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# A Comparative Study of Maximal Aerobic Power and Living Style for Determing Optimal Load

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# 至適な運動負荷を知るための生活形態と体力に関する比較研究

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健康の維持増進のためには，適度の運動が必要であるといわれる。しかし，適度の運動（至適運動負荷）とは，どの程度の量や質であるのかは，ほとんど明らかにされていない。

これまで著者たちは，ヒトのからだが採集狩猟民としての生活に適応するように進化してきたことに注目し，進化論的比較論的立場から，至適負荷の解明を試みてきた。

そして，Sedentary な生活を営む人々にとっても，最大酸素摂取量を 40～50ml/kg/min（成人男子の場合）に保持することが可能な，長時間にわたるModerate な運動，すなわち，歩行のような運動を行うことが，望ましいであろうと考えるに至った。

本研究は，この仮説をさらに確かめるために，異なる生活形態をもつ12集団の，食事，日常生活中の身体活動，%Fat，最大酸素摂取量を比較したものである。対象は，ネパール人および日本人成人男子，合計208名である。

最大酸素摂取量は，日常生活中の身体活動の影響を強く受けていたが，%Fat や食事などの影響はほとんど認められなかった。また，ネパール人集団のほとんどには，長時間にわたる歩行の習慣が認められた。

Mortorization などの影響を強く受けている Sedentary な都市生活者集団は，日本人の場合もネパール人の場合も，40ml/kg/min 以下の最大酸素取摂量を示した。山間部などに住み，重労働に従事しているネパール人集団の最大酸素摂取量は，50ml/kg/min 以上であった。これらを除いた集団の最大酸素摂取量は，40～50ml/kg/min の範囲であった。

これらの結果は，前述の仮説を支持するものであると考えられた。

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There is considerable discussion with referenec to the lack of physical activities required in day-to-day living in modern society and the possible harmful effect of this on health or fitness. However, the optimal load for successful living in modern society or in future ages is not clear now.

Though there is little discussion concerning maximal aerobic power (MAP) as a measure of health or fitness, it remains the best single measure of heath or fitness at the moment [Cumming (1967)[3], Konno & Yasunaga (1978)[8]]. Therefore, it is said that the comparative study of MAP, living style, nutritional conditions and so on, in diffrent population groups and specific situations, is an effective method for determing the optimal load for successful living in modern society or in future ages.

Many comparative studies of MAP in different population groups have been conducted. Results of some studies show the fact that ethnic group difference in MAP are not significant [Wyndham (1963)[17], Diprampero et al. (1969)[6], Davis et al. (1972)[5]]. It is clearly seen from the results of several studies of long-term measurement of heart rates that habitual activities are likely to be one of the main reason why MAP is low or high [Andersen (1967)[2], Ekblom & Gjessing (1968)[7], Lammert (1972)[11], Chan et al. (1976)[4], Konno et al. (1978)[9]]. On the other hand, Weitz & Lahiri (1977)[16] show the possibility that deletorious diseases and nutritional conditions may significantly affect the MAP.

These studies present results of value in providing physiological or anthoropological pers-pectives of health or fitness. However, fruitful discussion concerning the optimal load is rarely found in these studies. According to Cumming (1967)[3], men whose MAP is above 40 ml/kg/min are called fit, and those below 40 ml/kg/min are called unfit. This cutoff point for adult males is only an arbitrary figure, but a supporting theory and some supporting facts are pointed out.

Konno & Yasunaga (1978)[8] compare MAP of different ethnic groups on the hypothesis that the human body has adapted itself to the circumstances of pristine society such as those of hunters and gatherers. They point out the tendency of the mean MAP of the pristine population groups to be above 40 ml/kg/min with only few exceptions. Though MAP is improved by intensive short exercises, e.g. running or cycling less than 10 minutes, habitual activities of men in pristine societies are generally moderate but continue for a fairly long period of time. They assume that moderately long period of exercises, which lead MAP 40-50 ml/kg/min in the case of adult males, may be considered the main optimal load for successful living in modern society or in future ages.

However, there is very little knowledge at present to support this hypothesis. Therefore, a comparative study of MAP, like the previous investigation, is carried out as a basic study for determing the optimal load. However, in this study, measurement of MAP for nine Nepalese groups and three Japanese groups is made by almost the same method and some investigation concerning habitual activities, diet and %Fat are also made at the same time.

