

Relationship between percent body fat, body anthropometric indices and body composition in Japanese elementary school children

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ABSTRACT

The body compositions of 966 school children were measured and a comparison of the difference in judgment of obesity was made through a study of the relationship between body indices and percent body fat, as well as body composition, the Kaup index and percent body fat. Percent body fat showed a strong correlation to body indices, however, upon comparison of the judgment of obesity by the Kaup index and percent body fat, the Kaup index showed children with high lean body mass and total body water, as well as well developed bone and muscular physique, to be obese. Judgment through percent body fat showed children with high percent body fat to be obese. It was found that the judgement of obesity for 6th grade boys and girls by percent body fat, showed Kaup index of greater than 22, indicating obesity.

KEY WORDS

Body composition, Kaup index, Rohrer index, Obesity degree index, Percent body fat

Introduction

It has been found that the most effective way to judge obesity is in the measurement of body fat¹⁾. From this, in recent years our country has also come to judge obesity by the measurement of body fat. However, body indices derived from height and weight calculations have been used to judge obesity. In this case of using only anthropometric body indices to judge obesity, it is necessary to think more carefully about special characteristics in judging obesity through the use of various body indices. The present research presents a standard for judgment of obesity in children relative to body composition.

Methods

The survey took place in September of 1998, at the Ibaraki Prefecture Public Elementary School, with 966 children in 3rd to 6th grade (494 boys and 472 girls)

as subjects. A Sekisui Science Bio-impemeter SS103 (Japan) was used to measure body fat. From height (H) and weight (W), the three most commonly used indices of obesity in our country, the Kaup index, Rohrer index and obesity degree index were used. For each body index formula, we have for the Kaup index : $Wg/Hcm^2 \times 10$, for the Rohrer index : $Wg/Hcm^3 \times 10^4$, and for the obesity degree index :
$$\left\{ \frac{\text{actual measured body weight}}{\text{standard body weight}} - 1 \right\} \times 100\%.$$

Results

From figures 1 through 8, we show the correlation between body index and percent body fat relative to school grade and sex of the subjects. Figure 1 shows the results for 3rd grade girls, with Rohrer index $r=0.709$, Kaup index $r=0.701$, and obesity degree index $r=0.580$, respectively showing strong correlation. Fig.

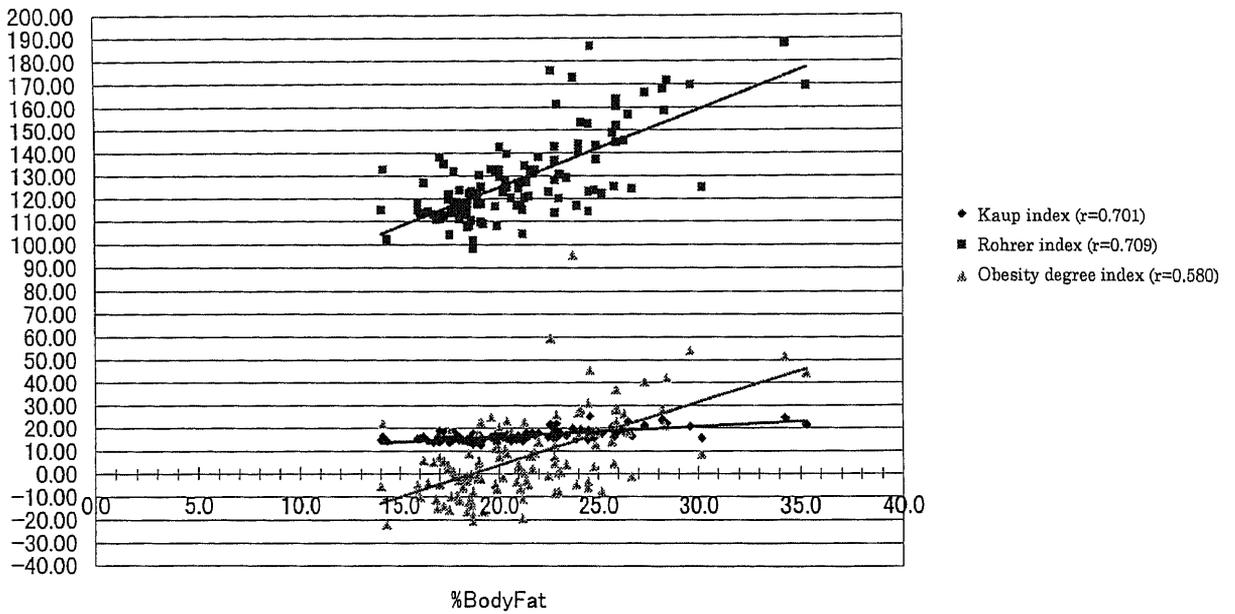


Figure 1. Relationship between percent body fat and body indices for 3rd grade girls.

