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# An Analysis of Physigues in University Sports Athletes using a Body Composition Chart

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**Abstract**

The present study examined the variability of body composition in Japanese university students. Subjects were 360 males and 313 females who grouped into various sports categories and sedentary by sex. Body height, weight, and underwater weight were measured to estimate the percentage of body fat. Fat mass (FM) and fat-free mass (FFM) were put on an x- and y-axis in Body Composition Chart 1, and fat mass index (FMI: FM/height$^2$) and fat-free mass index (FFMI: FFM/height$^2$) were taken on an x- and y-axis in Body Composition Chart 2. The plots on the charts reveals the superior of fat-free mass for male athletes even after adjusting for body physique by dividing height$^2$ comparing to female athletes. By comparing the data between sedentary and athlete groups, it is suggested that the reduction of additional body fat is a key for improving the performance of local-level university athletes.

## Introduction

Competitive athletes in each category of sport demonstrate peculiar physiques and body compositions owing to the long term training specific to their sports (Mokha and Sidhu, 1987; Russo et al., 1992;Hattori et al., 1998; Hattori et al., 1999). In general, a body with sufficient muscle mass is considered to be advantageous in sports requiring power or muscle strength, while a body without excessive fat may be advantageous to sports requiring endurance (Sinning, 1996). Many studies devoted to clarifying the relationships between physique and performance have been attempted using the somatotype method (Viviani, 1994;Katzmarzyk and Malina, 1998). However, the methodological process of somatotyping is complicated and explanation of the results projected onto a somatochart are not necessarily simple (Wilmore, 1970;Lohman et al., 1978; Bolonchuk et al., 1989; Hattori, 1996).

In the present study, the variability of physiques among university athletes was explored using Hattori's body composition chart (Hattori,1997). The body composition chart is a simple graphic presentation of the gross body structure.

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## Methods

The study subjects were 192 male and 127 female university athletes who participated competitive sports clubs and 168 male and 186 female students who were not engaged in special exercise programs.

Height was measured to the nearest 0.1cm using a stadiometer fixed to the wall. Weight was obtained to the nearest 0.1kg using an electrical scale.

Body composition was evaluated by hydro-densitometry. Underwater weighing was repeated for each individual at least three times until values reached a plateau. Body density was determined by hydrostatic weighing, while residual lung volume was calculated using the $O_2$ rebreathing method (Wilmore et al., 1980). FFM and FM were calculated according to the equation summarized by Siri (1956). Body fat mass (FM) and fat-free mass (FFM) were calculated based on %fat and body weight.

We also evaluated body composition by calculating BMI, the fat mass index (FMI) ,and the fat-free mass index (FFMI) as proposed by Hattori (1991). BMI was determined by body weight divided by the square of stature. The FMI and FFMI were obtained using the same adjustments, dividing FM and FFM by the square of stature.

Two types of body composition chart have been introduced in this paper. First, the means of FFM and FM of each group were plotted (Body Composition Chart 1). FFM and FM were taken on the x-axis and y-axis, respectively. Since the sum of FM and FFM equals body weight, and the percentage of fat equals FM/(FM+FFM), the body weight and fat percentage were added as diagonal lines. The means of FFMI and FMI for each group were plotted on Body Composition Chart 2. The x-axis represents FFMI and the y-axis FMI, with additional diagonal lines indicating BMI and the percentage of body fat (Hattori, et al., 1997) .

An unpaired Student's t-test was used to compare the corresponding mean values between the exercise and non-exercise groups with an alpha level of 0.01 and 0.05. ANOVA was used to test the difference of variables among sports categories with multiple comparison by Scheffe's method. All statistical procedures were achieved by statistical application Statview (J5.0) and SPSS (11.0J).

## Results

Means and standard deviations of body composition variables for university athlete and non-athlete groups are presented in Table 1 (males) and Table 2 (females). The results of t-test between athlete and non-athlete groups are also listed in the table. All variables except BMI for males showed significant difference between two groups.

Descriptive statistics of body composition variables for each sport category are presented in Tables 3 (males) and 4 (females) with the results of one way ANOVA. The differences between sport categories were indicated in FFM and FFMI for both sexes.

FM and FFM for university students are plotted on Body Composition Chart 1 (Fig. 1). The plots for females indicated less than 50kg and the plots for males indicated more than 50kg on the FFM axis. Namely, the plots for both sexes are separated without any overlapping on the FFM scale. The heaviest FFM was recorded for judo in both sexes.

