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An Analysis Regarding Mean Growth Velocity Curve Classified by M P V Age in Boys' Weight and Chest Girth

男子の体重、胸囲におけるＭＰＶ年齢別平均発育速度曲線の解析

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ABSTRACT　The effectuality of a Wavelet Interpolation Method (W I M) for local approximation was proposed by author's previous paper. In this paper, it is to analyze and describe mean growth velocity curve classified by M P V age of that by the W I M to examine the characteristics of weight and chest girth growth velocity curve. The growth distance curve is interpolated to longitudinal weight and chest girth growth distance data(6 to 17 years of age), and is differentiated as the growth velocity curve. M P V age is determined from the growth velocity curve, and the statistic of the M P V age is used to describe the mean growth velocity curve in weight and chest girth. As a result, five groups in the mean growth velocity curve classified by M P V age was set up as maturity types (early, somewhat early, average, somewhat late and late maturity type), and both phenomena of mid-growth spurt and after-growth spurt was shown in almost maturity types. This tendency in weight and chest girth was a little different from the case of height.

1. INTRODUCTION

author[1)2)3)4)] proposed Wavelet function to express mathematically the growth curve fluctuated on time axis devided infinitely by expanding Togo and Kobayasi's idea [5)]. This means the theoretical background based on that we hypothesized 『 Multiresolution Phenomena』 totalized a self-similar phenomenon which same figure is regenerated even if magnified or reduced. Since wavlet bases are most effective for local approximation, author proposes the Wavelet Interpolation Method(W I M) as a new approach which applied interpolation method for the multiresolution phenomena. In this method, the growth distance curve $F(t)$ and the growth velocity curve $f(t)$, as the derivative of F(t) at t, are assumed to be smooth and $L^2(R)$ functions. These functions can be approximated by Wavelet series. As a result, based upon time series (longitudinal data of height growth), the growth velocity curve ($t, f(t)$) is described approximately by finite wavelet series. For the above reasons, the peak and the peak age(M P V age) of weight and chest girth are identified by computer simulation, and the mid-growth spurt and the after-growth spurt in the mean growth velocity curve classified by M P V age are examined.

2 Subjects and Method

The data used for this study were gleaned from the Health Examination Records in Nagoya City during the period from 1972 to 1983. These longitudinal growth data consisted of height, weight, chest girth and sitting height. Author considers the longitudinal weight and chest girth data of 98 Japanese boys, measured annually from 6 to 17 years of age. And the

Wavelet Interpolation Method (W I M) is applied as the method here. The algorithm of the W I M is stated as follows.

Wavelet Interpolation Method

Assume that a growth distance curve $F(t)$ and a growth velocity curve $f(t)$, $f(t)=dF(t)/dt$, are smooth and $L^2(R)$ functions where

$$L^2(R)=\{g(t): \int_{-\infty}^{\infty} g(t)^2 dt<\infty\}$$

Then it is shown the following Wavelet expansion:

$$F(t)=\sum_{j,k} a_{j,k}\,\psi(2^j t-k)$$

where j, k an integers.

$\psi(t)$ is Meyer Wavelet[6] that has a localised oscillatory form. $\{\psi(2^j t-k): j,k;\ an\ integer\}$ are an orthogonal basis for $L^2(R)$. So, this Wavelet expansion is becoming the extension of Fourier series which had a characteristic of localization[7].

