

Verification of Changes in Body Proportions in Humans

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ABSTRACT

So far, the growth curves proposed by Scammon (1930) have been often used to advantage when explaining the changes in human proportions. With regard to these explanations, the growth was understandable if seen as the relative growth of the general growth pattern for things such as height and weight and the neural growth pattern showing growth of the head. However, the point here is that the validity the logic for the growth curves proposed by Scammon almost 90 years ago should obviously be tested. Even assuming that the growth curves of Scammon (1930) were to be re-examined, the changes in human proportions can probably not be verified simply with the differences between the general and neural type growth patterns alone. Thus, it is necessary to verify the actual height and weight growth patterns and the head growth pattern. Therefore, the present study attempts to verify the changes in human proportion by applying the wavelet interpolation model to growth distance values obtained through measurements of growth in height and head circumference from early childhood to adults, and to analyze the behavior of the velocity curves of height and head circumference derived as differential curves. As result, this study was able to provide unequivocal findings on the changes in proportion by applying the wavelet interpolation model proposed by the author (1999) (2006). However, the study had the limitations that there was no longitudinal data on the organs, actual face length, or longitudinal data on head circumference.

INTRODUCTION

The author (2013b) has previously analyzed growth patterns in four-legged animals, and found that large four-legged animals reach an adult weight in about two years. The weight growth curves followed by these animals differ greatly from the growth curves of humans. More recently, citing the proposed Fujimmon growth curves the author (2017) showed that their growth curves are a mixed type of the general and neural types. If anything, they are closer to the neural type. In other words, puberty was not detected in these animals. In the earlier study by the author (2013b), Japanese macaques and similar animals showed a slight pubertal peak in weight growth, although it not as long as the peak in humans. Thus, in non-primate four-legged mammals, the growth pattern does not differ depending on the part of the body. Rather, they grow uniformly and as a result there is no change in their proportions as they grow. In contrast, it is well known that the physical proportions of humans differ significantly during the growth process. Stratz (1921) proposed a proportion diagram of humans from birth to adulthood, and showed that during early childhood humans are about 4 heads tall, whereas in adults this had changed to 8 heads tall.

The question, then, is why humans change in proportion as they grow. One theory is that while growth in head size approaches quite closely to that of adults in the first half of the growth period, as in four-legged animals, body size continues to grow even after that. Consequently, it is conjectured that the change in proportion occurs relatively. This is closely related to upright walking on two legs in humans, and is thought to be a result of evolution. For humans, growth of the brain is a priority, and the period referred to as puberty is necessary for growth to protect the brain and facilitate brain activation. The brain is enhanced in this period. It may be conjectured that changes in human proportions became entrenched as a result. But what is the best way to prove these changes? As mentioned above, the growth pattern of the head differs from the growth pattern of the body. Therefore, it would be useful to verify the phenomena in which the growth of the body enters puberty after the growth of the head reaches a plateau, rapidly growing afterward to achieve an adult form. However, there have been no reports to date clearly verifying these phenomena.

The growth curves proposed by Scammon (1930) have been often used to advantage when explaining the changes in human proportions. With regard to these explanations, Takaishi (2003) said that growth was understandable if seen as the relative growth of the general growth pattern for things such as height and weight and the neural growth pattern showing growth of the head. However, it should be noted that in the age-related changes of the head and body, the growth of the mandible shows a general growth pattern. The changes in proportions can be explained conveniently when the growth patterns of Scammon (1930) are used in this way. Because of this convenience, however, growth researchers today have come under the illusion that the changes in human proportions have already been proven. For example, Tanner (1962)(1978), Takaishi et al. (1981), and Matsuura et al. (2005), have cited Scammon's growth curves but have not tested their credibility or the changes in human proportions. Kimura (1966) cited Scammon's growth curves in explaining changes in proportions from differences in the changes with age in measurements of height, head circumference, and face height, but the scientific basis is lacking. The point here is that the validity the logic for the growth curves proposed by Scammon almost 90 years ago should obviously be tested. Even assuming that the growth curves of Scammon (1930) were to be re-examined, the changes in human proportions can probably not be verified simply with the differences between the general and neural type growth patterns alone. Thus, it is necessary to verify the actual height and weight growth patterns and the head growth pattern.