Table 1. Descriptive statistics of body composition for university athletes and non-athletes (males)

| | Athletes | | | Non-athletes | | | t-test |
|---|---|---|---|---|---|---|---|
| | n | Mean | S.D. | n | Mean | S.D. | |
| Stature(cm) | 192 | 172.8 | 5.64 | 168 | 171.4 | 5.31 | * |
| Weight (kg) | 192 | 65.2 | 8.09 | 168 | 63.0 | 10.39 | * |
| Percent body fat (%) | 192 | 11.5 | 5.46 | 168 | 15.0 | 6.36 | ** |
| Fat mass (kg) | 192 | 7.6 | 4.40 | 168 | 9.9 | 6.04 | ** |
| Fat-free mass (kg) | 192 | 57.5 | 6.20 | 168 | 53.1 | 6.90 | ** |
| Body mass index (kg/m$^2$) | 192 | 21.8 | 2.39 | 168 | 21.4 | 3.18 | |
| Fat mass index (kg/m$^2$) | 192 | 2.6 | 1.51 | 168 | 3.4 | 2.02 | ** |
| Fat-free mass index(kg/m$^2$) | 192 | 19.3 | 1.62 | 168 | 18.1 | 1.69 | ** |

Table 2. Descriptive statistics of body composition for university athletes and non-athletes (females)

| | Athletes | | | Non-athletes | | | t-test |
|---|---|---|---|---|---|---|---|
| | n | Mean | S.D. | n | Mean | S.D. | |
| Stature(cm) | 127 | 160.7 | 5.78 | 186 | 159.0 | 5.09 | * |
| Weight (kg) | 127 | 55.5 | 6.84 | 186 | 51.5 | 6.05 | ** |
| Percent body fat (%) | 127 | 20.4 | 4.45 | 186 | 24.0 | 4.80 | ** |
| Fat mass (kg) | 127 | 11.4 | 3.13 | 186 | 12.5 | 3.53 | ** |
| Fat-free mass (kg) | 127 | 44.2 | 5.52 | 186 | 39.0 | 3.86 | ** |
| Body mass index (kg/m$^2$) | 127 | 21.5 | 1.92 | 186 | 20.4 | 2.17 | ** |
| Fat mass index (kg/m$^2$) | 127 | 4.4 | 1.19 | 186 | 5.0 | 1.38 | ** |
| Fat-free mass index(kg/m$^2$) | 127 | 17.1 | 1.46 | 186 | 15.4 | 1.26 | ** |

Table 3. Descriptive statistics of body composition for each group of sports event and results of ANOVA (males)

| | | Non-athletes (N) | Badmintor (B) | Baseball (Bb) | Basketball (Bsk) | Judo (J) | Rugby (R) | Soccer (S) | Swimming (Sw) |
|---|---|---|---|---|---|---|---|---|---|
| | n | 168 | 7 | 8 | 23 | 5 | 7 | 7 | 6 |
| Stature (cm) | Mean | 171.4 | 170.8 | 175.0 | 176.5 | 174.5 | 172.2 | 174.4 | 174.2 |
| | *S.D.* | *5.31* | *3.95* | *9.34* | *3.87* | *2.89* | *6.23* | *4.47* | *6.73* |
| Weight (kg) | Mean | 63.0 | 68.6 | 68.4 | 68.5 | 78.3 | 68.4 | 68.4 | 68.9 |
| | *S.D.* | *10.39* | *8.09* | *9.27* | *7.66* | *7.67* | *9.16* | *9.85* | *13.49* |
| Percent body fat (%) | Mean | 15.0 | 16.2 | 12.6 | 10.0 | 12.2 | 9.8 | 14.4 | 14.3 |
| | *S.D.* | *6.36* | *5.08* | *7.69* | *5.40* | *4.42* | *2.78* | *8.83* | *6.65* |
| Fat mass (kg) | Mean | 9.9 | 11.4 | 9.0 | 7.1 | 9.7 | 6.9 | 10.5 | 10.5 |
| | *S.D.* | *6.04* | *4.61* | *6.25* | *4.54* | *3.90* | *2.73* | *8.86* | *7.07* |
| Fat-free mass (kg) | Mean | 53.1 | 57.2 | 59.4 | 61.4 | 68.6 | 61.5 | 57.8 | 58.4 |
| | *S.D.* | *6.09* | *4.15* | *6.36* | *4.78* | *5.76* | *6.68* | *2.29* | *7.57* |
| BMI (kg/m$^2$) | Mean | 21.4 | 23.5 | 22.4 | 22.0 | 25.7 | 22.9 | 22.6 | 22.6 |
| | *S.D.* | *3.18* | *2.95* | *3.18* | *2.33* | *2.33* | *1.98* | *4.49* | *3.25* |
| FMI (kg/m$^2$) | Mean | 3.4 | 3.9 | 3.1 | 2.3 | 3.2 | 2.3 | 3.6 | 3.4 |
| | *S.D.* | *2.02* | *1.62* | *2.17* | *1.44* | *1.31* | *0.82* | *3.28* | *2.18* |
| FFMI (kg/m$^2$) | Mean | 18.1 | 19.6 | 19.4 | 19.7 | 22.5 | 20.7 | 19.1 | 19.2 |
| | *S.D.* | *1.69* | *1.40* | *1.42* | *1.55* | *1.57* | *1.22* | *1.49* | *1.29* |