The algorithums to a Wavelet Interpolation Method (W I M) can be stated as follows:

1. Time series (longitudinal) data $\{(t_i, y_i): i=1, 2, \cdots, n\}$ are given.
2. Construct the Meyer Wavelet $\psi(x)$ which satisfies the following condition.
   $|\psi(t)| \leqq \varepsilon$ for $t<0$ or $t>1$.
3. Take n pairs of integer (j, k) which satisfy
   $|\psi(2^j t_i-k)| \geqq \varepsilon : i=1, 2, \cdots\cdots, n$.
4. Determine Wavelet coefficients $\{a_{j,k}; j,k\}$ from the time series data and values of a Wavelet function $\psi(2^j t_i-k)$, by solving such simultaneous linear equations such that

$$y_1=\sum_{j,k}^{n} a_{j,k}\,\psi(2^j t_1-k)$$
$$\cdots$$
$$y_n=\sum_{j,k}^{n} a_{j,k}\,\psi(2^j t_n-k)$$

Table 1 Mean and standard deviation of M P V age in weight, and classifications of maturity type

Mean	12.60	early maturity type	M P V ≦ 10.7
S D	1.12	somewhat early maturity type	10.8 ≦ M P V ≦ 11.9
Max	15.0	average type	12.0 ≦ M P V ≦ 13.1
Min	9.4	somewhat late maturity type	13.2 ≦ M P V ≦ 14.3
Range	5.6	late maturity type	14.4 ≦ M P V

Table 2 Mean and standard deviation of M P V age in chest girth, and classifications of maturity type

Mean	12.81	early maturity type	M P V ≦ 10.3
S D	1.58	somewhat early maturity type	10.4 ≦ M P V ≦ 11.9
Max	16.0	average type	12.0 ≦ M P V ≦ 13.6
Min	9.2	somewhat late maturity type	13.7 ≦ M P V ≦ 15.2
Range	6.8	late maturity type	15.3 ≦ M P V

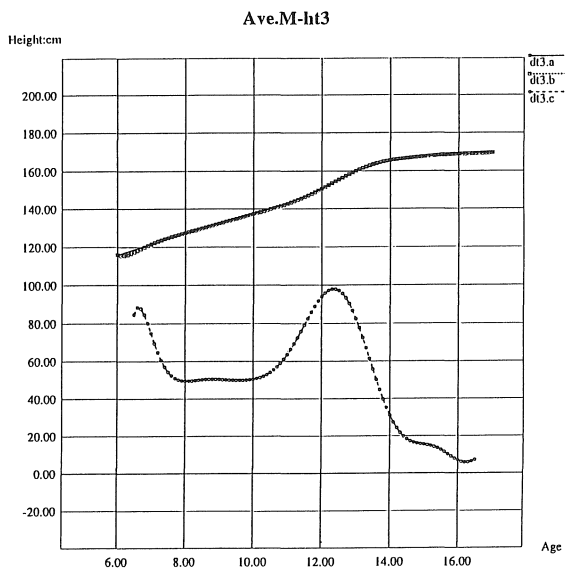

Fig 1 An example graph of distance and velocity curve approximated by Wavelet Interpolation Method

5. Substitute $\{a_{j,k}\ ;\ j,\ k\}$ for the following equations and describe a graph of $y = F_n(t)$ and $y = f_n(t)$.

$$F_n(t) = \sum_{j,k}^{n} a_{j,k}\psi(2^j t - k)$$

$$f_n(t) = \sum_{j,k}^{n} 2^j a_{j,k}\psi(2^j t - k)$$

6. Determine the extremal values of y=fn(t) by computer simulation.
7. Investigate the other local maximal points of y=fn(t).
8. Examine the characteristics of time series model from the data of extremal values by the statistical analysis.

