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A Groping Approach to Delayed Menarche in Female Athletes

女子運動選手の初潮遅延に関する模索的アプローチ

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ABSTRACT　The hypothesis in regard to delayed menarche in female athletes has been constructed in U.S.A, however, has been not verified yet. Therefore, it would be considered that the verification of delayed menarche can be derived from examination based on comparison between female athletes and non-athletes in regard to the difference between the age at menarche and MPV (Maximum Peak Velocity : Age at adolescent peak derived from wavelet interpolation method). In this study, the age at MPV as the index of physical maturity rate was identified by the wavelet interpolation method (WIM), so the delayed menarche in female athletes and control groups is verified based on examination the difference between the age at menarche and MPV. Health examination records of 110 female athletes of first grade of women university in Tokai area which participated in the national level competition were researched from the first grade of elementary school until the third grade of high school(from 1984 to 1995) as athletes groups. The longitudinal data of height and weight were obtained from the health examination records. The age at menarche in these data were researched by questionaires. The control group as non-athletes was researched as similar to the athletes group, and 68 female non-athletes were picked up. The difference between the age at MPV of height and at menarche in athletes group was 1.54 years(SD=1.01) and was 0.96 years(SD=1.18) in control group. There was a significant difference between the two groups($P<0.05$). This finding provides evidence that athletic training may cause delay in menarche.

INTRODUCTION

Age at menarche is popularly known as the index of maturity rate previously in girl. There are details which have been supported as the stable index of matuety rate in girls, because the age at menarche is contred by the factor of heredity.

However the age at menarche as the stable index of maturity rate in girls is doubted by the critical weight or critical fatness hypothesis proposed by Frisch[1)2)]. This problem was made clear by the suggestion that sports training delays menarche that was reported by Malina[3)] and Malina and Bouchard[9)]. In other word, the suggested mechanism for the association between training and delayed menarche is hormonal. It is suggested that intensive training influences circulating levels of gonadotropic and ovarian hormones, and in turn menarche. This hypothesis has not been verified yet. Malina[3)] reports about the comparison of delayed menarche between various athletes and control groups in girls.

However, if athletes is originally late matured and delaying menarche, training is not regarded as the verification of delayed menarche. Even if the delayed menarche was examined regarding comparison between athletes and control groups, it is not regarded as objective verification if the maturity rate

in the both groups is not approximately equal. Therefor, it is necessary to set the condition that physical matunty rate in athlete and control groups is approximately equal to verify the delayed menarche. As information on the effects of regular training on physical maturity rate are not available, the verification of delayed menarche can be derived from examination based on comparison between athletes and control groups in regard to the difference between age at menarche and MPV. In fact, the significant method in other to derive the index of physical maturity rate has not been developed previously. MG (Maximum Growth) proposed by Shuttleworth[6] and PHV (Peak Height Velocity) derived from graphic method proposed by Tanner[6] have popularly been applied to the index of physical maturity rate. By the way, Takaishi et al[7] examined the difference between age at menarche and PHV, as the result, show that mean of the difference was 1.24 age of year(SD=0.73).

However, the method in order to determine age at PHV and MG have drawback not being able to derive strict accuracity. In other words, the PHV and MG are not parameters derived from exact growth velocity. Therefore, Wavelet Interpolation Method(WIM)was proposed by Fujii and Yamamoto[8] to overcome the drawback like this, and the validity of the WIM was explained by Fujii and Matsuura[9]. In this study, the age at MPV as the index of physical maturity rate was identified by the WIM. So the delayed menarche in athletes and control groups is verified based on examining the difference between the age at menarche and MPV.

METHOD

1) data

Health examination records of 110 female of first grade of woman univercity in Tokai area which paticipated in the national level conpetition were researched from the first grade of elementary school until the third grade of high school (from 1984 to 1995) as athlete group. Longitudinal data of height and weight were obtained from the health examination records. Age at menarche in these data were reseached by quetionnaire. It shows detail as follows.

No name Birthday

1. About the sport in the high school
   1)What sports was it playing?
   ( )
   2)What is the best record?
   ( )
   3)How many day was the training doing for a week?
   ( )
2. About the sport in the junior high school
   1)What sports was it playing?
   ( )
   2)How many day was the training doing for a week?
   ( )
3. About the sport in the elementary school
   1) What sports was it playing?
   ( )
   2) How many day was the training doing to 1 week?
   ( )
4. About the menses for the first time
   1) When was a menses for the first time?
   ( )
   2) When was a next menses?
   ( )
   3) When was a 3rd menses?
   ( )
   4) How many month did it approximately spend until the next from the menses for the first time?
   ( )

57 female athletes were picked up based on this research. Longitudinal data of height and weight from the first grade of elementary school until the third grade of highschool (from 1984 to 1995) in non-athlete were obtained from the first grade of

elementary school until the third grade of high school (from1984 to 1995). Ages at menarche in non-athlete were also resarched in these data. As a result, 68 female non-athletes were picked up.