| Table Teniss(TT) | Teniss (T) | Track & Field(TF) | Volleyball (V) | F-value | | Multiple comparison |
|---|---|---|---|---|---|---|
| 19 | 43 | 34 | 22 | | | |
| 171.6 | 170.7 | 171.7 | 177.3 | 4.45 | ** | V>N |
| 4.7 | *5.18* | *4.22* | *5.14* | | | |
| 64.0 | 60.5 | 61.5 | 68.5 | 3.46 | ** | |
| 4.3 | *5.94* | *6.01* | *6.39* | | | |
| 14.1 | 12.2 | 7.4 | 10.0 | 5.81 | ** | N>TF |
| 5.8 | *3.88* | *3.23* | *3.86* | | | |
| 8.6 | 7.5 | 4.6 | 6.9 | 3.90 | ** | N>TF |
| 4.2 | *2.75* | *2.21* | *2.94* | | | |
| 54.8 | 53.0 | 56.9 | 61.7 | 12.24 | ** | Bsk>N,J>N,V>N,J>T |
| 3.8 | *4.52* | *5.42* | *6.09* | | | V>T,Bsk>T,J>TT |
| 21.7 | 20.8 | 20.8 | 21.8 | 2.86 | ** | N>TF |
| 1.5 | *1.61* | *1.52* | *1.87* | | | |
| 3.1 | 2.6 | 1.6 | 2.2 | 3.91 | ** | N>TF |
| 1.4 | *0.93* | *0.72* | *0.92* | | | |
| 18.6 | 18.2 | 19.3 | 19.6 | 8.03 | ** | J>N,J>T,J>TT |
| 1.3 | *1.21* | *1.46* | *1.68* | | | |

**(*): Significant at 0.01(0.05)level.

Table 4. Descriptive statistics of body composition for each group of sports event and results of ANOVA (females)

