Measurement of anaerobic power in men and women with excess weight experimentally equated

Hiroh YAMAMOTO* · Naomi KAWAMOTO** · Shigako TAKEUCHI*** · Masami TAKANO****

ABSTRACT

To study the effect of excess body weight experimentally equated on Anaerobic power, Anaerobic power by Margaria Power Test was measured in ten male and ten female students under six conditions: (1)with normal body weight, (2)with weight equal to 10% of LBM, (3) similarly 15% of LBM, (4) similarly 20% of LBM, (5) similarly 25% of LBM and (6) similarly 30% of LBM. According to adding weight, Mechanical Power (kgm/sec) for male increased and Mechanical Power for female decreased. In any conditions, Anaerobic Power for male was higher than that for female by about 10kcal/kg · h. Anaerobic Power similarly decreased for male and female according to adding weight. This indicated that Anaerobic Power decreased by the sex of the subjects regardless of adding weight. In conclusion, the result of this study indicated there was sex difference on Anaerobic Power by Margaria Power Test.

At adolescence, body fat of girl increases remarkably. Generally, physical work capacity for female falls at reaching adolescence. Cureton et al.(1980)[6] reported that excess body fat influenced on performance of distance running and 12-min run. Previous studies have indicated that excess body weight influenced on aerobic exercise[8)21]. Physical work contains aerobic processes and anaerobic processes[9]. As for these two processes, Åstrand et al. (1970)[2] reported in their *Textbook of Work Physiology*, "During light work, the required energy may be almost exclusively produced by aerobic processes, but during more severe work anaerobic processes are brought into play as well. Anaerobic energy-yielding metabolic processes play an increasingly greater role as the severity of the work loads increases."

The effects of excess body weight on physical performance capacity have been studied by Keys (1959)[13], Johnson et al. (1968)[12], Parizkova (1961)[20], and many other researchers up to now. The relationship among body weight and physical activity has been systematically studied, for example, in mature rats by Mayer et at.(1954)[17] and adolescent girls by Bullen (1964)[3].

Received on September 17, 1986.
* Department of Physical Education, Faculty of Education, Kanazawa University
** Tsubata Elementary School, Tsubata, Ishikawa
*** Togi Junior High School, Togi, Ishikawa
**** Kohryoh Junior High School, Takaoka, Toyama

Including by Cureton et al. (1978[4], 1979[5], 1980[6]), many studies have reported significant, inverse relationships between body fatness and distance running performance or related tests of physical work capacity. In aerobic exercise the relationship between body fat and performance has been studied a little. For anaerobic power, the methods of measurement have been investigated and devised by Margaria et al. (1966)[15][16], Ikuta et al. (1972)[10][11], Nakatou (1980)[19], and others. As mentioned above, there have been many studies on maximal Anaerobic Power and body fat, but the relationship between these two parameters seemed to be studied not yet. Now, does excess body fat influence on performance of anaerobic exercise[7]? The purpose of this study is to study the effect of excess weight experimentally equated in men and women on Anaerobic Power.

METHODS

Ten male and ten female students majoring physical education in Kanazawa University served as subjects in the present study. The physical characteristics of the subjects were showed in Table 1.

In order to estimate body density, according to Nagamine et al. (1964)[18], skinfold thicknesses were measured with a Harpenden caliper.

Body density (male) $= 1.0913 - 0.0016 \times (X+Y)$

(female) $= 1.0897 - 0.00133 \times (X+Y)$

X ; Skinfolds of triceps(cm)

Y ; Skinfolds of subscapular (cm)

$\%Fat = (4.570 \times \text{Body density} - 4.142) \times 100$

$\text{Fat (kg)} = \text{Body weight} \times \%Fat/100$

$\text{LBM(kg)} = \text{Body weight} - \text{Fat}$

The subjects were tested under six conditions ; (1)with normal weight, (2)with weigth equal to 10% of LMB, (3)similarly 15% of LMB, (4)similarly 20% of LBM, (5) similarly 25% of LBM, (6)similarly 30% of LBM. The addition of the external weight to the body were added with weigth belts.

Anaerobic Power was measured according to Margaria Power test.(Figure 1)

Mechanical Power outputs were calculated from the formula ;

$$MP = \frac{W \times D}{t} = W \times \frac{D}{t}$$

where MP = Mechanical Power (kgm/sec)

W = weight of person (kg)

D = Vertical height between 8th and 12th stair (m)

t = Time from 8th to 12th stair (sec)

D/t = Vertical component of the speed (m/sec)

Table 1. Physical characteristics of each subject.