This study attempts to verify the changes in human proportion by applying the wavelet interpolation model to growth distance values obtained through measurements of growth in height and head circumference from early childhood to adults, and to analyze the behavior of the velocity curves of height and head circumference derived as differential curves.

METHODS

Data sets

Growth records were obtained for height, weight, chest circumference, and head circumference for children age 0 to 6 years old entered in the 1970 version of the physical growth records for infants and young children published by the Ministry of Health, Labor and Welfare. Next, the head circumference and growth records from age 5 to 20 years old described in a report by Okuda (1971), published in the journal *Anthropological Science*, were obtained. The growth

distance values for the obtained head circumference and height measurements from age 6 to 17 were extracted.

Analytical method

Wavelet interpolation method

The Wavelet Interpolation Model (WIM) is a method to examine growth distance values at adolescent peak. A growth curve is produced by data-data interpolation with a wavelet function, deriving the growth velocity curve obtained by differentiating the described distance curve to approximately describe the true growth curve from given growth data. The effectiveness of the WIM lies in its extremely high approximation accuracy in sensitively reading local events. Details on theoretical background and the basis for this effectiveness are omitted here as they have already been set forth in prior studies by Fujii (1995, 1999, 2006). Growth distance and velocity curve of height is described by wavelet interpolation model as in the following two graphs.

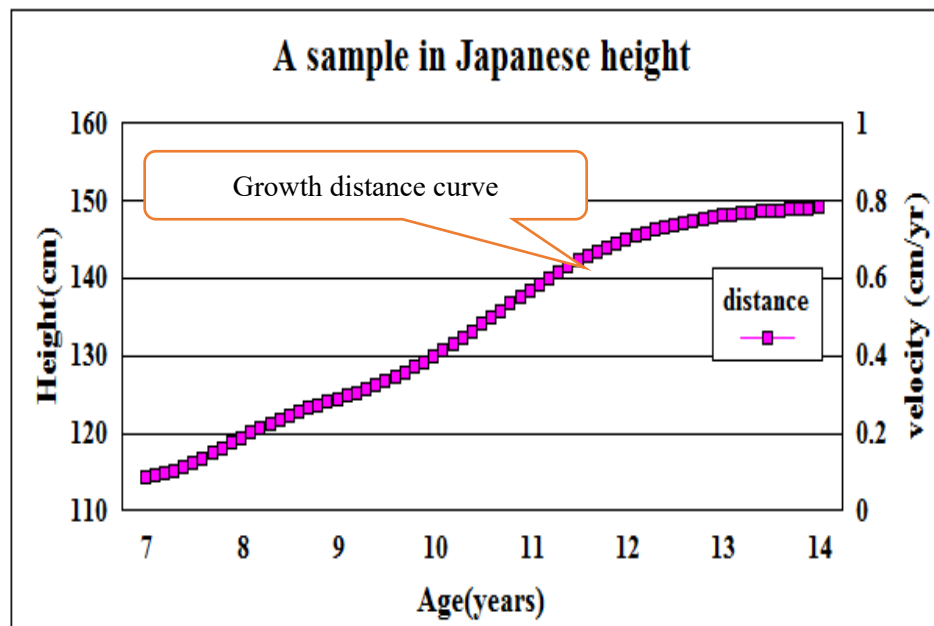


Figure 1. Growth distance curve of height described by wavelet interpolation model