| | | Non-athletes (N) | Basketball (Bsk) | Handball (H) | Judo (J) | Kendo (K) | Soft Tennis(ST) | Tennis (T) | Track & Field(TF) | Volleyball (V) | F-value | | Multiple comparison |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | 186 | 27 | 17 | 6 | 7 | 5 | 30 | 15 | 14 | | | |
| Stature (cm) | Mean | 159.0 | 163.0 | 162.2 | 159.3 | 158.4 | 156.1 | 157.2 | 162.1 | 165.0 | 4.1 | ** | V>T |
| | *S.D.* | *5.09* | *5.90* | *6.25* | *3.37* | *3.37* | *3.77* | *4.56* | *4.34* | *6.09* | | | |
| Weight (kg) | Mean | 51.5 | 56.6 | 57.9 | 60.7 | 55.7 | 52.6 | 52.6 | 53.7 | 60.0 | 6.1 | ** | V>N |
| | *S.D.* | *6.05* | *6.99* | *6.07* | *5.01* | *4.33* | *4.59* | *5.99* | *7.96* | *7.11* | | | |
| Percent body fat (%) | Mean | 24.0 | 18.1 | 18.3 | 18.7 | 23.1 | 26.4 | 22.7 | 18.3 | 20.9 | 8.5 | ** | N>Bsk,N,>H,N>TF |
| | *S.D.* | *4.80* | *3.99* | *4.11* | *5.63* | *2.07* | *1.50* | *4.22* | *3.82* | *4.67* | | | |
| Fat mass (kg) | Mean | 12.5 | 10.4 | 10.7 | 11.5 | 12.9 | 13.9 | 12.0 | 10.0 | 12.6 | 2.6 | ** | |
| | *S.D.* | *3.53* | *3.20* | *3.05* | *3.86* | *1.41* | *1.28* | *3.08* | *3.03* | *3.58* | | | |
| Fat-free mass (kg) | Mean | 39.0 | 46.2 | 47.2 | 49.3 | 42.8 | 38.8 | 40.5 | 43.7 | 47.4 | 22.8 | ** | Bsk>N, H>N, J>N, V>N, TF>N, Bsk>T, H>T, V>T, J>T, J>ST |
| | *S.D.* | *3.86* | *4.72* | *4.71* | *3.65* | *3.78* | *3.64* | *4.33* | *5.82* | *5.51* | | | |
| BMI (kg/m$^2$) | Mean | 20.4 | 21.2 | 21.9 | 24.0 | 22.2 | 21.6 | 21.2 | 20.4 | 22.0 | 4.0 | ** | |
| | *S.D.* | *2.17* | *1.58* | *1.52* | *1.87* | *1.70* | *1.33* | *2.13* | *2.39* | *1.45* | | | |
| FMI (kg/m$^2$) | Mean | 5.0 | 3.9 | 4.0 | 4.5 | 5.1 | 5.7 | 4.9 | 3.8 | 4.6 | 3.5 | ** | |
| | *S.D.* | *1.38* | *1.09* | *1.07* | *1.56* | *0.49* | *0.54* | *1.26* | *1.09* | *1.14* | | | |
| FFMI (kg/m$^2$) | Mean | 15.4 | 17.3 | 17.9 | 19.4 | 17.1 | 15.9 | 16.4 | 16.6 | 17.4 | 17.9 | ** | |
| | *S.D.* | *1.26* | *0.83* | *1.18* | *1.29* | *1.57* | *0.98* | *1.37* | *1.65* | *1.40* | | | |

**(*): Significant at 0.01(0.05)level.

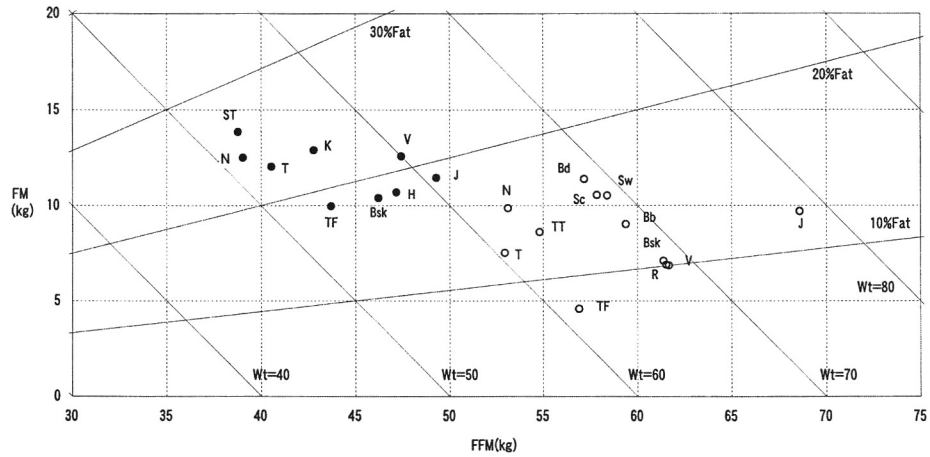


Fig. 1. Body Composition Chart 1 for university athletes. ( ● males; ○ females)
Bd:Badminton, Bb:Baseball, Bsk:Basketball, H:Handball, J:Judo, K:Kendo, R:Rugby, Sc:Soccer
ST:Soft Tennis, Sw:Swimming, TT:Table Tennis:T:Tennis, TF:Track & Field, V:Volleyball, N:Non-athletes