2. Method of analyzing

1) Procedure of the analysis

① It fixes maximum peakvelocity (MPV :Maximum Peak Velocity) of height as the index of maturity having to do with a body by the Wavelet Interpolation Method.

② To examine the normarity of the age at MPV of height and weight and the age at menarche which was derived from the Wavelet Interpolation Method, it applies to the normal distribution function.

③ It compares with the athletes and control groups about the age at MPV of height and weight.

④ It calculates differences between the age at menarche and the age at MPV of height and it makes a distribution figure of the statistical value. Then, it compares the athlete and control groups.

2) The procesure of identifying age at MPV

The growth distance and velocity curves from 6 to 17 are descrived by the Wavelet Interpolation Method(WIM), so the age at MPV is identified as maximum values of growth velocities as shown in the graph of growth curve described by the WIM. The algorism of the WIM was left out because of having been already shown by Fujii[8)9)]

RESULT and DISCUSSION

1. Determination of age at MPV (Maximum Peak Velocity) of height and weight in athlete and control growps.

1) Evaluation of normality of age at MPV in height and weight derived by Wavelet Interpolation Method (WIM).

We applied the Wavelet Interpolation Method (WIM) to the longitudinally measured height and weight for each indinidual member of both the athlete and control (non-athlete) groups from the first grade of elementary school until the third year of high school. We then drew approtimation curves of the growth velocities derwied from these results. Fig 1 is an example of the measured heights and weights in the athlete and control groups and the velocity curves prepared using the WIM. As shown in this graph, the age at MPV is define as the age at which the maximum velocities occur. The age at MPV of height and weight were thus determined for the 57 subjects in the athlete group and the 68 subjects in the control groups. The statistics for the ages at MPV of height and weight in both groups are shown in Table 1. The normality for both groups with respect to these statistics was then evaluated.

Next, we evaluated whether fitting to a normal distribution was valid with respect to tating of normality. The normal distribution function for calculation of the critical frequencies in both groups are shown below.

(Athletes group)

The age at MPV of height

$$f(x)=\frac{0.5\times 57}{\sqrt{2\pi}\times 1.14}e^{-\frac{(x_i-11.18)^2}{2(1.14)^2}}$$

The age at MPV of weight

$$f(x)=\frac{0.5\times 57}{\sqrt{2\pi}\times 1.22}e^{-\frac{(x_i-11.79)^2}{2(1.22)^2}}$$

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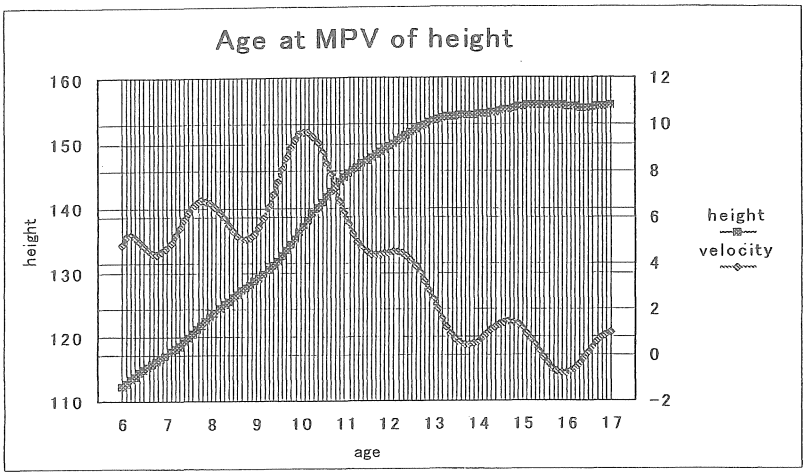