**Materials and Method**

Subjects

117 Nepalese males in nine different groupes and 91 Japanese males in three different groups were selected as the subjects for the comparison of diet, habitual activities, %Fat and MAP. Characteristics of each group are given in Table 1. It is generally said that the modernization of Japan has rapidly come about since Meiji Era and the socio-economical conditions of Nepal today are almost the same as those of Japan in the Meiji Era. And it is also said that the Japanese people

have lostmany important things for successful living such as active lives etc. during the process of modernization.

| | N | AGE yr | HEIGHT cm | WEIGHT kg | % FAT % | M.A.P. ml/kg/min |
|---|---|---|---|---|---|---|
| FUKUOKA | | | | | | |
| Sedentary Worker | 18 | 30(6) | 167.0(3.7) | 60.4(7.5) | 15.2(4.8) | 35.8(5.2) |
| Student | 47 | 19(1) | 169.2(5.3) | 59.9(6.7) | 16.9(4.5) | 46.6(6.5) |
| Fireman | 26 | 22(3) | 168.9(5.3) | 65.6(7.7) | 14.1(3.1) | 47.4(8.1) |
| KATHMANDU & POKHARA | | | | | | |
| Sedentary worker | 20 | 32(8) | 163.6(6.5) | 55.5(8.1) | 16.8(5.3) | 37.9(4.5) |
| Student | 28 | 19(2) | 163.5(6.4) | 49.2(7.0) | 13.6(2.6) | 44.8(7.8) |
| Hotel worker | 29 | 22(5) | 160.3(7.5) | 50.0(7.4) | 13.6(2.1) | 46.2(8.1) |
| NARAYANTHAN | | | | | | |
| Policeman | 11 | 31(6) | 163.0(5.7) | 52.4(7.5) | 12.4(1.6) | 44.0(8.0) |
| THIMI | | | | | | |
| Farmer | 23 | 32(12) | 159.9(7.7) | 52.2(5.2) | 16.8(4.2) | 46.9(8.1) |
| KOTYANG | | | | | | |
| Farmer | 21 | 27(8) | 159.3(9.2) | 49.9(6.9) | 13.6(1.9) | 54.3(7.1) |
| SHIVAPURI | | | | | | |
| Active worker | 11 | 24(4) | 160.5(6.9) | 51.9(9.6) | 14.8(3.4) | 50.7(5.2) |
| NAMCHBAZAR etc. | | | | | | |
| Sherpa & porter[a)] | 9 | 22(4) | 158.8(5.0) | 52.5(6.3) | 10.9(0.6) | 62.5(8.7) |
| Sherpa & porter[b)] | 19 | 25(7) | 161.9(6.5) | 56.6(6.0) | 14.0(2.6) | 46.9(6.3) |

a):in the end of trekking season at Ghorepani (3, 000m a.s.l.)
b):in the off season at Kathmandu (1, 300m a.s.l.)

Table 1. Characteristics of each group. Figurers denote mean and S.D.

**Method**

All measurements and observations were carried out in the living areas of each subjects except for Sherpas and Porters in the trekking season. Measurements in the trekking season were made at Gorepani Villiage (3, 000m.a.s.l.)[7] .

Measurement of MAP was made indirectly by the modified method of Margaria et al. (1965)[12] with only one exception for Japanese sedentary workers who were subjects of the previous investigation (they were loaded progressive maximal cycling exercises)[8]. Most of subjects were given 2-5 different intencity step up and down exercises, and MAP was calculated from heart rates immediately after exercises, and estimated maximal heart rates and estimated oxygen intake during exercises.

%Fat was estimated from skinfold thichness, body weight and body surface area according to the method of Nagamine (1975)[13] . Informations with regard to diet and habitual activities were accumulated by routine questioning and observation.

**Results**

1. Diet and Habitual activities

The diet and habitual activities of each group are summarized as follows:

a) Nepalese groups

1) Students (Kathmandu City, about 1,300m.a.s.l. and Pokhara City about 900m a.s.l.)

They live in urban districts of Nepal, go to and from university on foot, they walk for about 97 mintes to attend school at a usual speed of about 93 m/min. Their diet is a medium between sedentary workers and hotel workers. None partcipate in any kind of sport or physical training regularly.

2) Sedentary workers (Kathmandu City and Pokhara City)

Most of them are hotel managers and high officers, go to work by car, do sedentary work about 9 hours per day, and eat meat everyday.