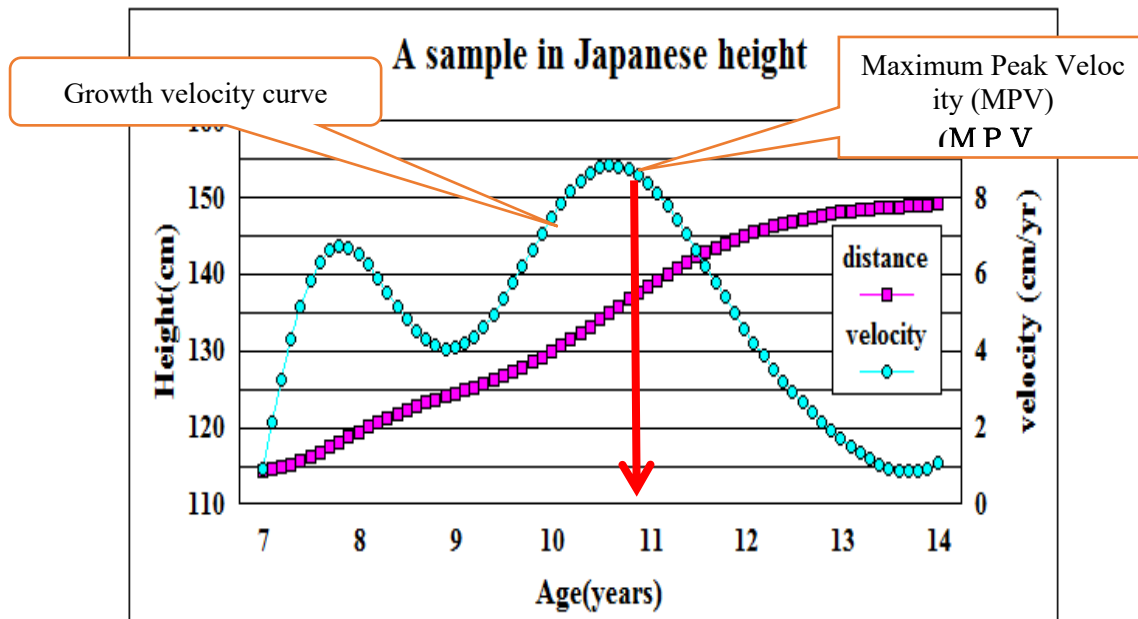


Figure 2. Growth velocity curve of height described by wavelet interpolation model

RESULTS

Verification of general and neural type growth patterns based on the growth curves of Scammon

Figure 3 is an original drawing from the time Scammon proposed his four growth patterns. The curves described here were drawn free-hand using his ideas. Figure 4 is comparative growth curve of Fujimmon and Scammon. Fijimmon's growth curve was proposed by Fujii (2017), and were drawn based on wavelet interpolation model. In these curves, the growth patterns of brain weight and organs represented by the neural growth pattern and the general growth pattern are analyzed. However, since they are curves of four patterns drawn free-hand it is impossible to determine whether the brain weight and organ growth curves correspond to the neural and general growth curves. The author then applied an original method to examine whether they fit the neural or general pattern. The graph in Figure 4 describes brain weight in boys with the wavelet interpolation model applied to the growth distance values for brain weight. The velocity curve shows a rapidly declining behavior, as if demonstrating the rapid increase in growth distance values in early childhood. It may be said to present a reverse neural type growth pattern from the behavior of the growth distance values and velocity curves described with the wavelet interpolation model. Similarly, the right graph in Figure 5 was made with application of the wavelet interpolation model to the distance values of kidney weight, but it unquestionably shows the maximum peak velocity (MPV), which indicates the period of rapid increase in puberty, and will demonstrate an S-shaped curve or sigmoid curve. The general growth pattern may also be said to show that model.

