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Cardiorespiratory responses to graded exercise and determination of aerobic fitness in untrained males

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Abstract

Introduction: Aerobic power or Vo2max which involves a full functional support from cardiorespiratory and metabolic pathway is an appropriate test to study cardiopulmonary fitness. Sufficient informations are not available on the extent of changes observed in different systems in untrained Indian subjects. The present study has therefore been undertaken to investigate the cardiovascular and respiratory responses to graded exercise and for determination of aerobic fitness among untrained males.

Material and Methods: The present study was conducted at Department of Physiology, Alluri Sitarama Raju Academy of Medical Sciences, From April 2013-March 2014. Hundred apparently healthy untrained men in the age group of 18-21 years were selected, to establish normal standards of cardiorespiratory responses to moderate, predetermined graded exercise on a bicycle ergograph. Parameters like heart rate, blood pressure and respiratory rate were recorded at rest, peak exercise and during recovery. Vo2max or aerobic power was calculated indirectly from Astrand – Ryhming nomogram after determining the work rate in kilopond meter per minute.

Results: Heart rate, systolic blood pressure, double product and respiratory rate rose linearly with increasing grades of exercise, while diastolic blood pressure recorded a fall. Mean arterial pressure was found to change very little. Aerobic power was found to be 49.19 ml/kg/min in 20 years age group and 49.16 ml/kg/min in 21 years category. The reduction in the systolic blood pressure during recovery period, after 5 minutes and 15 minutes was also analysed. Statistical analysis was done to compare it with the resting SBP. At the end of 5 minutes the systolic blood pressure showed a statistically significant increase from the resting SBP ($p< 0.001$).

Conclusion: During graded exercise the heart rate increased linearly, which could be due to sympathetic stimulation, increased venous return and withdrawal of parasympathetic inhibition. Systolic blood pressure rose linearly which reflects a normal sympathetic drive on cardiovascular system. Diastolic blood pressure decreased, may be due to decrease in peripheral resistance. Mean blood pressure changed very little. Double product also increased linearly and being an index of myocardial O2 consumption, showed a gradual fall during recovery.

Keywords: Bicycle ergo-graph, Vo2max, cardiorespiratory

Introduction

Exercise is a stressful condition which produces marked changes in body function, specially cardiovascular, respiratory and nervous activities. It has been a mean of finding out the physical capabilities and physiological responses of an individual [1].

Physical fitness, characterized by optimum responses to environmental stimuli, plays an important part in mental, physical and social well-being and may retard the aging process. Together with physical health, it is also important in equipping persons to fulfill specific task [2].

In contemporary society, the pattern and intensity of physical activity are changing. In highly industrialized societies, the necessity for hard physical work is diminishing; however in developing societies, the changing patterns are less clear. An important aspect of such changes in physical activity is its possible relationship to health [3].

Physical fitness is defined as the ability to perform muscular work satisfactorily under specified conditions and may be assessed by the magnitude, duration and type of the maximum exercise that a subject can withstand; the relationship between the level of submaximum exercise and the response of the body to such exercise; and the rapidity of recovery of the cardiorespiratory system from either maximum or submaximum exercise [4].

Many aspects of fitness, (e.g) aerobic power, anaerobic power and capacity, can be measured in physiological terms. Aerobic power or Vo2max which involves a full functional support from cardiorespiratory and metabolic pathway is an appropriate test to study cardiopulmonary fitness [5].

The determination of aerobic power gives an idea of the capacity and regulation of O2 transporting system and also sets a norm in assessing the physical fitness [6].

Sufficient informations are not available on the extent of changes observed in different systems in untrained Indian subjects. The present study has therefore been undertaken to investigate the cardiovascular and respiratory responses to graded exercise and for determination of aerobic fitness among untrained males (18- 21 years).

Aim and Objectives

To assess the cardiorespiratory responses to graded exercise and to determine the aerobic fitness in untrained males in the age group 18-21 years. To determine the heart rate, blood pressure and respiratory rate during graded exercise among untrained males of 18-21 years.