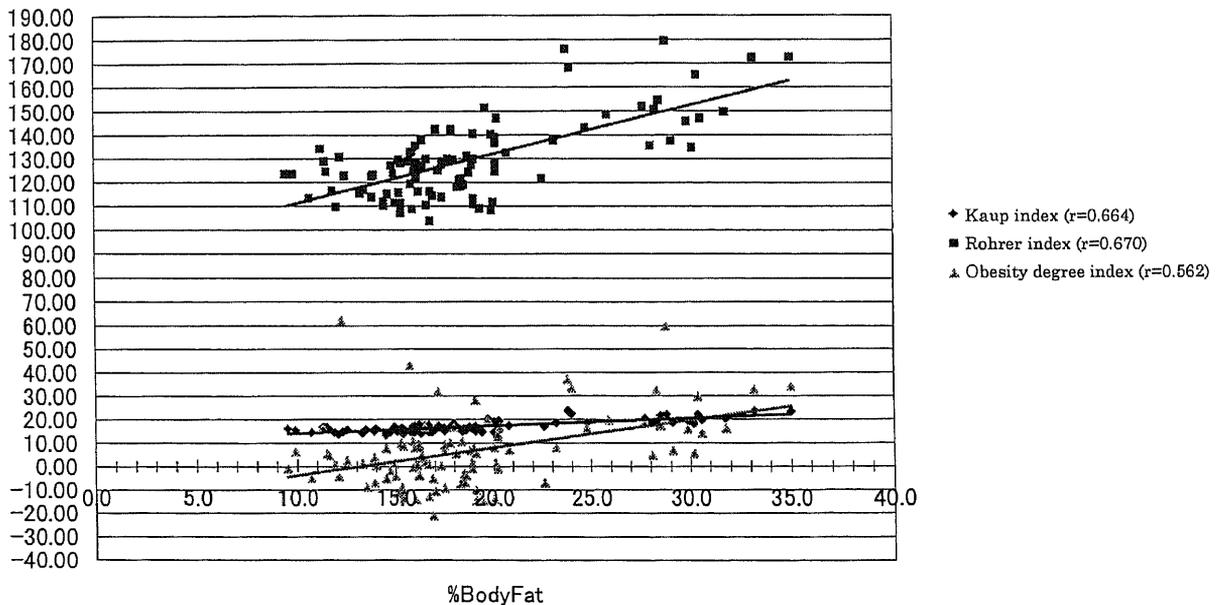


Figure 2. Relationship between percent body fat and body indices for 3rd grade boys.

2 shows results for 3rd grade boys, with Rohrer index $r=0.670$, Kaup index $r=0.667$, and obesity degree index $r=0.562$, respectively showing strong correlation, particularly in that boys and girls show strong correlation in percent body fat relative to Rohrer and Kaup indices. In comparing boys with girls, girls showed stronger correlation. Fig. 3 shows results for 4th grade girls, with Kaup index $r=0.611$, Rohrer index $r=0.599$, and obesity degree index $r=0.539$,

respectively showing strong correlation. Fig. 4 shows results for 4th grade boys, with Kaup index $r=0.808$, Rohrer index $r=0.757$, and obesity index $r=0.738$, showing strong correlation. For both boys and girls, Kaup and Rohrer indices showed strong correlation. In comparing boys with girls in this case, boys showed stronger correlation. Fig. 5 shows results for 5th grade girls with Kaup index $r=0.664$, Rohrer index $r=0.660$, and obesity degree index $r=0.645$,