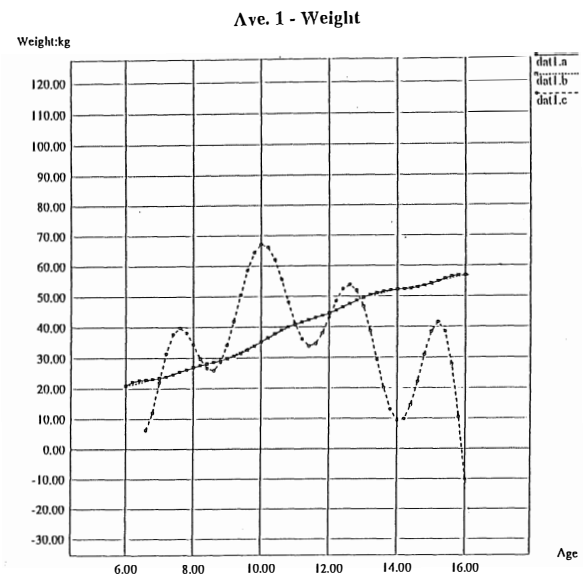

Fig 2 Early maturity type in weight

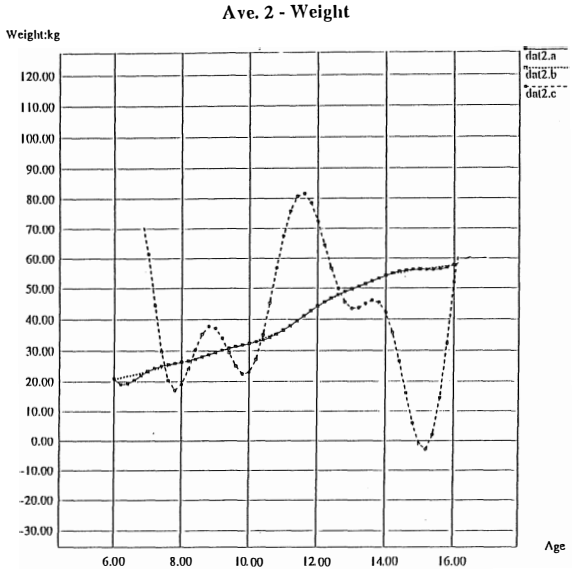

Fig 3 Somewhat early maturity type in weight

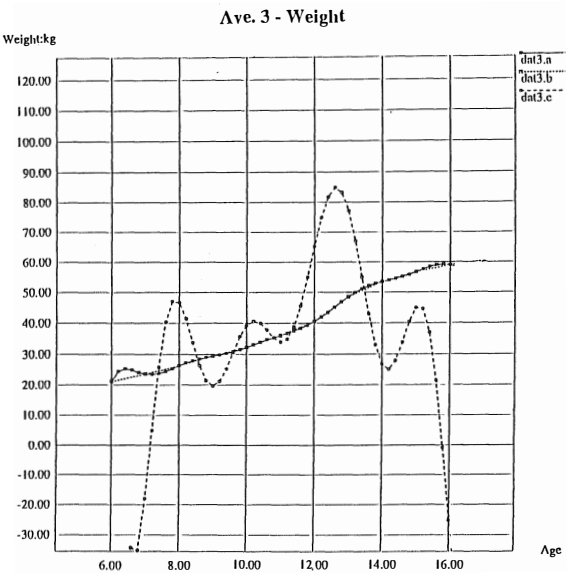

Fig 4 Average type in weight

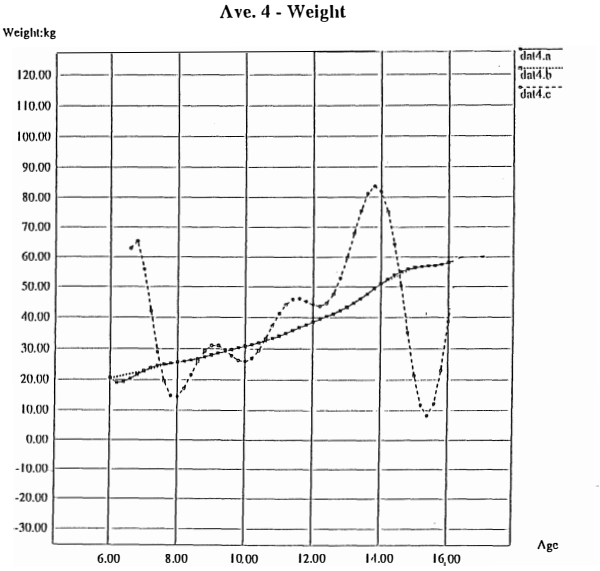

Fig 5 Somewhat late maturity type in weight

3 Results and discussion

Growth distance and velocity curve were simulated with UNIX work-station as shown in Fig 1 by the W I M. This graph is one of 98 boys' samples in height , the graph described with solid line is the growth distance curve, the one with dotted line is the growth velocity curve. The unit of mark with degree on the vertical axis is set up with matching for the growth distance curve of height in this graph, though regarding that in the growth velocity curve, it is set up with lowering ten figures in rank than that in the growth distance curve.