Material and Methods

The present study was conducted at Department of Physiology, Alluri Sitarama Raju Academy of Medical Sciences, From April 2013-March 2014. The study was undertaken to analyse the cardiorespiratory responses to graded exercise and to determine the aerobic fitness in the untrained male in the age group of 18-21 years. Normal healthy untrained male subjects in the age group of 18-21 years were randomly selected and included in the study. Subjects with chronic illness and systemic illness and trained healthy males were excluded from the study so as to minimize the bias. All subjects gave an informed consent after detailed procedure of the non-invasive technique was explained to them. Physical examination like height in cms and weight in kgs was done. Body Mass Index was derived by Quetelet's index i.e. weight (kg) / height (m^2). Body surface area was calculated using Dubois nomogram.

Vital parameters like pulse rate, blood pressure and respiratory rate were recorded. A detailed clinical examination of respiratory system, cardiovascular system and central nervous system was done. Subjects performed graded exercise on a mechanically braked bicycle ergo-graph.

The use of bicycle in testing has several advantages. It is chosen to perform graded exercise since progressive workloads can be changed with short rest periods, thus giving the subject, time to recover before starting next period of exercise.

The subject's body weight does not influence exercise capacity appreciably and sitting on a bicycle often produces less anxiety than walking on a mechanically driven treadmill. In addition bicycle requires less space in the laboratory and less expensive than a treadmill.

A brake band is applied to the rear wheel which has a circumference of about 1.68 m and the work done calculated from the tension difference between the two sides of the bands and the linear velocity of the circumference of the wheel. With a standardized tension difference, the work done depends on the rate of pedaling which is determined by the revolution counter attached to the rear wheel.

Pedaling the cycle at a rate of 60 times per minute is equivalent to 156 revolutions per minute at the wheel. Peddling rate – wheel rate

Results

The present study, entitled "Cardiorespiratory responses to graded exercise and determination of aerobic fitness in untrained males" was conducted two zymnagiasms in srikakulam. 60 male untrained subjects were analysed for the results. The results obtained are expressed as mean standard deviation. The age of subjects ranged from 18-21 years. Out of the hundred subjects, 27 subjects were in the age group of 18 years and 15 subjects were in the age group of 19 years (Table 1).

Table 1: Age -wise distribution

Age Groups (yrs)	No. of Cases	Percentag e
18	27	45
19	15	25
20	10	16
21	8	14
Total	60	100

Table2: Physical characteristics

Parameters	Range	Mean ± S.D.
Height (cm)	140-182	165 ± 8.0
Weight (kg)	40-84	55.1 ± 7.5
Body Mass Index (BMI)-kg/m^2	12.30 – 26.58	20.06 ± 2.89
Body Surface Area (BSA)-m^2	1.38 – 1.87	1.5 ± 0.1

Table 3: Cardiorespiratory changes during session i and during recovery

Parameters	At rest R	Session I S1	Difference S1 – R	P value	Post exercise 5 minutes S5	Difference S5- R	P value	Post exercise 15 minutes S15	Difference S15-R	P value
Heart rate (beats / min)	74.2 ± 6.9 (62-96)	128.4 ± 8.5 (96 – 144)	54.2 ± 8.4	< 0.001 HS (t = 60.9)	98.2 ± 13.0 (76 – 140)	24.0 ± 13.4	< 0.001 HS (t = 17.9)	81.3 ± 6.9 (69 – 96)	7.1 ± 5.9	< 0.001 HS (t = 12.0)
S.B.P. (mm of Hg)	109.9 ± 9.2 (90-134)	127.4 ± 7.8 (110-144)	17.5 ± 6.6	<0.001 HS (t = 26.5)	115.7 ± 6.2 (94-138)	5.8 ± 4.9	< 0.001 HS (t = 11.8)	110.1 ± 8.1 (90-134)	0.2 ± 3.9	< 0.61 NS (t = 0.51)
D.B.P. (mm of Hg)	71.9 ± 6.4 (60-84)	68.7 ± 7.4 (58-82)	- 3.2 ± 2.7	< 0.001 HS (t = 11.8)	70.4 ± 6.5 (60 – 82)	- 1.4 ± 1.7	< 0.001 HS(t = 8.2)	71.4 ± 6.3 (60-84)	- 0.5 ± 1.4	< 0.20 NS(t = 1.31)
Respiratory rate / min	13.6 ± 1.4 (11-16)	22.7 ± 2.2 (16-29)	9.1 ± 2.2	< 0.001 HS (t = 41.4)	17.1 ± 1.9 (14-24)	3.5 ± 1.8	< 0.001 HS (t = 19.4)	14.0 ± 1.4 (12-18)	0.4 ± 1.0	< 0.001 HS(t =4)