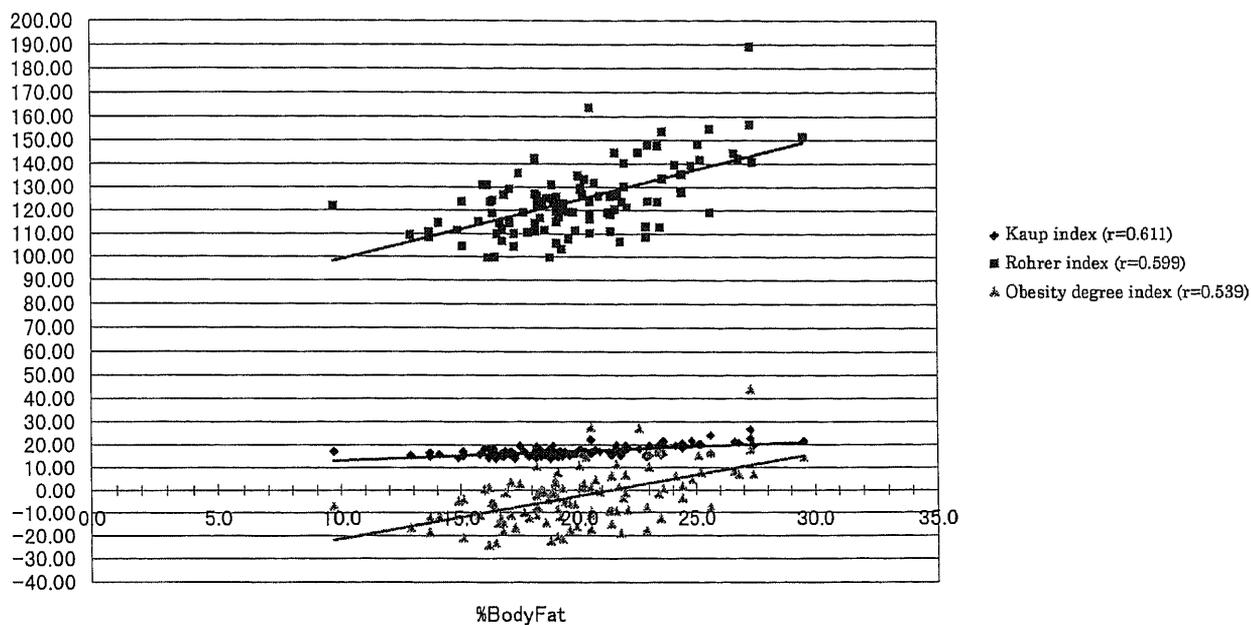


Figure 3. Relationship between percent body fat and body indices for 4th grade girls.

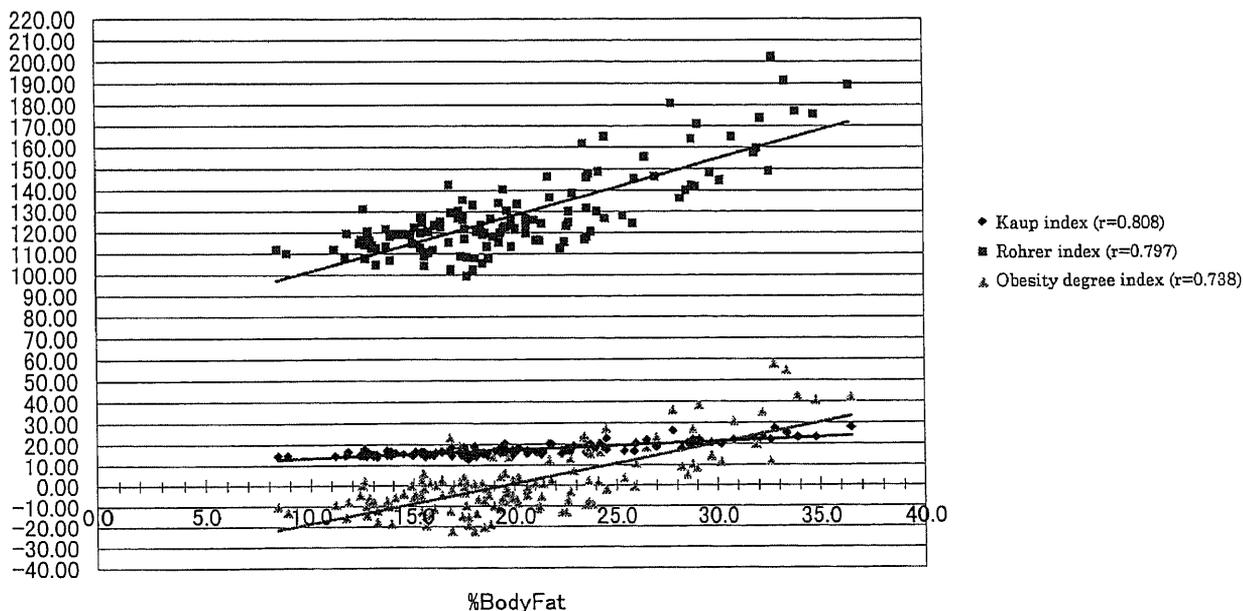


Figure 4. Relationship between percent body fat and body indices for 4th grade boys.

respectively showing strong correlation. Fig. 6 shows results for 5th grade boys, with Kaup index $r=0.726$, Rohrer index $r=0.724$, and obesity degree index $r=0.694$, respectively showing strong correlation. In comparing boys with girls, boys again showed stronger correlation. Fig. 7 shows results for 6th grade girls, with Rohrer index $r=0.713$, Kaup index $r=0.710$, and obesity degree index $r=0.709$, all showing strong correlation. Fig. 8 shows results for 6th grade

boys, with Rohrer index $r=0.631$, obesity degree index $r=0.620$, and Kaup index $r=0.582$, all showing strong correlation. In comparing boys with girls girls showed stronger correlation.

