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The Contact Between Sports Talent Identification and Tracking of Tall and Short Height

Hikaru Tanaka[1], Katsunori Fujii[1, *], Yusaku Ogura[2]

[1]Graduate School of Business Administration and Computer Science, Aichi Institute of Technology, Toyota, Japan
[2]Department of Early Childhood Education, Chubu Gakuin College, Seki, Japan

Email address:
thikarux@gmail.com (H. Tanaka), fujii@aitech.ac.jp (K. Fujii), ogura-yusaku@chubu-gu.ac.jp (Y. Ogura)
[*]Corresponding author

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Abstract: Understanding the qualities of elite athletes is necessary in trying to determine ability as sports talent. However, there are few findings based on analyses that objectively grasp the characteristics of exceptional athletes. If the characteristics of changes with age in tall and short height ranking could be clarified, the physical characteristics of tall and short height judged to be advantageous in certain sports could be identified. In this study, we analyzed the tracking status of tall and short individuals and verified the changes in height ranking level with changes in age. We then verified a logical system for the viewpoint of sports talent identification from the genetic contribution to height after birth. We then established a span evaluation chart for height with age using the wavelet interpolation model, and demonstrated the tracking of height rankings. In other words, individuals ranked as short or tall moved within that rank without change into adulthood. The major significance of this study is thought to be that, by verifying the tracking phenomenon for height, it paradoxically revealed a potential methodology for discussing heritability. By elucidating the tracking of height ranking, a logical system for the viewpoint of identifying sports talent based on the genetic contribution to height after birth could be seen in this study. Thus, if people with superior athletic ability and tall height could be identified from a very young age, it would lead to the identification of future talent in sports where height is an advantage. In sports where short height is an advantage, identifying individuals with superior athletic ability and short height would be beneficial. Therefore, a logical system for sports talent identification may have been established in this study by establishing a tracking analysis for tall and short height rank.

Keywords: Tracking, Sports Talent Identification, Span Evaluation Chart with Age, Tall and Short Height

1. Introduction

Understanding the qualities of athletes is necessary in trying to determine ability as sports talent. Of course, this differs depending on the sports event, but common elements can be identified. However, there have been no reports clarifying the characteristics of athletes. There are reports related to the talent identification business, but there are few findings based on an objective understanding and analysis of the characteristics of exceptional athletes. Fujii et al. [1] and Ogura and Fujii [2] applied the wavelet interpolation model to methods determining level of physical maturity, and analyzed the physique qualities of exceptional athletes. Fundamentally, exceptional male athletes are tall and tend to mature early, with a good balance in physique of a difference of less than 0.2 years in the age at maximum peak velocities (MPV) of height and weight. Like males, exceptional female athletes tend to be tall, and to have a physical maturity level that is average or late. The difference between the MPV of height and weight is a little larger than that of males, at about 0.5 years. Of course, they have a well-balanced physique. Naturally, they also have an athletic ability that is suited to their specific sport.

Ogura et al. [3, 4] analyzed the physical elements of athletes called professionals at the national level and indicated that many athletes, including both men and women, are tall. Fujii et al. [1] and Ogura and Fujii [2] have stated that exceptional athletes are tall, but this only means that being tall can be used to advantage in some sports

competitions. Certainly, it cannot be denied that tall height is an advantage in many games. The background for this theory includes circumstances that have been taken as evidence that there is a high correlation between height and athletic ability. There is scientific evidence that strength is proportional to the cross-sectional area of muscle, and the theory is that as height becomes taller cross-sectional area also increases, as does strength, which then increases athletic ability. However, there is a major error in this theory, which is that the correlation between height and athletic ability in adults is actually not that high, as has been pointed out by Fujii [5]. During puberty, the contribution of maturity level is essential in increasing height. Therefore, it is not currently clear how much height affects athletic ability.