All values expressed as mean ± SD (range) Analysis for all parameters done by paired 't' test.

Table 4: Cardiorespiratory changes during session ii and during recovery

Parameters	Session II At rest S15	Session II S2	Difference $S_2 – S_{15}$	P value	Post exercise 5 minutes S ʾ5	Difference S ʾ – S155	P value	Post exercise minutes S15 '	Difference S ʾ-S1515	P value
Heart rate (beats / min)	81.3 ± 6.9 (69 – 96)	164.5 ± 8.8 (108 – 170)	83.2 ± 10.8	< 0.001 HS (t = 77.0)	116.2 ± 16.0 (96 – 160)	34.9 ± 16.4	< 0.001 HS (t = 21.3)	94.7 ± 15.5 (72 – 120)	13.4 ± 15.7	< 0.001 HS(t = 8.5)
S.B.P. (mm of Hg)	110.1 ± 8.1 (90-134)	144.8 ± 6.2 (130-160)	34.7 ± 8.0	< 0.001 HS(t = 43.6)	121.7 ± 11.9 (100 – 152)	11.6 ± 8.6	< 0.001 HS t = 13.5)	110.8 ± 8.2 (90 – 134)	0.7 ± 3.4	< 0.02 S(t = 2.32)
D.B.P. (mm of Hg)	71.4 ± 6.3 (60-84)	65.8 ± 7.7 (50-82)	- 5.6 ± 3.6	< 0.001 HS (t=15.5)	69.3 ± 6.5 (58-82)	-2.0 ± 3.4	< 0.001 HS (t = 5.9)	71.3 ± 5.9 (60-82)	- 0.1 ± 1.8	0.55 NS (t = 0.62)
Respiratory rate / min	14.0 ± 1.4 (12-18)	30.9 ± 3.7 (22-38)	16.9 ± 3.6	< 0.001 HS (t=46.9)	20.5 ± 2.4 (16-30)	6.5 ± 2.4	< 0.001 HS (t = 27.1)	15.4 ± 2.7 (12-20)	1.4 ± 2.3	< 0.001 HS (t = 6.1)

All values expressed as mean ± SD (range) Analysis for all parameters done by paired 't' test.

Table 5: Double product and M.A.P. changes during session i and during recovery

Parameters	At rest R	Session I S1	Difference S1 – R	P value	Post exercise 5 minutes S5	Difference S5 – R	P value	Post exercise 15 minutes S15	Difference S15 – R	P value
Double product	8154 ± 1031	16358 ± 1085	8203 ± 1048	< 0.001 HS (t = 48.5)	11361 ± 1709	3207 ± 1856	< 0.001 HS (t= 10.8)	8910 ± 1006	756 ± 222	< 0.001 HS(t = 7.0)
M.A.P. (mm Hg)	84.5 ± 7.1	88.0 ± 7.2	3.5 ± 4.0	< 0.001 HS(t = 8.6)	85.6 ± 12.9	1.1 ± 11.7	0.07 NS(t = 0.97)	84.3 ± 7.0	0.3 ± 1.1	< 0.55 NS(t = 0.62)

All values expressed as mean ± SD
Analysis for all parameters are done by paired 't' test.
HS € highly significant, S € Significant and NS € not significant.