As shown above, it was recognized that Kaup and Rohrer indices showed strong percent body fat correlations for any grade level. On that point, investigations of the present research first of all show the relationship between body composition and the Kaup

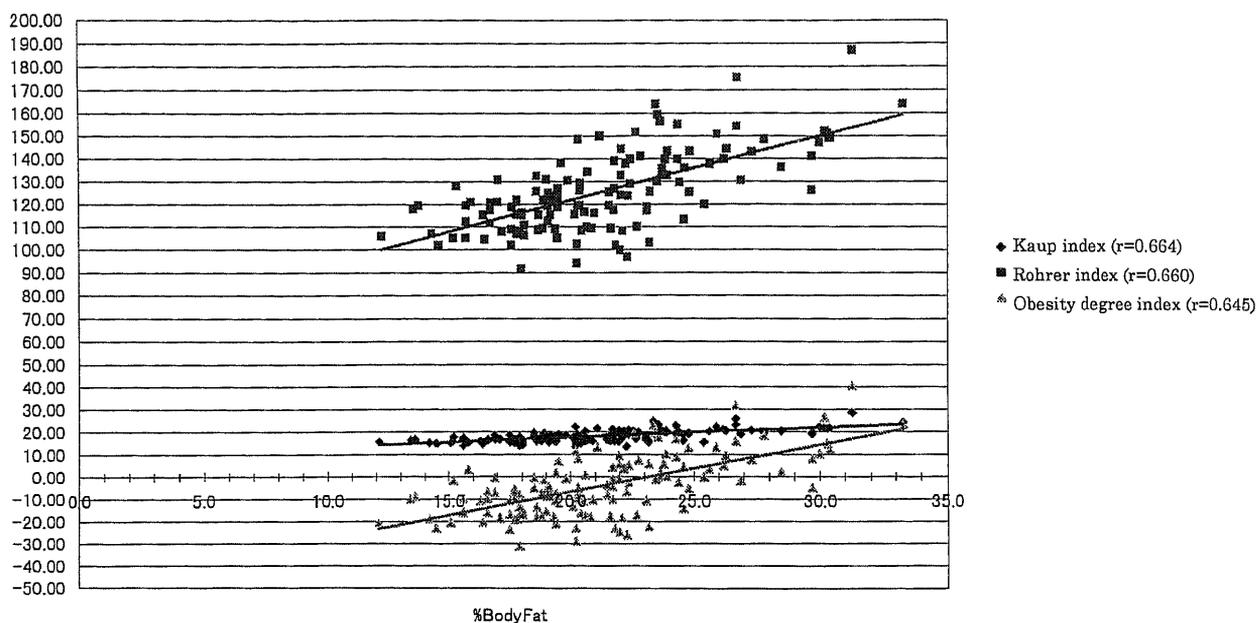


Figure 5. Relationship between percent body fat and body indices for 5th grade girls.