3) Hotel workers (Kathmandu City and Pokhara City)

They are migrants from rural districts and hotel workers in urban districts, most of them usually walk 15,000 - 20,000 steps per day, and eat high carbohydrate diets twice a day.

4) Policemen (Narayan Than Village, about 1,300m a.s.l.)

Policemen near Kathmandu City, patrol 2-5 hours on foot usually, and eat high carbohydrate diets twice a day.

5) Farmers (Thimi Village, about 1,200 m a.s.l.)

Newar tribe near Kathmandu City, most of them walk 1-3 hours with heavy loads every day to sell vegitables, the weight of the loads are almost the same as 80% of their body weight, time of work in the fields is about 10 hours per day, and eat high carbohydrate diets twice a day.

6) Farmers (Kotyang Village, 1,100-1,300m a.s.l.)

Tomang tribe in a mountainous village; they have a self-sufficient life style, time of heavy work in large terraced fields is about 12 hours per day, and half of them eat high carbohydrate diets twice a day, others eat three times a day and eat meat sometimes.

7) Active workers (Shivapuri Village, 1,200-1,400m a.s.l.)

Tomang tribe in an economically poor mountainous village, most of them are farmers, habtiually walk 2-3 hours with heavy loads to sell wood, the weight of their loads are almost the same as their body weight, and they eat high carbohydrate diets twice a day.

8) & 9) Serpas and Porters (Namch Bazar etc., 2,000-2,5000m a.s.l.)

They work actively as Sherpas or Porters for trekking one third of the year when they walk with a load of about 30kg, spend another third of the year as farmers in their hometowns when they work actively in large terraced fields, and spend the remaining months as sedentary unemployed workers in Kathmandu City, and most of them eat high carbohydrate diets twice a day.

b) Japanese groups

1) Students (Fukuoka City, lower than 100m a.s.l.)

They live in urban districts of Fukuoka City, have 90 minutes of physical education once a week, one thrid of them take part in some kind of competitive sports 3-5 days per week as members of university sports clubs, their walking time per day going to and from school is only about 20 minutes, and most of them lead irregular lives regarding meal time and sleeping time.

2) Sedentary workers (Fukuoka City)

Most of them live in urban districts of Fukuoka City, travel to work by car and do sed-

entary work, participate in some kind of recreational sports about once a month, mean maximal heart rates during habitual activities is about 113 bpm, and no nutritional problems are found.

3) Firemen (near Fukuoka City)

They receive training for firemen, and lead active regular lives under nutritional and physical control.

2. %Fat and MAP

Mean %Fat ranged within 10.9-16.9% (Table 1) . Some differences were found in the mean values, but clear relations between the %Fat and diet, %Fat and MAP or habitual activities, and diet and MAP or habitual activities were not found respetively.

Results of measurements of MAP are given in Table 1 and Figure 1. A close relation between MAP and habitual activities was found. Both groups of sedentary workers in Japan and in Nepal showed 35.8 ml/kg/min and 37.9 ml/kg/min in mean MAP, respectively. Habitual activities of subjects in these groups are very inactive. Mean MAP above 50 ml/kg/min were found in three Nepalese groups such as farmers in Kotyang, active workers in Shivapuri and Serpas and Porters at the end of trekking season. Subjects in these groups are very active and lived in mountainous areas. Mean MAP of other population groups ranged within 44.0-47.4 ml/kg/min. Most of the subjects in these groups are not always very active but not very inactive. These Nepalese groups have the walking habit for a fairly long period of time and Japanese groups participate in the sport or physical tainning regularly.