Table 6: Double product and m.a.p. changes during session ii and during recovery

	At rest S15	Session II S2	Difference S2 – S15	P value	Post exercise 5 minutes S5'	Difference S5' – S15	P value	Post exercise 15 minutes S15'	Difference S15'-S15	P value
Double product	8910 ± 100.6	23819 ±1758	14909 ±1747	< 0.001 HS (t = 46.9)	14141 ± 1898	5231 ±1743	< 0.001 HS (t = 18.6)	10340 ±1620	1430 ±509	< 0.001 HS (t = 8.0)
M.A.P. (mm Hg)	84.3 ± 7.0	91.5 ±9.7	6.7 ±8.1	< 0.001 HS (t = 8.3)	86.3 ±6.9	1.9 ±2.8	< 0.001 HS (t = 6.8)	84.5 ±6.9	0.2 ±3.0	< 0.48 NS (t = 0.7)

All values expressed as mean ± SD
Analysis for all parameters are done by paired 't' test.
HS € Highly significant, S € Significant and NS € not significant.

Table 7: Cardiorespiratory responses to two sumaximal exercises

	At rest R	Session I			Session II		
		S1	S1 – R	P value	S2	S2 – S1	P value
Heart rate beats / min	74.2 ± 6.9	128.4 ± 8.1	54.2 ± 8.9	< 0.001 HS (t = 60.9)	164.5 ± 8.8	36.1 ± 11.0	< 0.001 HS (t = 32.8)
S.B.P. (mm of Hg)	109.9 ± 9.2	127.4 ± 17.8	17.5 ± 6.6	< 0.001 HS (t = 26.5)	144.8 ± 6.2	17.4 ± 5.9	< 0.001 HS (t= 23.5)
D.B.P. (mm of Hg)	71.9 ± 6.4	68.7 ± 7.4	- 3.2 ± 2.7	< 0.001 HS (t = 11.8)	65.8 ± 7.7	- 2.9 ± 9.4	< 0.001 HS (t = 9.4)
Respiratory rate / min	13.6 ± 1.4	22.7 ± 2.2	9.1 ± 2.2	< 0.001 HS (t = 41.4)	30.9 ± 3.7	8.2 ± 2.8	< 0.001 HS (t = 23.4)

All values expressed as mean ± SD
Analysis for all parameters are done by paired 't' test.
HS € Highly significant, S € Significant and NS € not significant.

Table 8: Comparison of cardiorespiratory parameters

		After session I S1 – R	After session II S2 – S15	15 minutes after session II S15 – R
Heart rate (Beats / min)	Dtp	54.2 ± 8.160.9 < 0.001 HS	83.2 ± 10.877.0 < 0.001 HS	20.5 ± 16.312.6 < 0.001 HS
Systolic Blood Pressure (mm of Hg)	Dtp	17.5 ± 6.626.5< 0.001 HS	33.0 ± 6.253.2 < 0.001 HS	1.1 ± 5.41.82 <0.07 NS
Diastolic Blood Pressure (mm of Hg)	Dtp	-3.2 ± 2.711.8< 0.001 HS	-5.6 ± 13.615.50.001 HS	-0.6 ± 1.83.3< 0.01 S
Respiratory Rate/ min	Dtp	9.1 ± 2.241.4<0.001 HS	16.9 ± 3.646.9<0.001 HS	1.8 ± 2.37.8<0.001 HS

Discussion

In the present study, heart rate increased linearly with increasing grades of exercise, and there was a statistically significant increase in heart rate over the pre-exercise values during both the exercise sessions. Similar findings were reported by many workers, Lars Hermansen *et al*., [8]

Jain AK *et al*. have studied the cardiac frequency at various workload and observed that the heart rate rose linearly with increasing workloads[9]. Dalia Biswas and Kher Jeyant reported that linear increase in heart rate occurred during graded exercise in bicycle ergograph [10].