The peak (M P V) and the figure of curve in

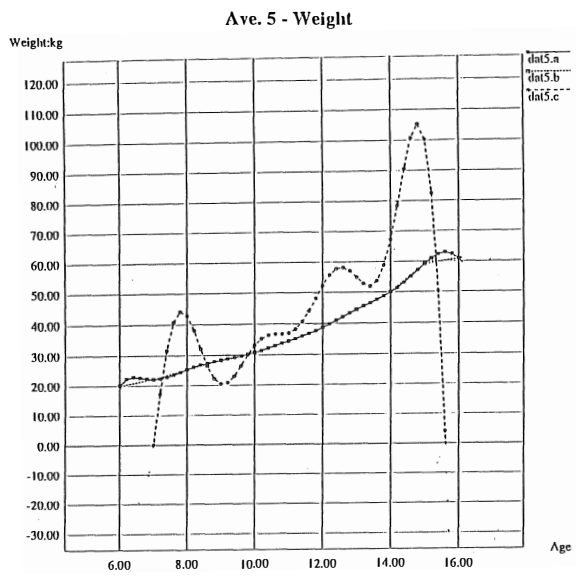

Fig 6 Late maturity type in weight

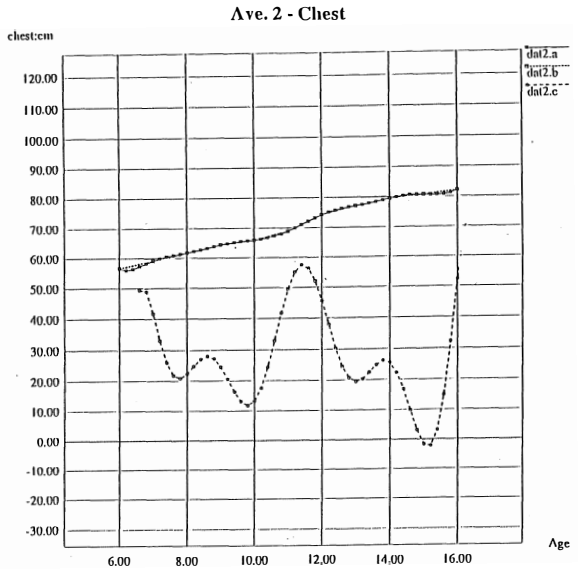

Fig 8 Somewhat early maturity type in chest girth

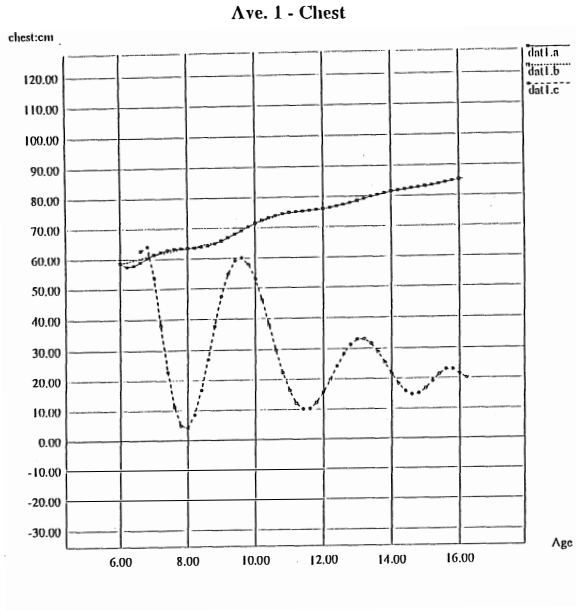

Fig 7 Early maturity type in chest girth

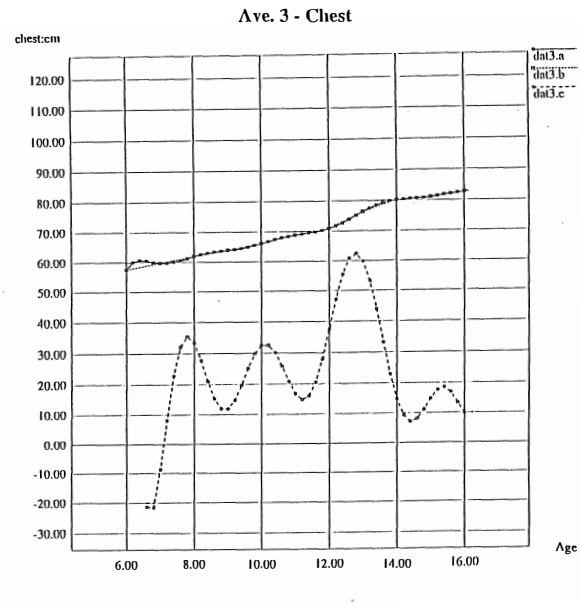

Fig 9 Average type in chest girth

this graph can be grasped clearly, therefore, M P V and M P V age in weight and chest girth were derived individually from wavelet function which requested the curve approximated in the graph of 98 boys by UNIX work-station. As shown in table 1 , mean M P V age was 12.60 (SD = 1.12) in weight and was 12.81(SD = 1.58) in chest girth, and the difference between mean M P V age of weight and chest girth was about 0.2 years of age. A criterion of maturity rate was attempted to device with judging from the mean and standard deviation of M P V age in weight and chest girth.(Table 2)