Subj	Height (cm)	Weight (kg)	Age (yrs)	Team	Skinfolds (cm)
male					
F.U.	176.5	81.5	21	Volleyball	1.30
T.D.	166.0	61.0	22	Soccer	.73
M.K.	177.5	64.5	22	Basketball	.63
T.N.	168.0	54.5	22	Handball	.67
Y.I.	168.0	63.0	22	Swimming	.98
H.F.	165.0	60.0	22	Basketball	.85
S.K.	170.8	60.0	22	Volleyball	.68
T.O.	174.5	61.0	22	Table tennis	.77
S.K.	167.0	66.0	23	Handball	.88
M.F.	175.0	81.0	21	Kendo	1.35
M	170.8	62.3	—	—	.88
S.D.	4.4	8.5	—	—	.24
Female					
Y.K.	162.0	65.0	22	Volleyball	1.86
C.U.	156.0	46.0	22	Dance	1.09
N.K.	161.8	57.0	22	Basketball	1.59
A.F.	160.2	53.0	22	Basketball	1.12
N.K.	156.0	50.0	20	Volleyball	1.13
N.S.	167.0	51.0	21	Tennis	.96
Y.T.	160.0	52.0	22	Volleyball	.99
A.O.	156.5	52.0	21	Tennis	1.19
H.T.	165.0	55.0	22	Volleyball	1.46
K.O.	165.0	55.0	22	Dance	1.55
M	160.7	53.6	—	—	1.29
S.D.	3.8	4.8	—	—	.29

Anaerobic Power outputs were calculated from the formula :

$$AP=\frac{MP}{W}\times 2.347\times 60\times 60\times 4\times 0.001$$

where AP = Anaerobic Power (Kcal/kg·h)

1kgm/sec = 2.347kcal/sec

Mechanical efficiency = 0.25[13]

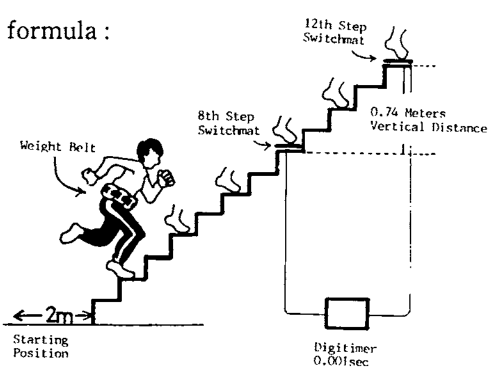

Fig. 1 Margaria Power Test

RESULT

Plots of the individual values for the vertical compoment of the speed (m/sec) under the six added weight (kg) conditions were presented in Figure 2. Addition of weight to the both sexes significantly decreased the mean values for vertical component of the speed. At no addition and 30% of LBM weight, the difference between M and vertical component of the speed was significant both sexes. ($P<0.001$). In female, the speeds were decreased largely than in male. Table 2 showed the relationship between % of LBM and Mechanical Power. Mechanical Power of females showed a tendency to be constant for all six conditions. (The values were about 76kgm/sec.) In fact, Mechanical Power of male decreased gradually as the added weight was increased. Anaerobic Power of both sexes were presented in Table 3 for all measurments that were taken. Figure 3 showed the reduction in Anaerobic Power on added weigth of % of LBM. In Anaerobic Power, a superior female and an inferior male were taken out. Figure 4 showed the changes of their Mechanical Power and Anaerobic Power on the % of LBM.

Table 2. Mechanical power of each subject in condition Ⅰ, Ⅱ, Ⅲ, Ⅳ, Ⅴ and Ⅵ.