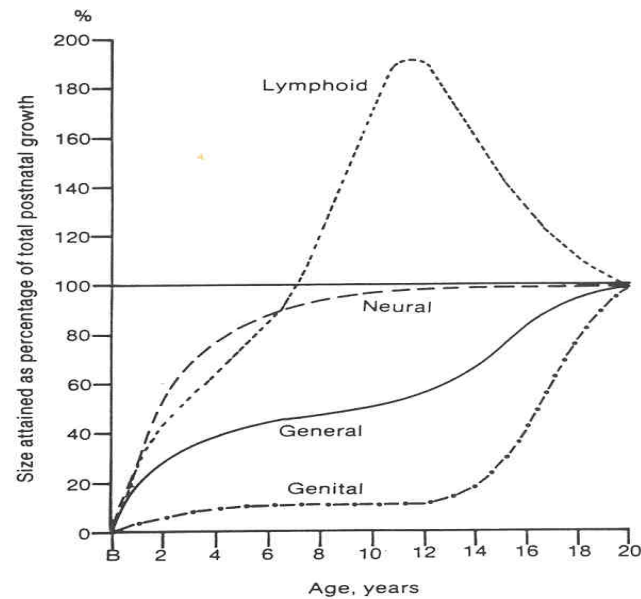


Figure 1.2 Scammon's curves of systemic growth. Growth of each structure is expressed as a percentage of the total gain between birth and 20 years. Size at age 20 equals 100% on the vertical scale. From "The Measurement of the Body in Childhood" by R.E. Scammon. In *The Measurement of Man* (p. 193) by J.A. Harris, C.M. Jackson, D.G. Paterson, and R.E. Scammon (Eds.), 1930, Minneapolis: University of Minnesota Press. Redrawn by permission of the University of Minnesota Press.

Figure 3. Four growth patterns in humans described free-hand, based on Scammon (1930)

