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A comparative study of Vo_2max and anaerobic threshold between aerobic and non-aerobic exercising in different aged males

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This study was to compare the cardiopulmonary capacity between 17-30 and 31-40 year-old of aerobic and non-aerobic exercising males. The Vo_2max and anaerobic threshold (AT) of 65 healthy men (17-40 year-old) were measured by direct gas analysis during exercise (Spiro-Ergometry). The parameters were declining significantly with age of both groups. The values of Vo_2max and AT of aerobic exercising subjects were significantly higher than of non-aerobic exercising ones ($p<0.001$).

This study revealed that the declining rate of cardiopulmonary capacity aging could be decelerated by regular aerobic exercise.

Key words : *Vo_2max, Anaerobic threshold, Aging, Fitness.*

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ชาญวิทย์ โคธีรานุรักษ์, บังอร ชมเดช, พัสมณฑ์ คุ้มทวีพร, เจริญทัศน์ จินตนเสรี, ออง มินท์. การศึกษาเปรียบเทียบค่าวีโอ 2 แมกซ์ และแอนแอโรบิค เทรสโฮลด์ ในผู้ชายที่มีกิจกรรมการออกกำลังและไม่ได้ออกกำลังแบบแอโรบิคในระดับอายุต่าง ๆ. จุฬาลงกรณ์เวชสาร 2534 กรกฎาคม; 35(7): 443-449

การศึกษานี้มุ่งเปรียบเทียบค่าสมรรถภาพการทำงานของหัวใจและปอดของชายไทยอายุระหว่าง 17-30 และ 31-40 ปี ที่มีและไม่มีกิจกรรมออกกำลังแบบแอโรบิค โดยวัดค่าสมรรถภาพการใช้ออกซิเจนสูงสุด (Vo_2max) และค่าการใช้ออกซิเจนสูงสุดที่ร่างกายยังออกกำลังได้โดยไม่เกิดการสะสมของกรดแลคติก (AT) ด้วยวิธีวิเคราะห์แก๊สโดยตรง พบว่า ค่าตัวแปรทั้งสองจะลดลงในกลุ่มที่อายุมาก แต่จะสูงในกลุ่มที่มีกิจกรรมออกกำลังแบบแอโรบิค จากการศึกษานี้ แสดงให้เห็นว่า การมีกิจกรรมออกกำลังแบบแอโรบิคอย่างสม่ำเสมอสามารถชลอความเสื่อมของระบบไหลเวียนเลือดและปอดจากความชราได้

Aerobic training could alter physiologic changes in the cardiopulmonary system. They must engage in a prolonged exercise in order to improve cardiopulmonary fitness rather than physical strength and flexibility.(1) The improvement of performance brought about by endurance training for at least one year could be correlated with the increasing in lung compliance as well as in the efficiency of oxygen removed from the air and diffused into the blood.(2,3) The total of the changes were expressed in a higher Vo_2max,(4) or anaerobic threshold (AT).(5) The Vo_2max is the ability of the individual to utilize the greatest amount of oxygen of the whole body. It has been a highly reproducable parameter related to cardiac output and the arteriovenous oxygen difference.(6) At is a level of oxygen uptake above aerobic energy production, which was supplemented by anaerobic metabolism.(7,8) Later parameter has been used to determine peripheral factors such as capillary density or enzyme activity of skeletal muscle.(9)

The lower Vo_2max found in old rat and after training both age groups had increased Vo_2max above sedentary age-matched controls.(10) The decreasing in strenuous activity with age might account for the large reduction in Vo_2max(11) and AT.(12) Until now, the relationship between aging and exercise in human subjects are unsolved.(13,14)

This study was undertaken to define normal range of aerobic parameters and compare the general endurance capacity by both Vo_2max and AT of aerobic and non-aerobic exercising in different aged males. Furthermore, the data will be summarized and added to further study in an attempt to define normal range of aerobic parameters.

Materials and methods

Subjects

Sixty five healthy males (17-40 year-old) were included in this study. The subjects were divided into two groups by age. Each age group was randominized to aerobic and non-aerobic exercising groups by a questionnaire (table 1). Aerobic exercising group is the group of subjects who performed aerobic exercise at least 30 minutes in every other days or not less than 3 days a week. The period of aerobic exercise in this group is not less than 12 months and still maintained exercising activity prior to the test. Non-aerobic exercising group is the group of subjects who do not perform regular aerobic exercise in daily life.