Subject	Mechanical power (kgm/sec)					
Male	I	II	III	IV	V	VI
F.U.	134.92	135.83	139.95	144.71	141.26	144.68
T.D.	123.00	118.25	118.76	114.63	118.53	117.56
M.K.	106.30	107.49	110.53	105.82	108.18	110.65
T.N.	97.89	97.41	94.64	97.15	100.37	100.41
Y.I.	117.73	110.74	114.81	116.74	116.74	121.31
H.F.	102.07	104.33	104.46	104.00	107.53	107.16
S.K.	105.46	103.11	98.47	103.51	104.48	109.23
T.O.	92.50	93.01	94.78	95.10	98.49	99.33
S.K.	110.25	109.18	112.64	110.27	113.83	112.59
M.F.	126.46	122.17	116.14	120.15	123.94	119.84
M	111.66	110.15	110.52	111.21	113.34	114.28
S.D.	12.82	11.91	12.92	13.58	12.08	12.34
Female	I	II	III	IV	V	VI
Y.K.	93.95	92.29	94.45	90.58	87.67	86.17
C.U.	64.17	63.17	56.92	57.89	58.23	58.47
N.K.	80.96	76.07	79.28	74.82	77.35	78.63
A.F.	80.04	75.65	77.79	77.50	79.33	77.21
N.K.	64.80	66.24	62.57	64.61	61.74	62.00
N.S.	72.44	75.59	76.92	78.87	79.28	80.30
Y.T.	83.47	80.19	77.29	76.31	77.02	74.23
A.O.	76.81	74.27	72.70	69.44	69.86	72.40
H.T.	77.08	76.98	76.57	77.23	79.66	79.31
K.O.	82.06	78.10	82.92	81.04	82.56	79.06
M	77.58	75.86	75.74	74.87	75.27	74.78
S.D.	8.40	7.42	9.80	8.61	8.77	8.09

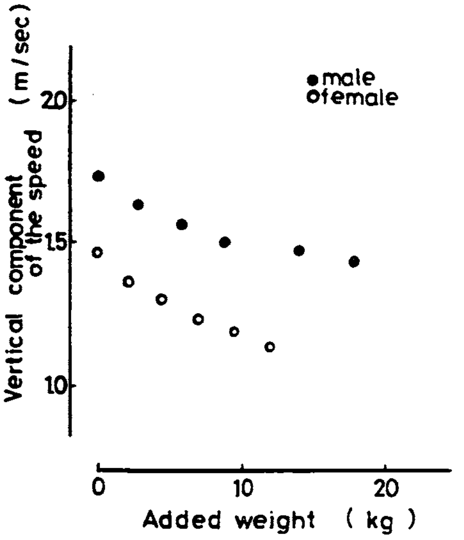

Fig. 2 Vertical component of the speed in meters per second as a function of added weight in the mean of male (n=10) and female (n=10).

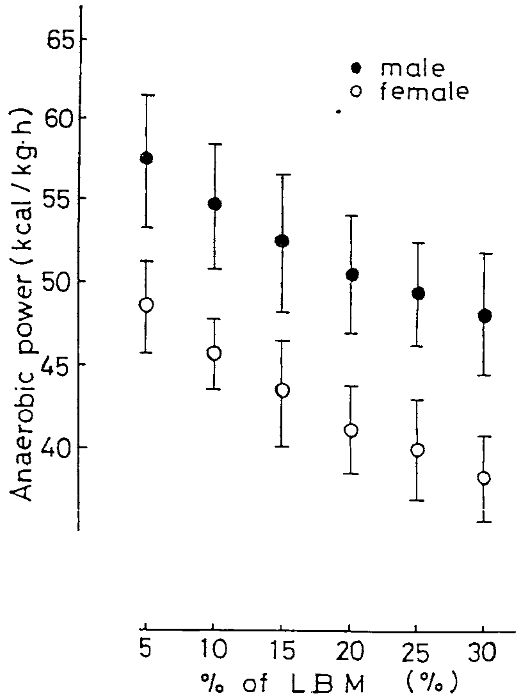

Fig. 3 Average values and standard deviations (vertical line) of Anaerobic power (kcal/kg・h) as a function of six % of LBM conditions.

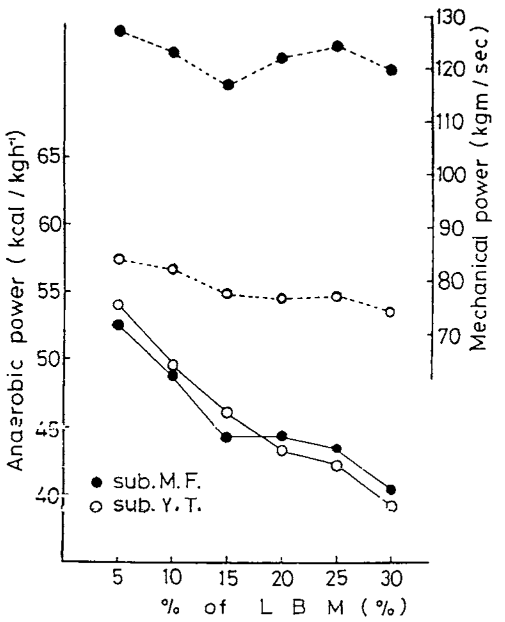

Fig. 4 Anaerobic power (kcal/kg・h) and Mechanical power (kgm/sec) of Subj. M.F. (male) and Subj. Y.T.(female) for the six % of LBM conditions. The solid line is the line of Anaerobic power. The broken line is the line of Mechanical power.