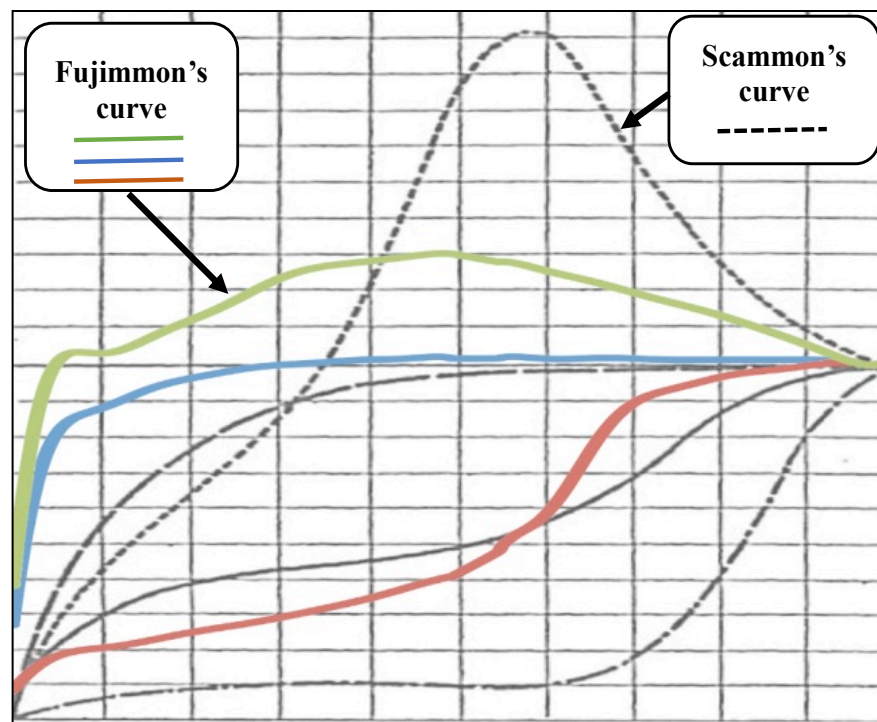


Figure 4. Comparative growth curve of Fujimmon and Scammon

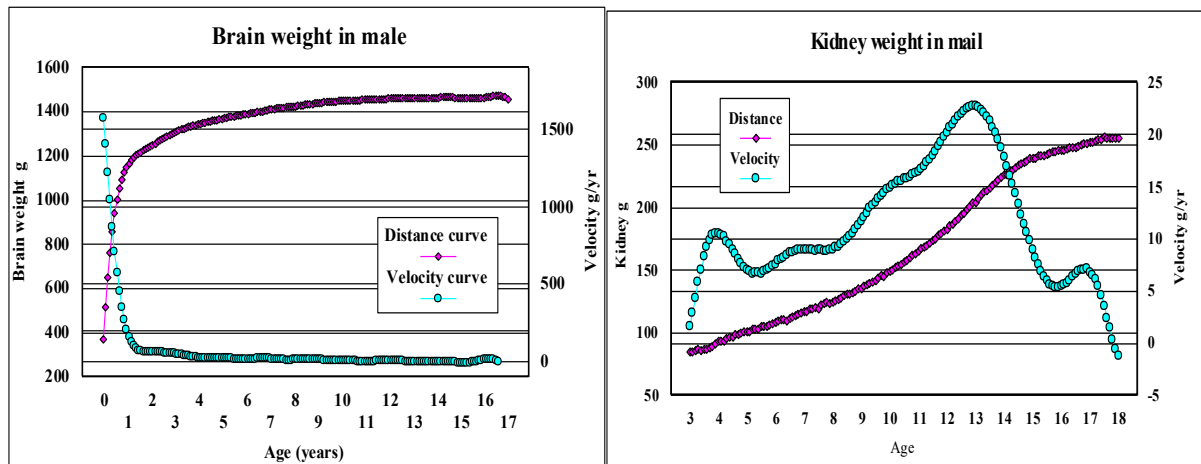


Figure 5 Growth distance and velocity curves of brain and kidney weight described by WIM

Verification of growth in head circumference and height

From the above results it is shown that in the neural growth pattern the growth of the head is representative of the growth in brain weight. At the same time, it was shown by Fujii (2017) that the growth in body weight, including organs such as the kidneys, and the growth in height are representative of the general growth pattern. Growth records for height and head circumference were then extracted from the physical growth records for infants and young children published in 1970 by the Ministry of Health, Labor and Welfare. The reason for adopting the 1970 version was that the records for head circumference from age 4 to 20 years old measured by Okada (1971) were measured in 1970. The graph in Figure 6 was made with application of the wavelet interpolation method to the growth process for height and head circumference of boys age 0 to 6 years old. The growth distance curve for height shows a rapid increase from birth to about 1 year old, followed by a gradual increase until age 6. The behavior of the velocity curve shows a rapid decrease until about 1 year old and a gradual decrease until about 3 years old, after which it remains steady. However, it is seen that a rapid increase is shown from birth until about 1 year old in the growth distance curve for head circumference, which is greater than the size of the increase in growth in height. Afterward, a slight increase or a steady trend is seen until around age 6. The behavior of the velocity curve in particular shows a rapid decrease until age 1 in both attributes, after which they remain steady. However, the growth in head circumference shows a growth pattern similar to that of brain weight.