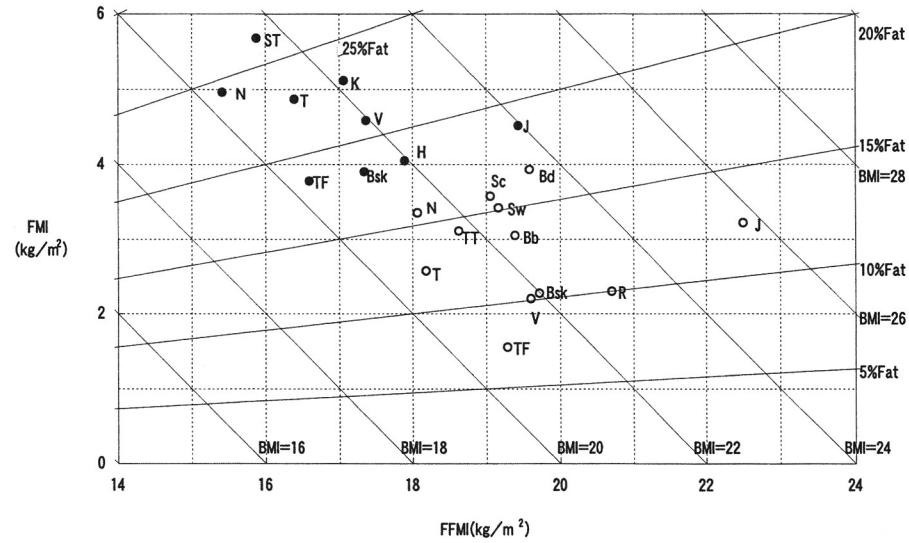


Fig. 2. Body Composition Chart 2 for university athletes. ( ● males; ○ females)
Bd:Badminton, Bb:Baseball, Bsk:Basketball, H:andball, J:Judo, K:Kendo, R:Rugby, Sc:Soccer
ST:Soft Tennis, Sw:Swimming, TT:Table Tennis:T:Teniss, TF:Track & Field, V:Volleyball, N:Non-athletes

FMI and FFMI are plotted on Body Composition Chart 2 (Fig. 2). The separation on the plots in terms of sexes is preserved in this chart, but judo for the females overlaps the male area on the x (FFMI) axis. As seen, the plots for the female are distributed on the upper left part and the plots for males tend to be distributed in lower right area of the chart, which indicates that they had less FMI and more FFMI than females.

Figure 2 also shows that the plots for judo indicate the largest FFMI among all sports categories. On the other hand, the plots for untrained students were the smallest in each sex and were followed by tennis players. On the FMI axis, the plots for females and males are also distributed in the upper and lower areas. Japanese style tennis (soft tennis) for females and badminton for males show the largest FMI.

## Discussion

It is obvious that muscle cross sectional area is enlarged and fat mass is reduced after exercise training. Hence, athletes bodies are generally much more muscular and leaner than the bodies of sedentary persons (Hattori et al.1999). The university students who belong to local-level athletic clubs are also expected to have athletic- type physiques, but their degree of body development has not been discussed by comparing various sports categories.

The average body weight of university students varied between 60kg and 70kg for males and 50kg and 60kg for females except for judo players. The body weights of non-athletes were lightest in females and the third lightest in male subjects. However, their percent body fat was relatively high in both sexes. It is suggested that weight gain for athletes is due to the increment of FFM. Hence, the BMI is not an appropriate standard by which to identify the adiposity level

as shown in Body Composition Chart 2 (Hattori, 1997).

The previous reports focusing on female volley ball and basket ball players revealed that they were superior in FFM but analogous in FM to non-athletes (Hattori et al., 1998). In the present study, the analysis of variance with multiple comparison showed that male track and field athletes had significantly smaller FM than did non-athletes.

The plot of non-athletes on the FMI axis positions a higher region among all plots, but the plots regarding soccer, badminton, and swimming for males, and soft tennis, and kendo for females are positioned higher than non-athletes. On the other hand, all plots of athletes are located on the right in relation to non-athletes on the FFMI axis. Among athletes, those participating in judo have conspicuously high FFMI, while those participating in track and field have the lowest FMI among both sexes.

We noticed that local-level university athletes have superior fat-free mass and fat-free mass indexes, but that their fat mass and fat mass indexes are not necessarily smaller than sedentary subjects as demonstrated in body composition charts. Therefore, the reduction of additional body fat is a key for improving the performance of the local-level university athletes.

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