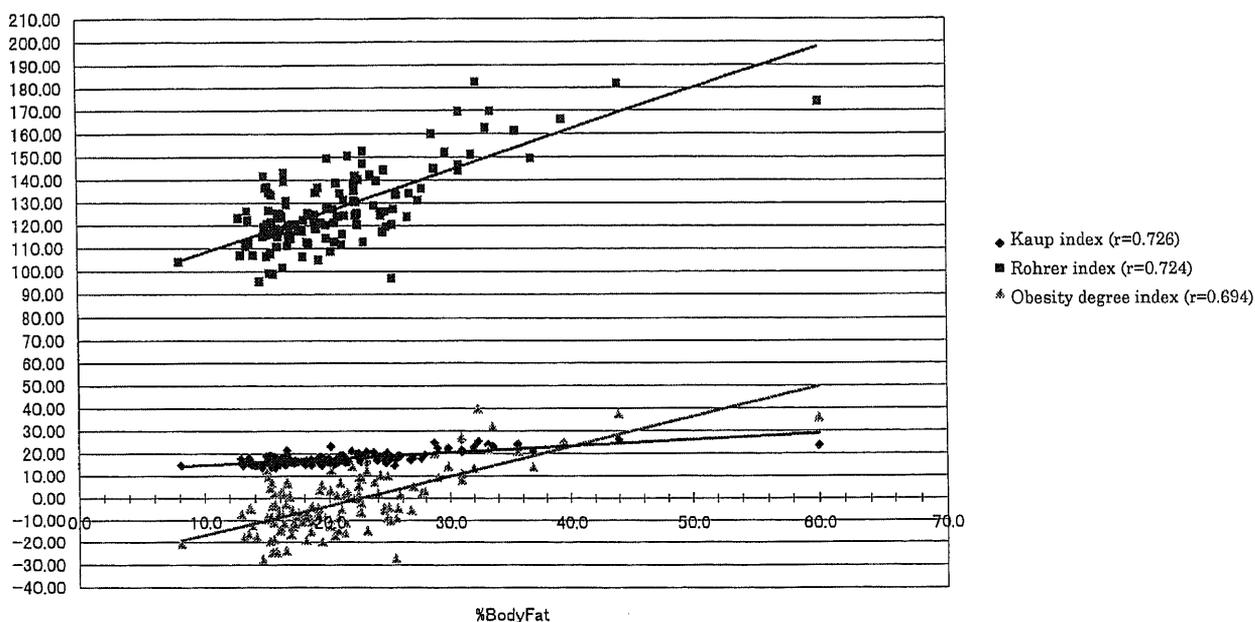


Figure 6. Relationship between percent body fat and body indices for 5th grade boys.

index. The Kaup index, similar to the Body Mass Index (BMI{Wkg/Sm²}), has been used throughout the US and Europe to judge obesity in adults and children, and widely recognized to show strong correlation to percent body fat^{2,3)}.

In Table 1 are listed height, weight, body composition, as well as Kaup index with average and standard deviation, categorized by grade level and sex. Compared to the national average for height and

weight, the children in this study were average. The height for 4th graders : F = 16.363, P<0.001, around which there was a difference recognized by sex, in all cases girls being the taller. There was no difference recognized for weight. Percent body fat for 3rd graders was : F = 7.88, P<0.01, and for 6th graders, with girls significantly higher : F = 4.727, P<0.03. For lean body mass, there was a difference between the sexes recognized only for 5th graders, with girls significantly

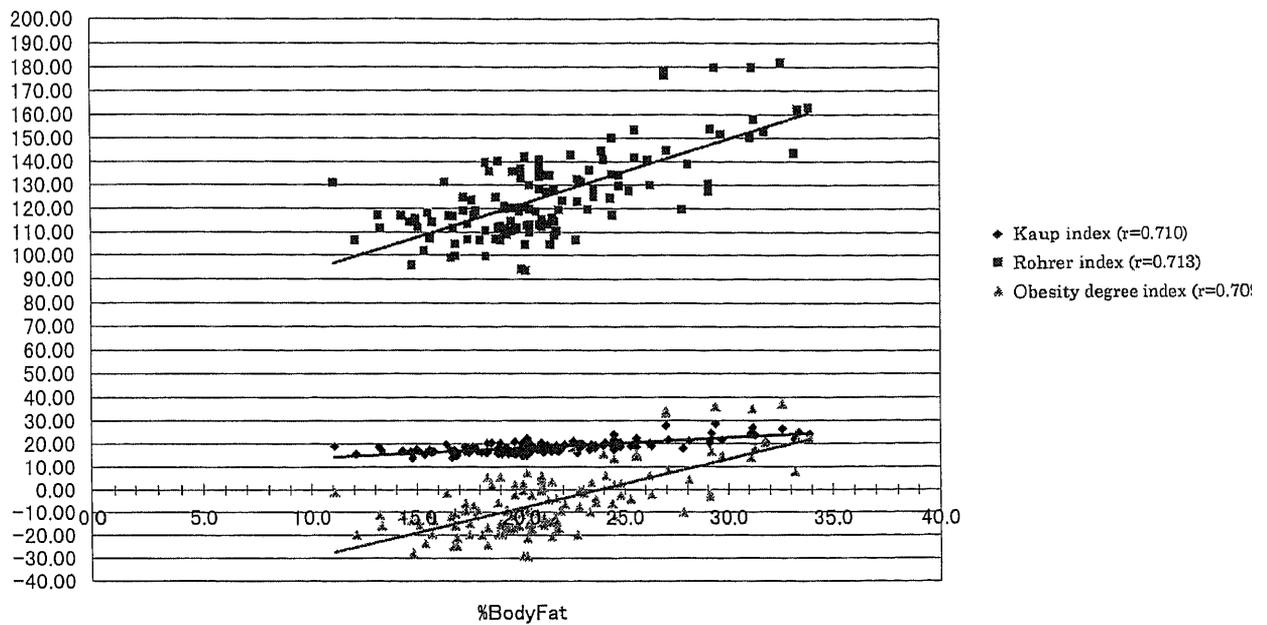


Figure 7. Relationship between percent body fat and body indices for 6th grade girls.