Study done by Bhave *et al*., reported that during graded exercise the heart rate rose linearly with increasing grades of exercise.[11] Similar linear increase in heart rate during graded exercise were also reported by Gupta GD *et al*. [12] and Sharma Rajesh *et al*. [13] in Indian adults.

During graded exercise the heart rate progressively increases owing to an increase in intensity of sympathetic nervous system, increased venous return and withdrawal of parasympathetic inhibition. These changes in autonomic activity are reversed and the heart rate decreases during recovery. The rate at which heart rate decreases after exercise is a reflection of a person's physical fitness, as in case of active endurance athletes; the more rapid decline, the higher is the level of fitness [14].

In the present study there was persistent increase in the heart rate even after the rest of 15 minutes following the second session of exercise. Study done by Fraser Robert *et al*. [25] on effect of exercise on cardiovascular function also showed that the heart rate exceeded 15 percent above the resting value after 6 minutes of post exercise. Madan Mohan *et al*. [66] also reported a persistent increase in the heart rate even after 10 minutes of post exercise. Similar findings were reported by many workers, Fortuin Nicholas *et al*. [15] this could be due to sustained release of catecholamines during submaximal exercise and even after the cessation of the exercise in untrained subjects [16].

In the present study systolic blood pressure rose linearly with increasing grades of exercise and it is statistically significant. Exercise induced significant rise in systolic blood pressure reflects the normal sympathetic drive on cardiovascular system which enables the heart to pump more blood to the active tissues in the body, as physical conditioning of person greatly influences the heart rate, blood pressure and rate of blood flow of the individual.

In the present study, the systolic blood pressure had a steady decline during recovery period. Systolic blood pressure was slightly above the resting value at the end of 5th minute in the recovery period but almost too resting value at the end of 15th

minute.

Stevenson *et al*., also found that return of both systolic and diastolic pressure to preexercise values generally did not occur until the tenth minute of recovery.[17] Wolthuis Roger *et al*. [18] also reported that systolic blood pressure won't come to the normal level at the end of 5 minutes. Systolic pressure slightly above the preexercise value at the end of 10th minute was reported by Thomas Thulin *et al*. [19]

In the present study, there was a decrease in diastolic blood pressure in both the sessions of exercise. This decrease is thought to be due to decrease in systemic vascular resistance which occurs during exercise. Change in the diastolic blood pressure was minimal (10-15 mm of Hg) as compared to the change in systolic blood pressure (30-40 mm of Hg). This result is consistent with the earlier work done by Fraser Robert *et al*. [20]. In the present study, mean arterial pressure was found to change very little since changes in systolic and diastolic blood pressure are opposite in direction. This finding is in consistency with the earlier work done by Lars Hermansen *et al*. [21]

Double product gives an index of myocardial oxygen consumption. In the present study it showed a linear increment and being an index of myocardial oxygen consumption, showed a gradual fall during the recovery period. The double product at submaximal heart rate ranged from 8154 to 23819 in the present study. Similar findings were reported by Bhave *et al*. [23] and Madan Mohan *et al*. [22]. The double product did not reach the basal value at the end of the 15th minute. It may be due to reduced myocardial efficiency or increased catecholamines secretion due to emotional excitement of the subjects [24].

