedule results in changes in PNS reactivity? It is hard to answer this question at this stage, but it has been seen that sympathetic reactivity changes appear earlier than parasympathetic reactivity changes [12].

The findings related to E : I ratio, VR and 30:15 (parasympathetic reactivity parameters) in physical exercise group in the present study are similar to that Sharma RK *et al* [13] in that no significant change was observed in parasympathetic reactivity parameters after physical training.

Isometric handgrip test (IHG test) provides pressor stimuli to cardiovascular system through efferent sympathetic pathways with a resultant increase in HR and BP [5]. In our subjects, IHG test increased the mean DBP by 18.44±6.15 mm Hg before physical training. After training, rise in DBP (ΔDBP) was significantly decreased to 15.66±4.98 mmHg in response to IHG test. A significantly lower response of DBP due to handgrip indicates a lower sympathetic drives after physical training. Reduction of sympathetic over activity ensures better peripheral circulation and blood flow to tissues by decreasing arterial tone and peripheral resistance. [14, 15, 16] This reduction can be explained on the basis of an increase in parasympathetic tone and reduction in sympathetic tone.

Our result is in agreement with the Sharma RK *et al* [13] who observed that physical training of even fifteen days duration significantly decrease the diastolic blood pressure response to HGT. Previous studies on young trained athletes have also shown a lower sympathetic and hemodynamic response to the isometric exercise and this was accompanied by improved cardiac performance [17]. Girish *et al* [18] showed that trained subjects have attenuated response in HR, SBP and DBP to isometric handgrip contractions when compared to untrained controls and were associated with a corresponding change in sympathovagal balance, so this study confirmed the previous reports which showed that young trained subjects have a lower sympathetic and hemodynamic response to the isometric exercise in comparison to before training response.

Insignificant decrease in CPT-induced rise in SBP and DBP in subjects is in agreement with Bond V t al [19] who found no association between physical activity and blood pressure reactivity to the cold pressor test in African Americans who were engaged in different levels of physical activity.

6. Conclusion

The present study shows that 3 months of physical training produces an improvement in cardiovascular autonomic functions by decreasing sympathetic response to stress.

7. References

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