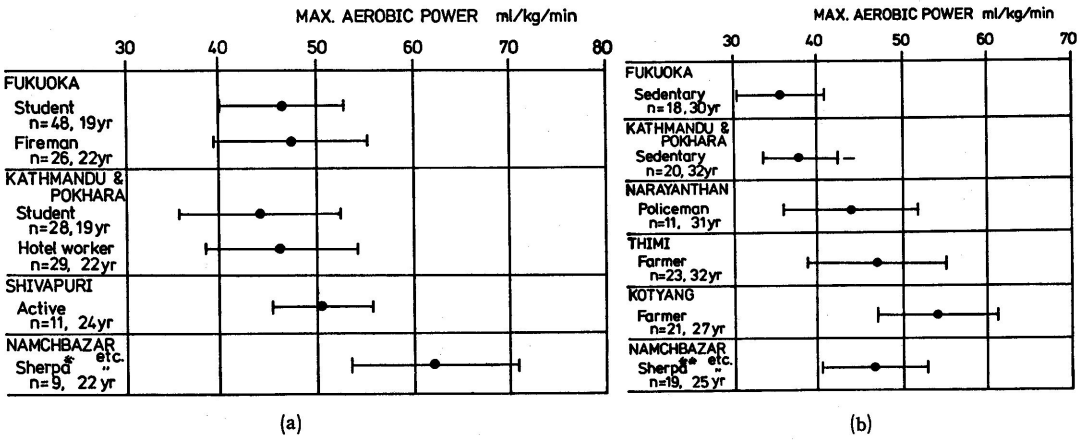


Fig. 1. Comparison of mean maximl aerobic power with S.D.

**Discussion**

Differences in diet and habitual activities among all groups were found, but clear relations among diet, %Fat and habitual activities or MAP were not found. These results concerning relations among diet, body composition and habitual activites are very interesting, however, there is insufficient data now, we must wait for more detailed experimental results.

A close relation between MAP and habitual activities was also found in this study. Both groups of sedentary workers in Japan and in Nepal showed MAP below 40 ml/kg/min. Habitual activities of these two groups were quite alike and their activities were deeply affected by the mortorization. According to the previous investigation of Japanese sedntary workers, mean

maximal heart rates during their habitual activities was about 113 bpm[9]. It is clear that the main reason for the low MAP of these groups is the lack of physical efforts by the subjects in their daily living.

MAP below 40 ml/kg/min were found generally in the very sedentary groups[1,9] or ill-health groups[16]. Moreover, the human body has not yet adapted itself to sedentary city life[8].

Mean MAP above 50 ml/kg/min was found in three Napalese groups which consisted of habitually very active persons in mountainous villages. It is said that these persons have a kind of specialized living style which may be created to adapt to the special circumstances, such as the mountainous or isolated society or environment.

In general, mean MAP above 50 ml/kg/min was found in very active population groups in pristine or isolated society[1,5,6,12] with few exceptions[16]. Most of these groups have also the specialized living style and there is no reason that the very high aerobic power above 50 ml/kg/min is need for successful living in modern society or in future ages.

From the facts described above, it may be said that sedentary populations in cities show MAP below 40 ml/kg/min and very active populations in specialized circumstances show MAP 50 ml/kg/min. Therefore, if we consider the factors of safety, it may be said that the cutoff points of MAP by Cumming[3], 50 ml/kg/min for young males and 40 ml/kg/min for adult males, are reasonable figures. In other words, one of the opthimal loads for sedentary persons is exercises which produce MAP above the cutoff points.

Mean MAP of the other two Japanese groups and five Nepalese groups ranged 44.0-47.4 ml/kg/min. These subjects did not live in mountainous villages or isolated society. Generally, mean MAP of many different population groupsin pristine societies, involving hunters and gatheres, are 40-50 ml/kg/min.

By the way, MAP is improved by short intensive exerciese, however, the main habitual activities of many populations in pristine societies are moderate but continue for a fairly long periods of time[8]. The foot of human races has evoluted to adapt to standing and walking for a fairly long periods of time. According to the results of the ethonological study by Yoshida(1970)[18], the walking capacity of about 40 km per day was the lowest standard for a fullfledged man for a long time before modernization of Japan. It is important that moderately long walks were the main physical activities before modernization. Therefore, it is not said that the short intensive exercises are the main activities for successful living in modern society or in future ages.

Mann, et al. (1965)[12] said that the Masai have very high MAP caused by long distance walking. Most[10] of Nepalese males in Kathmandu City also habitually walked faster and longer than Japanese males. Shido and Tanaka (Personal communication)[15] did interesting experiments. They gave 50% MAP of cycling exercises for one hour and showed that these exercises improve MAP above 40 ml/kg/min for middle aged males and above 50 ml/kg/min for young males.

These results show the possibility that fast long walking improve MAP above the cutoff points. Therefore, from the facts described above, we may conclude that one of the optimal loads for sedentary populations in modern society or in future ages may be moderately long exercises, e.g. fast long walking and so on. However, we must notice that the moderately long exercises do not just affect MAP and the effects of such exercises on health or fitness is not clear now.

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