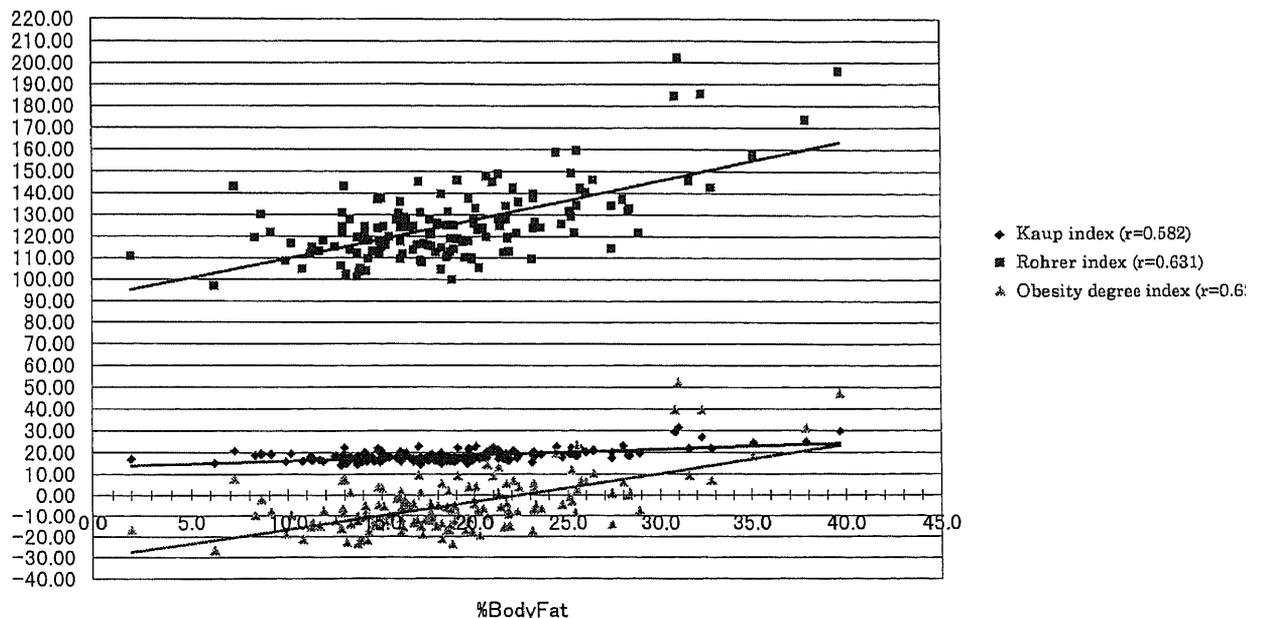


Figure 8. Relationship between percent body fat and body indices for 6th grade boys.

higher : $F = 4.150$, $P < 0.04$. For total body water, a difference between the sexes was also recognized for 5th graders, with girls significantly higher : $F = 6.314$, $P = 0.012$. There was no difference between the sexes recognized for the Kaup index.

Table 2 shows average height, weight, body composition and standard deviation, categorized by grade and sex for obese children with a Kaup index greater than 22. For boys, there were 8 subjects (8.2%) in the

3rd grade, 13 (10.2%) in the 4th grade, 25 (20.5%) in the 5th grade, and 14 (9.5%) in the 6th grade. In girls, there were 7 subjects (6.1%) in the 3rd grade (3.8%) in the 4th grade, 34 (26.4%) in the 5th grade and 32 (26.0%) in the 6th grade, with a difference recognized by sex and grade level in the rate of occurrence of obesity. With regards to body composition, with increasing grade level for both boys and girls, there is seen an increase in height, weight, to

Table 1 Average height, weight, body composition and Kaup index with standard deviation.

	N	BH	BW	%BF	TBF	LBM	TBW	Kaup
3 rd grade								
boys	97	130.504±5.381	29.129±5.606	19.196±6.027**	5.785±3.039	23.265±3.178	16.908±2.527	17.009±2.632
girls	115	130.017±6.147	28.453±5.681	21.138±3.918	6.104±2.214	22.344±3.854	16.308±2.825	16.840±2.638
4 th grade								
boys	127	135.439±5.682**	31.940±6.895	20.132±5.957	6.628±3.381	25.194±4.122	18.477±2.894	17.355±2.874
girls	105	137.580±7.079	32.713±6.862	20.045±3.575	6.649±2.438	26.060±4.811	19.036±3.518	17.206±2.390
5 th grade								
boys	122	140.649±5.993***	35.948±7.488	21.028±6.069	7.940±4.190	28.008±4.565*	20.457±3.348*	18.077±2.793
girls	129	144.088±7.315	37.664±7.502	21.022±4.151	8.081±2.938	29.327±5.571	21.587±3.727	18.137±2.794
6 th grade								
boys	148	147.577±7.937	40.742±9.851	19.130±6.085***	8.074±4.353*	32.869±6.623	24.003±4.850	18.453±3.328
girls	123	147.983±13.698	41.775±8.196	21.510±4.672	9.180±3.639	32.585±5.231	23.801±3.829	18.861±3.158