Materials and Methods

On the day of experiment all subjects had a rest for 6-8 hours(15) and omitted heavy diet 3-4 hours prior to the exercise test.(16) The subjects were measured for weight, height (Detecto, U.S.A.), vital sign and blood pressure (Eudameter, German) before the exercise test. The exercise test was set on a braked cycle ergometer (Monark, Sweden). During the experimental period, subjects were advised to rest on cycle ergometer for 10 minutes. All subjects were allowed to breath room air through a mouthpiece (a liter respirometer mouth piece, Collins), a three-way value with 90 ml. dead space, a pneumotachograph (Fleisch i/a 7320 (2 #), U.S.A.), a differential pressure transducer (PT5A Grass, U.S.A.), a 13 litters mixing chamber, an oxygen analyzer (OM-11 Beckman, U.S.A.) and a carbon dioxide analyzer (LB-2 Backman, U.S.A.). Thermo'probe (Surface Temperature-Banjo Type 408, U.S.A.) was a detector of temperature in the chamber which was recorded by telethermometer (Temp I, Thailand). All the signals were recorded on chart paper by a multi-channel polygraph (7DAC Grass, U.S.A.) .

When the exercise test started the subjects exercised following audio-visual feedback which rhythm monitored by metronome (Seiko, Japan). The metronome was set at 50 round per minute. The pedaling was begun at 300 kilopond-meter (kpm). The resistance was increased by 50 kpm every minute until exhaustion. Then subjects went on pedaling 0 kpm 10 minutes for cooling down purpose.(17)

Calculation

The volume of expired air, expired oxygen percentage and expired carbon dioxide percentage from polygraph recorder were changed to values at standard temperature, standard pressure and dry (STPD) and calculated to volume per minute by method of Jones.(4) The highest volume of oxygen in a certain minute was the value of Vo_2max.

The graphs of volume of oxygen uptake (Vo_2), volume of carbon dioxide output (Vco_2) and volume of expired air (V_E) at STPD against time scale were used to determine the value of AT under 2 criterias that:- the increase of Vco_2 and V_E were non-proportional to the work load, while the increasing Vo_2 was still linear to the work load.(18)

Statistics

The statistics used to determine the difference of aerobic parameters in each aged group was F-test (Analysis of Variance) using the statistic computer program "Epistat". The physiological differences between aerobic and non-exercising groups were also tested by F-test. A probability of 0.05 was selected as the criterion for statistical significance.

Results

Table 1 demonstrated that the mean values of all physical characteristics were not statistically significance ($p < 0.05$). Table 2 showed that the mean value of Vo_2max of non-aerobic exercising subject was not change with age. In aerobic exercising groups, the mean value of Vo_2max of younger aged group was significantly higher than the older one ($p < 0.01$). The comprison between aerobic and non-aerobic exercising subjects indicated that the Vo_2max of both 17-30 and 31-40 year-old aerobic exercising ones were significantly higher than of non-aerobic exercising in the same aged groups ($p < 0.001$).

The data from table 3 demonstrated that the changes of AT in different aged groups were statistically significance ($p < 0.01$ and $p < 0.001$). The comparison between aerobic and non-aerobic exercising subjects showed that the mean values of AT of aerobic exercising were higher than non-exercising significantly in both aged groups ($p < 0.001$).

Table 1. Selected characteristics of subjects of exercise activity.

Characteristics	Exercise activity		p value
	aerobic	non-aerobic	
Age group 17-30 yrs	n = 15	n = 15	
($\bar{X} \pm SD$)			
Age (yrs)	24.80 ± 4.23	25.47 ± 2.45	0.60
Weight (Kg)	60.80 ± 5.43	61.50 ± 7.91	0.78
Height (cm)	170.13 ± 5.95	170.07 ± 3.37	0.97
Age group 31-40 yrs	n = 16	n = 19	
($\bar{X} \pm SD$)			
Age (yrs)	36.06 ± 3.55	36.05 ± 2.93	0.99
Weight (Kg)	64.53 ± 5.32	66.63 ± 9.72	0.45
Height (cm)	170.56 ± 4.26	168.84 ± 5.48	0.31
p value of weight	**0.06**	**0.11**	

Table 2. The Vo_2max of subjects (mean ± SD).

Age (years)	Vo_2max (ml/min/kg)		p value
	aerobic exercise	non-aerobic exercise	
17-30	60.61 ± 4.01 (1)	44.86 ± 4.18 (2)	(1) > (2), $p < 0.001$
31-40	54.72 ± 5.26 (3)	43.76 ± 7.49 (4)	(3) > (4), $p < 0.001$
p value	(1) > (3) $p < 0.01$	(2) > (4) NS	

Table 3. The AT of subjects (mean ± SD).