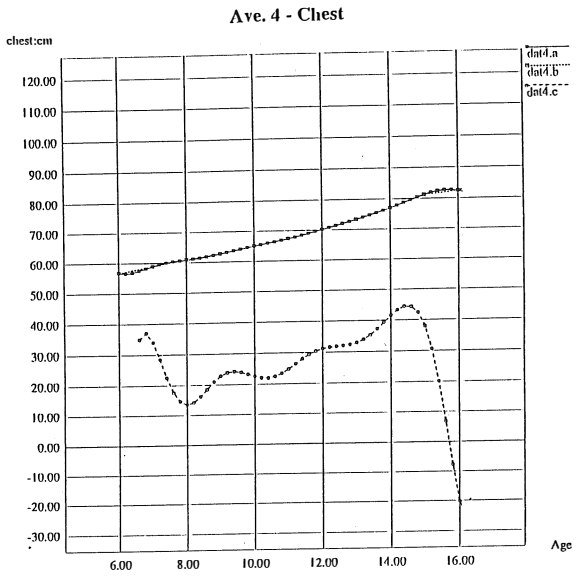

Fig 10 Somewhat late maturity type in chest girth

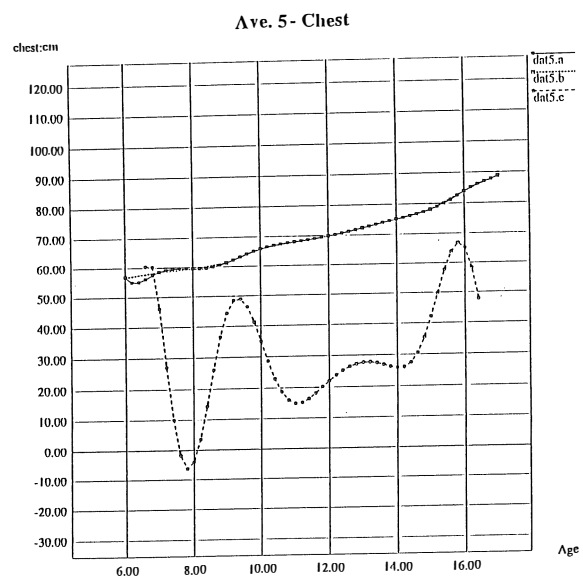

Fig 11 Late maturity type in chest girth

Mean of the growth distancies in respective group classified by a criterion of maturity rate judged from M P V age was computed in weight and chest girth. Approximated curve of that for the mean of the growth distancies was described respectively in five groups classified by maturity rate in weight and chest girth by the W I M, moreover the growth velocity curve which differenciated the approximated curve was described as well as the growth distance curve (Fig 2 ～ Fig 11).

The validity on the wavelet interpolation method (W I M) has been assured by author's previous studies [1)2)3)4)], especially, it was very significant that M P V is identified in the growth velocity curve and a criterion classified by maturity rate in height judged from M P V age is devised. Thus it is considered that criterions of five ranks classified by M P V age in weight and chest girth are also helpful to grasp as the standard growth velocity curve classified by maturity rate. The mid-growth spurt (which Tanner[8)] labelled) and the after-growth spurt (which Matsuura [9)] suggested and labelled) occur almost in maturity types of the growth velocity curves classified by M P V age in weight and chest girth. This tendency is a little different from the case of height. Tanner[10)] stated that the mid growth spurt more appeared in weight than in height, however, did not discuss adequately about this spurt. Matsuura [9)10)] suggested the existence of the after-growth spurt, though did not examine into detail about this spurt. As affairs now stand, number of the peak, correct age and growth velocities in the peak point in the mid- and after-growth spurt are not clarrified because methods which detect these spurt in previous investigations vary. Therefore, author intends

to examine the both phenomena based upon more longitudinal growth data by the W I M in the future.