N: no. of subjects BH: body height(cm) BW: body weight(Kg) %BF: percent body fat(%) TBF: total body fat(Kg) LBM: lean body mass(Kg)

TBW: total body water(Kg) Kaup: Kaup index

*:P<0.05 **:P<0.01 ***:P<0.001

Table 2 Kaup index greater than 22 for obese children categorized by grade level, sex, and average height, weight, and body composition with standard deviation.

	N	BH	BW	%BF	TBF	LBM	TBW	Kaup
Boys								
Grade								
3 rd	8	131.275±5.380	40.638±3.351	31.138±4.971	12.638±2.374	28.000±2.979	20.450±2.176	23.574±1.244
4 th	13	136.969±5.237	45.008±6.271	30.854±3.760	13.123±4.029	29.962±6.611	22.723±3.129	23.894±1.965
5 th	25	144.924±6.694	47.608±6.741	28.952±6.288	14.384±4.618	33.208±5.989	24.280±4.383	22.691±1.821
6 th	14	154.936±7.265	61.771±11.766	27.743±8.316	17.571±7.498	44.200±6.976	32.300±5.113	25.649±3.977
Girls								
Grade								
3 rd	7	136.843±5.341	43.043±3.797	28.000±2.905	12.014±1.431	31.029±3.265	22.686±2.383	23.837±1.560
4 th	4	144.075±7.298	49.675±6.240	27.175±1.033	13.425±1.217	36.250±5.039	26.500±3.665	24.065±2.015
5 th	34	147.441±4.782	46.524±5.833	24.835±4.106	11.735±2.684	34.788±3.944	25.418±2.890	21.913±1.898
6 th	32	151.103±6.269	51.572±8.285	26.506±4.671	13.784±3.790	37.788±5.559	27.606±4.071	22.957±3.154

N: no. of subjects BH: body height(cm) BW: body weight(Kg) %BF: percent body fat(%) TBF: total body fat(Kg) LBM: lean body mass(Kg)

TBW: total body water(Kg) Kaup: Kaup index

Table 3 %BF greater than 25% for obese children categorized by grade level, sex, and average height, weight, body composition and Kaup index with standard deviation.

	N	BH	BW	%BF	TBF	LBM	TBW	Kaup
Boys								
Grade								
3 rd	16	132.881±1.965	37.269±4.308	30.713±3.170	11.500±2.249	25.769±2.523	18.813±1.829	21.119±2.332
4 th	23	136.939±5.733	40.865±7.619	30.230±2.924	12.022±3.679	27.757±5.711	20.735±3.445	21.726±2.974
5 th	26	144.558±6.699	44.158±8.293	30.181±4.724	14.027±4.749	30.115±5.563	22.015±4.084	21.191±3.264
6 th	25	149.676±7.168	50.104±14.710	29.360±4.357	15.428±6.164	35.876±7.808	26.220±5.720	22.669±4.426
Girls								
Grade								
3 rd	17	131.288±7.795	35.565±6.385	27.947±2.877	9.941±2.143	25.624±4.637	18.712±3.399	20.867±2.699
4 th	11	142.473±5.777	43.673±7.281	26.809±1.328	11.700±2.047	31.973±5.337	23.355±3.909	21.474±2.672
5 th	19	144.926±6.096	45.258±8.276	28.326±2.189	12.847±2.892	32.411±5.642	23.679±4.143	21.764±2.791
6 th	23	150.017±7.480	51.526±10.117	29.134±2.685	15.062±3.494	36.457±7.009	26.630±5.123	22.737±2.907

N: no. of subjects BH: body height(cm) BW: body weight(Kg) %BF: percent body fat(%) TBF: total body fat(Kg) LBM: lean body mass(Kg)

TBW: total body water(Kg) Kaup: Kaup index

body fat and total body water, while a decrease in percent body fat.

Table 3 shows average height, weight, body composition and standard deviation, categorized by grade and sex, for obese children with percent body fat

greater than 25%. For obese children with percent body fat greater than 25%, for boys, there were 16 subjects in the 3rd grade (16.5%), 23 (18.1%) in the 4th grade, 26 (21.3%) in the 5th grade, and 25 (16.9%) in the 6th grade. For 3rd grade girls as

subjects, there were 17 (14.8%), 11 (10.5%) in the 4th grade, 19 (14.7%) in the 5th grade, and 23 (18.7%) in the 6th grade. There was no clear difference seen in the rate of occurrence of obesity based on grade level or sex. With regards to body composition, for both boys and girls, as grade level increased, height, weight, total body fat, lean body mass, and total body water increased, while the Kaup index also increased slightly.