Age (years)	AT (ml/min/kg)		p value
	aerobic exercise	non-aerobic exercise	
17-30	45.21 ± 5.30 (1)	33.52 ± 4.32 (2)	(1) > (2), $p < 0.001$
31-40	38.68 ± 5.99 (3)	26.74 ± 4.98 (4)	(3) > (4), $p < 0.001$
p value	(1) > (3) $p < 0.01$	(2) > (4) $p < 0.001$	

Discussion

The recent study has reported that the optimal of a direct exercise test of Vo_2max was approximately 8-17 minutes.[19] In this study, the duration of 8-16 minutes was used and showed that the highest value of Vo_2max in each test was not interfered by limitation of muscular force.

The aerobic exercising groups in this study were the subjects who performed aerobic exercise such as jogging, swimming, long distance walking and other aerobic activities in such a period of time. So the values of our aerobic parameters might be varied. But the Vo_2max of 17-30 and 31-40 year-old aerobic exercising subjects were 60.61 ± 4.01 and 54.72 ± 5.26 ml/min/kg, respectively that corresponded with the value of slow runner group that was 53.4 to 67.4 ml/min/kg which demonstrated by Sjodin and Svedengag.[20] The study also agrees with value of previous study of Coyle and his team.[21] The Vo_2max of 17-30 and 31-40 year-old non-exercising subjects were 44.86 ± 4.18 and 43.76±7.97 ml/min/kg, also agree with previous study.[22]

The AT in our study was higher than AT of obesity subjects.[23] The AT of non-exercising subjects was agree with AT of previous studies.[24,25] The AT of aerobic exercising subjects was higher than the AT of jogging persons in previous sutdy.[26] These might be due to our study being performed with more intensity and longer duration of aerobic exercise.

The age effect was not due to differences in body weight, since no significant difference in body weight was found between the groups of the study (table 1), and the difference in Vo_2max and AT were evident whether it was expressed relative to body weight (ml oxygen/min/kg body weight).

Both Vo_2max and AT decline with age. Vo_2max is the product of maximal cardiac output and maximal systemic arteriovenous oxygen difference,[6] and AT correlates with muscle oxidative capacity.[27] Most studies reported that maximal cardiac output declines with age because of a decrease in maximal heart rate associated with a decreased in Vo_2max with age.[28] The reduction in oxygen uptake at the ventilation threshold in elderly was stated by Seals and colleagues.[29] They indicated that this decline resulted from the limitation of the respiratory and hemoglobin oxygen transport system responding to facilitate tissue oxygenation in the elderly. The means Vo_2max in aerobic exercising groups were different significantly from those of non-aerobic exercising groups (table 2) and the results were acceptable as compared to the study of the athlete groups[30] and the sedentary groups.[31]

Table 3 demonstrated that aerobic exercising groups showed higher AT than non-aerobic exercising groups which agree with previous studies.[28,32] These AT also declined with age in the same manner as those of the study of Allen and co-workers.[33] Accordance with the result from Hagberg and co-workers,[30] that undergo less metabolic response than younger ones. Dudley et al.,[34] suggest that the signal that stimulates increased respiratory capacity might be influenced by the adaptation "itself". Unfortunately results of both areas are still not available for discussion, so that further studies are valuable.

The Vo_2max in this study was not different from other races in previous studies, whereas AT of aerobic-exercising subjects was higher than previous studies in caucasian. Both aerobic exercising groups showed higher cardiopulmonary capacity than non-aerobic exercising ones. These findings suggest that although central and peripheral circulation and pulmonary function declined by aging, the regular aerobic exercise can decelerate these processes in both age levels study. Further study will give our team more valuable data of aerobic parameters to define normal range of them.