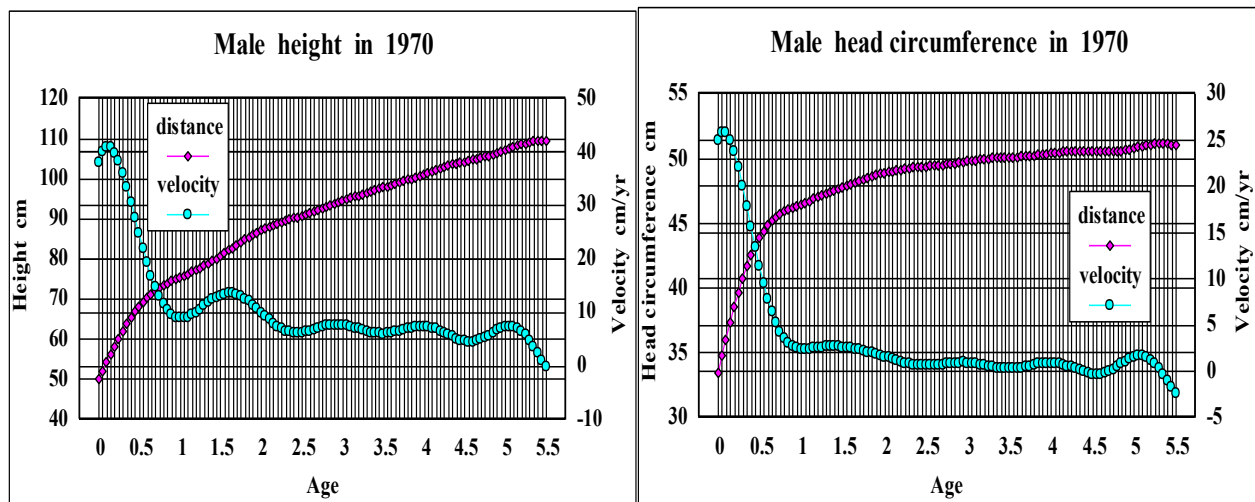


Figure 6. Growth distance and velocity curves of height and head circumference from 0 to 6 years described by WIM

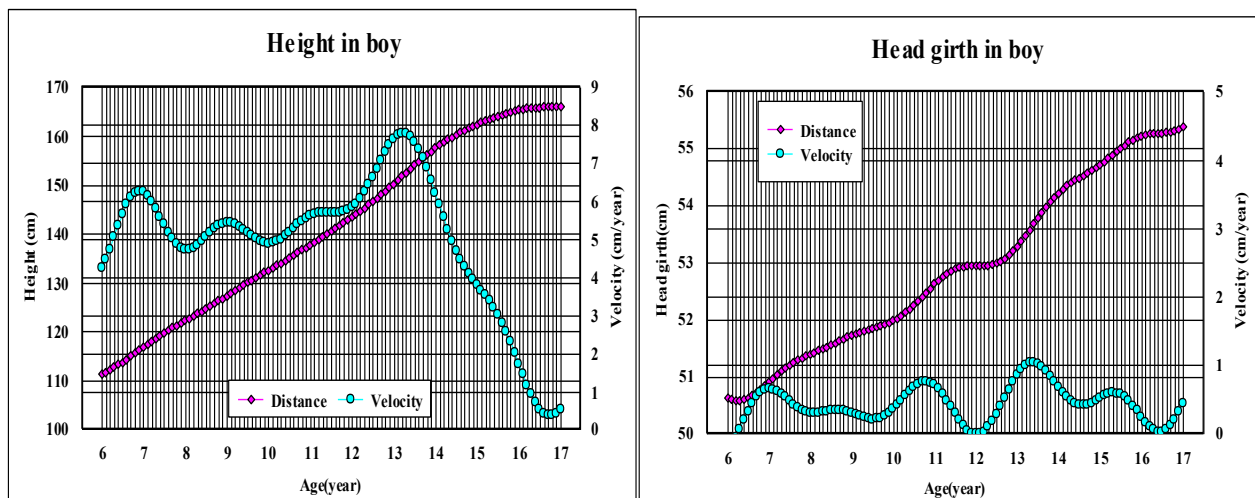


Figure 7. Growth distance and velocity curves of height and head circumference from 6 to 17 years described by WIM

Next, Figure 7 shows graphs of growth in height and head circumference from age 6 to 17 years old. The growth distance curve for head circumference shows a slight, gradual increase only. A slight undulation of within 1 cm/year, as shown in the behavior of the velocity curve, is seen but it mostly remains steady. Thus, compared with the amount of growth in head circumference from birth to age 6, only a slight increase is seen after age 6. In contrast, the growth distance curve for height shows a rapid increase from around puberty at age 9–10 years old. Looking at the behavior of the velocity curve, the pubertal peak (MPV of height) is clearly shown. The age at MPV was 13.2 years old, and the MPV was 7.79 cm/year. This is precisely the general growth pattern shown in the growth patterns of Fujimmon (2017). In any event, the growth patterns for height and head circumference differ greatly. Growth in both height and head circumference show rapid increases in early childhood, but while no rapid growth phenomenon during puberty was seen in head circumference, a rapid growth phenomenon during puberty was seen in height which surpasses the growth of head circumference with growth after puberty. In adults the body proportion changes so that height is about 7–8 heads tall.