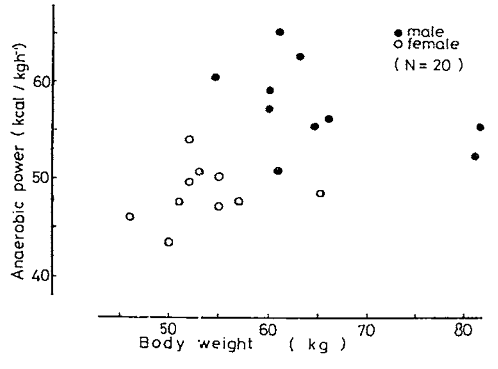

Fig. 5 The relationship between Anaerobic power (kcal/kg・h) and body weight(kg)

Table 3. Anaerobic power (kcal/kg・h) of each subject in condition I, II, III, IV, V, VI.

Subj	Anaerobic power (Kcal/kg・h)					
Male	I	II	III	IV	V	VI
F.U.	55.79	53.98	53.17	52.72	49.38	48.61
T.D.	65.17	62.66	60.09	55.67	55.17	52.61
M.K.	55.54	53.75	52.83	48.52	47.59	46.79
T.N.	60.53	57.59	53.52	52.72	52.28	50.28
Y.I.	62.97	57.33	57.07	55.88	53.75	53.86
H.F.	57.33	56.17	53.75	51.31	50.89	48.80
S.K.	59.25	55.42	50.58	51.00	49.38	49.68
S.O.	51.00	49.28	47.96	46.18	45.84	44.45
S.K.	56.29	53.40	52.72	49.48	48.99	46.61
M.F.	52.61	48.90	44.38	44.06	43.60	40.55
M	57.65	54.85	52.61	50.95	49.69	48.22
S.D.	4.19	3.84	4.15	3.63	3.34	3.68
Female	I	II	III	IV	V	VI
Y.K.	48.71	46.35	45.34	40.01	38.72	36.62
C.U.	46.01	43.58	37.61	36.67	35.42	34.21
N.K.	47.87	43.52	41.63	59.27	38.91	38.07
A.F.	50.89	46.44	45.67	43.83	42.78	40.09
N.K.	43.67	42.85	38.90	38.13	35.32	34.07
N.S.	47.87	48.80	46.88	45.59	44.45	43.30
Y.T.	54.10	49.68	46.18	43.30	42.34	39.27
A.O.	49.78	46.18	43.83	39.37	38.72	38.60
H.T.	47.23	45.59	43.37	41.91	41.49	39.77
K.O.	50.28	46.01	46.96	43.90	43.07	39.65
M	48.66	45.70	43.60	41.20	40.12	38.37
S.D.	2.72	2.07	3.13	2.77	3.03	2.77

About a male subject M.F. and a female subject Y. T., their mean values of Anaerobic power were 45.7±3.94 (mean±SD) kcal/kg・h (M.F.) and 45.8±4.91kcal/kg・h(Y.T.), respectively. Their difference of values were not significant.($p>0.1$) On the other hand, their mean of mechanical power were 121.5±3.27(mean ±SD) kgm/sec(M.F.) and 78.1±2.98kgm/sec (Y.T.), respectively. Their difference were significant. ($p<0.001$) The relationship between Anaerobic Power and body weight was presented in Figure 5. About the both sexes, no correlation existed. (male : $r=0.456$, $n=10$, $0.1<P<0.2$; female : $r=0.203$, $n=10$, $0.2<P<0.3$).

DISCUSSION

Nakatoh et al. (1980)[18] reported that the Anaerobic Power of bicycle ergometer method was almost similar to the Anaerobic Power of Margaria Power Test and that these two powers were corrected. Moreover, Ikuta et al. (1972)[10] reported that the Anaerobic Power of bicycle ergometer method and the power of 50m sprint test correlated each other. Ikuta et al. (1972)[10]

reported that the sprinter who could endure to a large weight had the advantage of displaying high Anaerobic Power. Anaerobic Power at normalweight for female was almost the same as the Anaerobic Power for male at adding weight 30% of LBM, that was about 17.8kg. There was no sex difference in the degree of decreasing Anaerobic Power. This shows that if man gained excess fat weight, Anaerobic Power decreased for male in the same ratio of decreasing for female. Anaerobic Power for male were higher than that for female, it caused that there were the difference of quantity, quality and content of LBM in the both sexes.