Discussion

Percent body fat and body index showed strong correlation, however the obesity degree index, most considered in development, showed a rather low value in comparison with the other two body indices. The Kaup index, equivalent to the BMI, showed strong correlation to percent body fat, and the results of other researchers^{4, 5)} agree (figure 1-8). From comparative results of body change categorized by grade level and sex, as grade level increased for both boys and girls, height and weight increased. Along with body development, total body fat, lean body mass, and total body water also reflected increase, with Kaup index also gradually showing a high value. For 3rd grade and 6th grade boys, percent body fat decreased. This is because, due to the fact that lean body mass is high, total body fat is low relative to weight. This matches reports that reflect this trend from ages 8 to 20⁶⁾. Also, 4th and 5th grade girls are taller than boys, the results reflecting values for lean body mass and total body water, and the observance of differences in compositional development between boys and girls (Table 1).

It is recognized that for children judged to be obese with a Kaup index of 22, as their grade level increases, there is an increase in height, weight, total body fat, lean body mass, and total body water. However, percent body fat decreased. Although an increase in weight reflects an increase in total body fat, lean body mass and body composition such as total body water, the decrease in percent body fat with increasing grade level indicates that the total body fat ratio is low and by this, it is suggested that the Kaup index does not reflect percent body fat, but that it strongly estimates weight as a body index. Also, the ratio of occurrence of obesity for 3rd and 4th graders

was high for boys, trending high for 5th and 6th grade girls, and depending upon the conditions for development of each sex in the various grade levels, the Kaup index judgment of obesity differed (Table 2).

For obese children with percent body fat greater than 25%, as grade level increased, height, weight, total body fat, lean body mass and total body water increased, while the Kaup index increased slightly. For boys, the 6th grade Kaup index value was rather high compared to other grades, however this is only after entering the 6th grade that lean body mass and total body water clearly increased, and here, the Kaup index for 6th grade boys reflects weight rather than percent body fat. Furthermore, compared to other grades, this indicates a small correlation between percent body fat and Kaup index for 6th grade boys. Similarly, the Kaup index increased for 4th grade girls while the correlation between percent body fat and Kaup index showed its lowest value for all girls. All of these results show the change in body composition of boys and girls as they approach puberty.

In comparing results for the judgment of obesity according to Kaup index and percent body fat, the average weight of those judged by the Kaup index had a percent body fat greater than 25%, a value much greater than for the average weight of children judged to be obese. Boys were especially high for all grades, with 3rd to 5th graders around 4 kg and 6th graders around 11.5 kg. Girls were not as high as boys. However, the lower the grade level, the higher the difference, with 3rd and 4th graders showing a difference of as much as 7kg. Moreover, for obesity judged by the Kaup index, for both boys and girls percent body fat for boys and girls was low, and those with high lean body mass, total body water and heavy weight were judged to be obese. For those judged to be obese by percent body fat, the Kaup index showed a normal range, compared to judgment by the Kaup index, and those with low lean body mass and total body water and high percent body fat were judged to be obese (Table 3). Following, the Kaup index showed a strong correlation to percent body fat. However, in the judgment of obesity, the estimates for body composition showed a clear difference. Here, the expected limitations of body indices through height and weight can be seen⁷⁾.

Conclusion

Percent body fat showed a strong correlation to body indices. However, judgment of obesity by percent body fat gives a Kaup index within the normal range for non-obese children, and children with high percent body fat were judged obese. On the other hand, by the judgment of obesity by the Kaup index, heavy children with good physique were judged to be obese. Categorized by sex, from the 6th grade, boys, and from the 4th grade, girls show a clear change in body composition. It follows that in the field of health in the schools, the results of this study will aid in the realization of the necessity to accurately judge obesity, to detect obesity early and to enact intervention in its early stages.

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学童の体脂肪率と体格指数, および体組成との関係

木村留美子

要 旨

小学3年生から6年生の児童966名(男子494名, 女子472名)を対象に, 子どもの肥満判定の検討を目的とし, Kaup指数, Rohrer指数, 肥満度の3つの体格指数と体脂肪率の関係を検討した。また, 体組成とKaup指数および体脂肪率の関係についても検討を行った。体脂肪率は体格指数と強い相関関係にあったが, Kaup指数による肥満判定は, 除脂肪量や体水分量により体重の重い体格のよい肥満ではない子どもも肥満と判定していた。体脂肪率による肥満判定では6年生の男女だけがKaup指数が22以上の肥満であった。