6 References

1) Fujii, K., Kawanami, K., Hasegawa, Y. and Yamamoto, Y. : Time series analysis in height growth by Wavelet analysis. Studies of Growth and Development. 22 :21-28, 1994.

2) Fujii, K. and Yamamoto, Y. : A Wavelet Interpolation Method for a Time Series Analysis for Growth and Development Study. Nagoya Journal of Health, Physical Fitness and Sports. 18 : 13-18, 1995.

3) Fujii, K. and Yamamoto, Y. : An examination regarding the P H V in weight growth of male students by Wavelet Interpolation Method. Studies of Growth and Development. 23 : 27-34, 1995.

4) Fujii, K. and Yamamoto, Y. : The analysis of the growth velocity curve in height based upon the maturity rate. Japanese Journal of Physical Fitness and Sports Medicine. 44 : 431-438, 1995.

5) Kobayasi, M. and Togo, M. : Twice-daily measurements of stature and body weight in two children and one adult. American Journal of Human Biology. 5 : 193-201, 1993.

6) Meyer, Y. :Ondelette et Operateur 1. Hermann. Paris. pp.1-127, 1990.

7) Strang, G. :Wavelet Transforms versus Fourier Transforms. Bull. A.M.S. 28 : 288-305, 1993.

8) Tanner, J. M : The morphological level of personality , Proceedings of the Royal Society of Medicine, 40 : 301-303, 1947.

9) Matsuura, Y. : A study on physical growth and development through investigating the polynomial fitted their distance curves - in the term over 6 and 18 years old. Bull of Health and Sport Sciences, Univ of Tsukuba. 14 : 211-222. 1991.

10) Matsuura, Y. and Kim, M. : Analysis of growth by fitting the polynomial to the longitudinal growth distance data of individual - age 6 to 17 - . Research Monograph. Growth and Developmental Research. Institute of Health and Sports Sciences. University of Tsukuba. pp 1-150, 1991.

11) Tanner, J. M. and Cameron, N : Investigation of the mid-growth spurt in height, weight and limb circumferences in single-year velocity data from the London 1966-67 growth survey. Annals of Human Biology. 7 : 565-577, 1980.

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