In the present study, respiratory rate increased in both the sessions of exercise. This result could be due to a rapid neurogenic component and a slower humoral component according to the neuron humoral theory of exercise hyperpnoea. Similar findings are reported by Phatak Mrunal *et al*. [25]

Conclusion

Systolic blood pressure rose linearly with increasing grades of exercise, which reflects a normal sympathetic drive on cardiovascular system which enables the heart to pump more blood to active tissues in the body. There was decrease in diastolic blood pressure in both sessions of exercise, may be due to decrease in peripheral resistance. Mean arterial pressure changed very little, since alterations in systolic and diastolic pressures are opposite in direction. Double product also increased linearly and being an index of myocardial O2 consumption showed a gradual fall during recovery. Respiratory rate rose linearly with increasing grades of exercise. The result could be due to rapid neurogenic component and a slower humoral component according to the neurohumoral theory of exercise hyperpnoea.

References

1. Fortuin NJ, Weiss JL. Exercise stress testing. Circulation 1977;56(5):699-711.
2. WHO meeting on Exercise tests in relation to cardiovascular function. Wld Hlth Org Techn Rep Ser. 1968;388:5-29.
3. Astrand PO, Kaare Rodahal. Text book of Work Physiology. 1st ed. KogaKusha McGraw Hill. 1996.
4. Lars Hermansen, Lange Anderson K. Aerobic work capacity in young Norwegian men and women. J Appl Physiol. 1965;20(3):425-431.
5. Chaudhuri SK. Concise Medical Physiology. 4thed. Calcutta: New Central Book Agency. 2002, 404-410.
6. Ellestad EH. Stress Testing: Principles and Practice. 4th ed. New Delhi: Jaypee Brothers. 1996, 1-41.
7. Jain AK. Manual of Practical Physiology for M.B.B.S. 1sted. New Delhi: Arya Publications. 2003, 161-162.
8. Berne RM, Levy MN. Physiology. 3rded. USA: International Edition. 1993:532-537.
9. Sembulingam K, Prema Sembulingam. Essentials of Medical Physiology 3rded. New Delhi: Jaypee Brothers Medical Publishers (P) LTD. 2004.
10. Ganong WF. Review of Medical Physiology. 21sted. USA: McGraw Hill. 2003.
11. Green JH. An introduction to human physiology. 1sted. Great Britain: Oxford Medical Publications. 1963, 72.
12. Chakrabarti BK, Ghosh HN, Sahana SN. Human Physiology. 2nded. Calcutta: The New Book stall. 1984.
13. Smith DE, Paterson Colin R, Scratcherd Thomas, Read NW. Textbook of Physiology. 11thed. UK: Churchill Livingstone, ELBS. 1988.
14. Guyton AC, Hall JE. Textbook of Medical Physiology. 10thed. Philadelphia: W.B. Saunders Company. 2000.
15. Keele CA, Neil Eric, Joels Norman, Samson Wright's Applied physiology. 13thed. UK: Oxford Medical Publication. 1982.
16. Opic LH. The heart – physiology from cell to circulation. 1997, 447-452.
17. West BJ. Physiological basis of Medical Practice. 12thed. New Delhi; BI Waverly Pvt. Ltd. 1996, 304-306, 585-586.
18. McCloskey DI, Mitchell JH. Reflex cardiovascular and respiratory responses originating in exercising muscle. J Physiol. 1972;224:173-186.
19. Nunn JF. Applied Respiratory Physiology. 3rded. Butterworth and Co publishers. 1987:297-302.
20. Shepherd JT. Circulatory changes in the lungs during exercise. Pediatrics part II; supplement. 1963 October, 683-686.
21. Mcllroy MB. The respiratory response to exercise. Pediatrics. 1963;2:680-682.
22. Phatak MS, Kurhade GA, Karore SB, Pradhan GC. Effect of exercise on acid – base status and ventilatory kineties. Indian J Physiol Pharmacol. 1998;42(3):417-420.
23. Chatterjee CC. Human Physiology. 11thed. New Mudran: Ashutosh Lithographic Company. 1985.
24. Bijlani RL. Understanding Medical Physiology. 3rd ed. New Delhi: Jaypee Brothers. 2004, 636-649.
25. Fraser Robert S, Chapman Carleton B. Studies on the effect of exercise on cardiovascular function. Circulation. 1954;9:193-198.