DISCUSSION

Head circumference growth and height growth have conventionally been classified as neural type and general type in the growth curves of Scammon (1930). These curves have been convenient in explaining changes in the human head and body. However, verification with the use of the Scammon's growth curves is risky. That is because this is a classic theory proposed nearly 90 years ago, and has still not been verified in any way. Recently, the author (2013)(2015)(2017) made several attempts to re-examine Scammon's growth curves, but since the internal weight of the body cannot be measured longitudinally, re-examination is limited. However, certain findings could be obtained. The details are given in previous reports by the author (2013)(2015)(2017). In short, it was possible to integrate three patterns, the neural, lymphoid, and general patterns. Dissimilarities between them could be examined and established by including the genital type in the general type. This was proposed as the new Fujimmon growth curves.

In this study, changes in human proportions were analyzed by applying the wavelet interpolation model to the behavior of head circumference and height growth curves. It was found that head circumference growth achieves nearly adult values by the time individuals enter puberty, whereas growth in height begins to rapidly increase in puberty. The increase in height then continues and converges on adult values. It is shown from these large differences in the growth patterns for head circumference and height that proportion changes relatively. Of course, a more accurate analysis of the changes in the head and body could be done if the length of the face could be measured, but sufficient evidence is produced even with head circumference alone. For example, at the age of MPV for height (13.2), the actual distance value for head circumference was shown to be 53.5 cm, a figure close to that of adults. The growth distance value for height at the age of MPV was 151.8 cm, a considerable difference with the adult value of 166 cm.

By examining these changes in proportion in humans, the facts that a difference exists between humans and four-legged animals and that the phenomenon of puberty has an important meaning for humans could be verified anew. Obviously, these differences are closely related to upright walking on two legs in humans, and in all likelihood are phenomena resulting from human evolution. Humans came to walk upright to protect and support the brain, and by freeing the hands humans also became able to use tools. The growth of the brain is a priority for humans, and the period of puberty is essential in facilitating the active growth of the brain. The enhancement of the brain in this period is an ordeal in becoming truly human. The common rebellious phase and other aspects of puberty may be called important trials in becoming an adult. Nevertheless, establishment of the changes in body proportion in today's humans may be one of the major results of evolution in humans.

CONCLUSION

Scammon's growth curves are used as growth curve graphs that can conveniently explain the phenomenon of human growth even today, after nearly 90 years. In the modern computer era there has still been no detailed examination of why Scammon's growth curves are classified into four patterns. This author thinks that it is probably because no scientific method to describe growth curves has yet been established. That is, growth curves cannot be easily drawn even with modern personal computers, and never will be until programs with pertinent

mathematical functions are developed. The author has proposed the wavelet interpolation model to describe the velocity curves of head circumference and height growth curves, and examined in detail the pubertal peak in relation to growth in height.

Ultimately, it may be said that verification of the changes in human proportion is impossible unless the behavior of growth curves can be analyzed. This study was able to provide unequivocal findings on the changes in proportion by applying the wavelet interpolation model proposed by the author (1995)(1999)(2006). However, the study had the limitations that there was no longitudinal data on the organs, actual face length, or longitudinal data on head circumference. Meanwhile, we have reached a time when body composition components can be measured in detail with biomedical impedance analysis (BIA) and other means, and organs with the same volume as real organs can be reproduced with 3D printers. With such advances in science there is sure to come a day when the parts of this study that were limited will be clarified. Then, if the Fujimmon growth curves constructed by the author are advanced, we may expect to rays of hope for the elucidation of human growth phenomena.

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