Fig 1-2 Growth distance and velocity curve of height derived from WIM

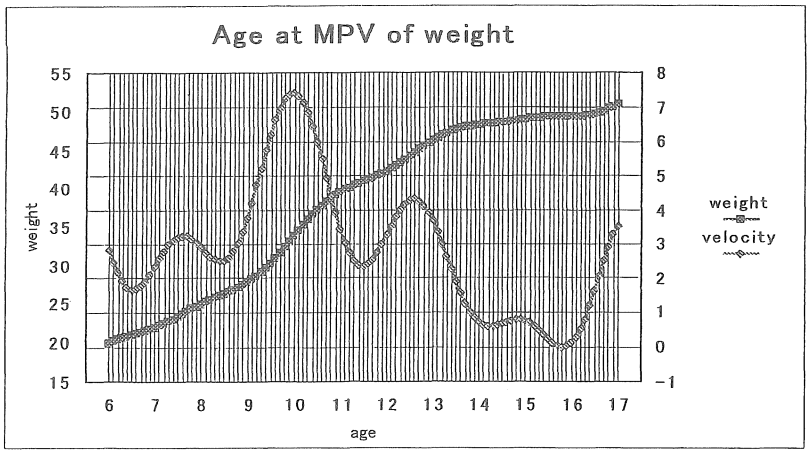

Fig 1-2 Growth distance and velocity curve of weight derived from WIM

Table 1 Statistics of the age at menarche, MPV of height and weight

		Age at menarche	Age at MPV of height	Age at MPV of weight
Athletes	Mean	12.59	11.18	11.79
	S D	1.17	1.13	1.21
Control	Mean	11.90	10.94	11.48
	S D	1.17	1.15	1.39

Table 2 Statistics of the difference between the age at MPV of height , weight and at menarche in athletes and control groups

		Difference between the age at MPV of height and menarche	Difference between the age at MPVof weight and menarche
Athletes	Mean	1.54	1.08
	S D	1.01	1.40
Control	Mean	0.96	0.42
	S D	1.18	1.28

(Control group)

The age at MPV of height

$$f(x)=\frac{0.5\times 68}{\sqrt{2\pi}\times 1.16}e^{-\frac{(x_i-10.94)^2}{2(1.16)^2}}$$

The age at MPV of weight

$$f(x)=\frac{0.5\times 68}{\sqrt{2\pi}\times 1.40}e^{-\frac{(x_i-11.48)^2}{2(1.40)^2}}$$

The X_0^2 (chi-spuare values) from above fomulas were 10.06 for the age at MPV of height and 11.18 for the age at MPV of weight in the athlete group, and 9.57 for the age at MPV of height and 17.51 for the age at MPV of weight in the control group. This suggested a good fit with normal distribution. Thus, we concluded that the age at MPV of height and weight showed an approximately normal distribution in both groups.

2) Comparative evaluation of age at MPV of height and weight in both groups.

Normality was presented for the age at MPV of height and weight in both groups. A between - group comparison showed an age at MPV of height of 11.18 years (1.17)in the control groups. Statistical analysis revealed no significant difference between the two groups. The age at MPV of weight was 11.79 years (1.12) in the athlete groups and 11.48 years (1.39) in the control group. Again, there was no significant difference between the two groups. The lack of significant differences between the groups, particularly with respect to the age at MPV of height, suggested a similar maturity rate in the two groups of subjects.

2. Comparison of age at menarche in athlete and control groups.

In a mannar similar to evaluation of normality for the age at MPV, the normal distribution functions for calculation of the critical frequencies with respect to normality for the age at menarche are shown below

The age at menarche of atletes group

$$f(x)=\frac{0.5\times 57}{\sqrt{2\pi}\times 1.18}e^{-\frac{(x_i-12.59)^2}{2(1.18)^2}}$$

The age at menarche of control group

$$f(x)=\frac{0.5\times 68}{\sqrt{2\pi}\times 1.18}e^{-\frac{(x_i-11.90)^2}{2(1.18)^2}}$$

The X_0^2 values from the above formulas were 28.70 in the athlete group and 34.55 in the control group. There was normality for the ages at menarche in both groups. We then conpared the ages at menarche in two groups based on the presence of normality. The age at menarche was 12.59 years (1.17) in the athlete group and 11.90 years (1.17) in the control group. There was a significant difference between the two groups ($p < 0.05$) in which the athlete group showed a significantly later age at menarche.

However, this finding does not itself imply a causative relationship between the later age at menarche and training. There may be other characteristic factors of athletes that cause a delay in maturation.

3. Evaluation of differences between age at MPV of height and at menarche in athlete and control group.

In the difference between the age for each subject, the statisties were 1.54 years (SD=1.01) in the athlete group and 0.96 years (SD=1.18) in the

control group. There was a significant difference between the two groups ($P<0.05$). Their results are based on date deriwed from our calculations(Table 2).

Regarding the differences between the age at MPV of height and age at menarch in the athlete and control groups, the larger difference in the former group suggests delayed menarche in atletes. In addition, examination of the frequency distribution of the differences between the age of MPV of haight and at menarche showed some negative values, indicating that in some cases, the age at menarche was earlier than the age at MPV of height (reverse seguence). This reverse seguence was present in 20.6% of the control group subjects, but in only 5.3% of the athlete group subjects. This finding also provides evidence that athletie training may cause dalay in menarche.

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