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References

2. Jones NL. Calculation of results. In: Jones NL, ed. Clinical Exercise Testing. Philadelphia: WB Saunders, 1988. 289-300
3. Yoshida T, Suda Y, Takeuchi N. Endurance training regimen based upon arterial blood lactate: effects on anaerobic threshold. Eur J Applied Physiol 1982; 49(2): 223-30
4. Walsh RA. Cardiovascular effects of the aging process. Am J Med 1987 Jan; 82(1B): 34-40
5. Wasserman K. The anaerobic threshold measurement to evaluate exercise performance. Am Rev Respir Dis 1984 Apr; 129 (Suppl.): S35-40
6. Stremel RW. Historical development of the anaerobic threshold concept. Physiologist 1984 Agu; 27(5): 295-8
7. Iwaoka K, Fuchin T, Higuchi M, Kabayashi S. Blood lactate accumulation during exercise in older endurance runners. Int J Sports Med 1988 Aug; 9(4): 253-6
8. Cartee GD, Farrar RP. Exercise training induces glycogen sparing during exercise by old rats. J Appl Physiol 1988 Jan; 64(1): 259-65
9. Cunningham DA, Nancekiewill Ea, Paterson DH, Donner AP, Rechnitzen Pa. Ventilation threshold and aging. J Gerontol 1985: Nov; 40(6): 708-7
10. Posner JD, Kevin MG, Howard SK, Cathy JC. Ventilatory threshold: measurement and variation with age. J Appl Physiol 1987; 63(4): 1519-25
11. Holloszy JO, Smith EK. Effects of exercise on longevity of rats. Fed Proc 1987 Apr; 46(5): 1850-3
12. Bruce RA. Exercise, functional aerobic capacity, and aging another viewpoint. Med Sci Sport Exerc 1984 Jan; 16(1): 8-13
13. Pollock ML, Broica J, Kendrick Z, Miller HS, Jene WR, Linnerud AC. Effects of training two days per week at different intensity on middle-aged men. Med Sci Sports 1972; 4(4): 192-7
14. Yoshida T. Effect of dietary modifications on anaerobic threshold. Sport Med 1986 Jan; 3(1): 4-9
15. deVries HA. Physical fitness testing. In: deVries HA, ed. Physiology of exercise for physical education and athletics. U.S.A.: WMC Brown, 1983. 246-77
16. Gibbons L, Blair SN, Kohl HW, Cooper K. The safety of maximal exercise testing. Circulation 1988 Oct; 78(4): 846-52
17. Chick TW, Somet JM. Exercise and the lung, In: Otto Appenzeller ed. Sports Medicine: Fitness, Training, Injuries. Baltimore-Munich: Urban and Schwarzenberg, 1988. 239-56
18. Taylor HL, Bushirk E, Henschel A. Maximal oxygen intake as an objective measure of cardio-respiratory performance. J Appl Physiol 1955 Jan; 8(1): 73-8
19. Astrand PO. Aerobic process. In: Astrand PO, Rodahl K, ed. Text Book of Work Physiology. Singapore: McGraw-Hill, 1986. 299-308
20. Buchfuhrer MF, Hansen JE, Robinson TE, Sue DY, Wasserman K, Whipp BJ. Optimizing the exercise protocol for cardio pulmonary assessment. J Appl Physiol 1983 Nov; 55(5): 1558-64
21. Sjodin B, Svedenhag J. Applied physiology of marathon running. Sport Med 1985 Mar-Apr; 2(2): 83-99
22. Coyle EF, Coggan AR, Hopper MK, Walters TJ. Determinants of endurance in well-trained cyclists. J Appl Physiol 1988 Jun; 64(6): 2622-30
23. Yeh MP, Gardner RM, Adams TD, Yanowitz FG, Carpo RO. Anaerobic threshold: problems

of determination and validation. J Appl Physiol 1983 Oct; 55(4): 1178-86

24. Tanaka K, Nakadomo F, Kumagai S, Nishizomi M. Clinical application of lactate threshold to the treatment of obesity. J Human Ergol 1987; 16: 145-50
25. Aunola S, Rusko H. Aerobic and anaerobic thresholds determined from venous lactate or from ventilation and gas exchange in relation to muscle fiber composition. Int J Sports Med 1986 Jun; 7(3): 161-6
26. Kavanahg T, Yacoub MH, Mertens DJ, Kennedy J, Combell RB, Sawyer P. Cardiorespiratory responses to exercision training after orthotopic cardiac transportation. Criluration 1988: Jan; 77(1): 162-71
27. Davis JA, Wasserman K. Anaerobic threshold alterations caused by endurance training in middle-aged men. J Appl Physiol 1979 Jun; 46(6): 1039-46
28. Cartee GD, Farrar RP. Muscle respiratory capacity and Vo_2max in indentically trained young and old rats. J Appl Physiol 1987 Jul; 63(1): 257-61
29. Seals DR, Hagberg JM, Hurley BF, Ehsani AA, Holloszy JO Endurance training in older men and women: I Cardiovascular response to exercise. J Appl Physiol 1984 Oct; 57(4): 1024-8
30. Hagberg JM, John EY, Douglas RS. Pulmonary function in young and older athletes and untrained men. J Appl Physiol 1988 Jul; 65(1): 101-5
31. Fleg JL, Stephen PT, Edward GL. Age-related augmentation of plasma catecholamines during dynamic exercise in healthy males. J Appl Physiol 1985 Oct; 59(4): 1033-9
32. Tanaka K, Matsuura Y, Matsuzaka A, Hirakoba K, Kumagai S, Sun SO, Acano K. A longitudinal assessment of anaerobic threshold and distance running performance. Med Sci Sports Exerc 1984 Jun; 16(3): 278-82
33. Allen WK, Douglas RS, Ben FH, Ali AE, James MH. Lactate threshold and distance-running performance in young and older endurance athletes. J Appl Physiol 1985 Apr; 58(4): 1281-4
34. Dudley GA, Abraham WA, Terjung RL. Influence of exercise intensity and duration on biochemical adaptations in skeletal muscle. J Appl Physiol 1982 Oct; 53(4): 844-50