In conclusion, results of this study indicated that Anaerobic Power for male might be higher than that for female by about 10kcal/kg·h, even if the additional sex-specific, essential fat of women is eliminated by diet or training. If man gained excess fat weight, Anaerobic Power decreased for male in the same ratio of decreasing for female.

REFERENCES

1. Åstrand, I. ; Aerobic work capacity in men and women with special reference to age, Acta Physiol. Scand., 169 ; 1-92, 1960.
2. Åstrand, P. O. and K. Rodahl, : Textbook of Work Physiology, : Physical work capacity, 277-315, 1970.
2. Bullen, B. A., R. B. Read, and J. Mayer ; Physical activity of obese and nonobese adolescent girls appraised by motion picture sampling, Amer. J. Clin. Nutr., 14 ; 211, 1964.
4. Cureton, K. J., P. B. Sparling, B. W. Evans, S. M. Johnson, U. D. Kong, and J. W. Pyrvis. Effect of experimental alteration in excess weight on aerobic capacity and distance running performance. Med. Sci. Sports. Vol. 10, No. 3, pp. 194-199, 1978.
5. Cureton, K. J., L. D. Hensley, and A. Tiburqi. Body fatness and performance differences between men and women. Res. Quart. 50 : 334-340. 1979.
6. Cureton, K. J., P. B. Sparing. Distance running performance and metabolic responses to running in men and wowen with excess weight experimentally equated. Med. Sci. Sports. Exercise, Vol. 12, No. 4, pp. 288-294, 1980.
7. Girandola, R. N. : Body composition changes in women : effects of high and low exercise intensity. Arch. Phys. Med. Rehab. 57 : 297-300, 1976.
8. Goldman, R. F. and P. F. Iampietro. Energy cost of boad carriage. J. Appl. Physiol. 17 657-676, 1977.
9. Hermansen, L., : Anaerobic energy release, Med. Sci. Sports, 1 : 32-38 1969.
10. Ikuta, K., and M. Ikuta, : Study on the development of maximum anaerobic power by bicycle ergometer. Jap. J. Phys. Educ. 17 : 151-157, 1972.
11. Ikuta, K., K. Watanabe and T. Ohtsuki, : Study on the mechanical working power during 50m dash, Jap. J. Phys. Educ. 17 : 61-67, 1972.
12. Johnson, Perry B. : Metabolism and weight control. J. Health, Physical Education and recreation, 32 : 39-40, 1968.
13. Keys, A. : Ocupational and environmental factors in the development of hert disease. In Rosenbaum and Belknap : Work and the Heart. Paul, B. Hoeber, Newyork, 1959, p. 103.
14. Margaria, R., P. Cerretelli, P. Aghemo, and G. Sassi. Energy cost of running. J. Appl. Physiol. 18(2) : 367 -370, 1963.
15. Margaria, R., P. Aghemo and E. Rovell, : Measurement of muscular power (anaerobic) in man. J. Appl. Physiol., 21 : 1162-1164, 1966.
16. Mathews, D. K. and E. L. Fox, : The physiological basis of physical education and athletics. Saunders,

Philadelphia, 201, 1971.

17. Mayer, J., N. B. Marshall, J. J. Vitale, J. H. Christensen, M. B. Mashaykhi, and F. J. Stare, : Exercise, food intake and body weight in normal rats and genetically obeth adult mice, Am. J. Physiol. 177 : 544, 1954.
18. Nagamine, S., and S. Suzuki. : Anthropometry and body composition of Japanese young men and women. Human Biol., 36 : 8-15, 1964.
19. Nakatoh, F., and K. Ikuta, : Anaerobic power of bicycle ergometer and running up stairs. J. Health Physical education and recreation., Vol. 30 : 933-937, 1980.
20. Parizkova, Jana. : Age trends in fat in normal and obese children. J. Appl. Physiol. 16(1) : 173-174
21. Pollok, M. L., H. S. Miller, A. C. Linnerud and K. H. Cooper : Frequency of training as a determinant for improvement in cardiovascular function and body composition of middleaged men. Arch. Phys. Med. Rehab. 56 : 141-145, 1975.