If these things are true, high athletic ability because of tall height is no longer essential to the reason why tall height is advantageous to athletes. In other words, the thinking that high athletic ability in a person who just happens to be tall would be a trigger for them to succeed as an athlete may be valid. It could be that in the path to success as an athlete, tall height has been positioned as an important element that is essential in sports. Therefore, it may be that, rather than the element of tall height being matched to athletes because of an inherent high athletic ability, that people with high athletic ability who happen to be tall is necessary to be an athlete. For example, there are cases when people have high athletic ability even when they are short, such as in gymnastics.

Incidentally, although it is reported the genetic factors for height are important [6], even in modern science no definitive findings are seen that can predict young children's final height in the future from the height of their parents. The problem of predicting height is considered to be very important in understanding an individual's potential to become an elite athlete and the phenomenon of the "three highs" (high income, high education, high height) in Japan during the period of its bubble economy. For example, in many reports, including those of Ogura et al. [3, 4], Shitara et al. [7], and Ikeda et al. [8], tall height has been shown to be a major element among the physical elements of elite athletes. Fujii [9] has also indicated tall height in the upper classes from historical secular trends in height, and suggested that elite athletes are an extension of this. With regard to the "three highs" in the bubble period, there are also reports that tall people were able to obtain high incomes [10, 11]. Thus, as in elite athletes and the "three highs," predicting tall height in the future is an important key.

Currently, however, no findings are seen for the prediction of final height, nor has the longitudinal growth process of tall people been established. For short people, there are reports of sports where short height works to the athlete's advantage, such as jockeying and gymnastics [12, 13]. For talent identification, however, while the longitudinal growth process for short people is important, such findings have not been established. Therefore, establishing a method that can evaluate the chronological trends in height may make it possible to understand the tracking status of height. Then, even if the final height cannot be predicted, if it were possible to analyze the tracking of height rank in the growth process, it may be possible to understand the growth level of the genetic trait of height.

In this study, by evaluating the tracking status of height and verifying the growth process using the wavelet interpolation model established as a longitudinal analysis method, we explored the contact with sports talent identification in consideration of the genetic growth level of height.

2. Methods

2.1. Subjects

The subjects in this study were 4922 males and 4685 females born in the 1994 and 1995 academic years, for whom longitudinal height growth data from the first year of elementary school to the third year of junior high school were obtained. Table 1 shows that data, obtained in cohorts, for the mean (M) height and standard deviation (SD) for height in the subjects in this study and the M height and SD nationally for people born in the 1994 and 1995 academic years published by the Ministry of Education, Culture, Science, Sports and Technology – Japan. This table shows that the height of the subjects for each year in this study was similar to the mean value nationally, from which it is thought that there were no major differences with the growth status of children in general.

Table 1. *Average height and standard deviation of subjects and nations.*

				Age (years)								
				6	7	8	9	10	11	12	13	14
Boys	Subject (N = 4922)	Mean	cm	116.72	122.56	128.24	133.66	139.01	145.29	152.81	160.06	165.16
		SD		4.74	4.99	5.23	5.49	5.92	6.83	7.60	7.18	6.24
	[a]National average	Mean	cm	116.95	122.87	128.24	133.70	138.84	145.41	152.72	159.86	165.37
		SD		4.97	5.18	5.42	5.34	5.91	7.14	8.07	7.61	6.72
	[b]National average	Mean	cm	116.83	122.63	128.55	133.58	139.08	145.13	153.08	160.11	165.21
		SD		4.95	5.20	5.25	5.56	6.14	7.02	8.14	7.52	6.47
Girls	Subject (N = 4685)	Mean	cm	115.77	121.58	127.37	133.48	140.11	146.77	151.73	154.64	156.09
		SD		4.88	5.15	5.55	6.16	6.82	6.70	5.87	5.43	5.35
	[a]National average	Mean	cm	115.98	121.63	127.55	134.02	140.53	146.67	152.19	155.10	156.79
		SD		4.82	4.96	5.39	5.91	6.75	6.92	5.70	5.39	5.23
	[b]National average	Mean	cm	116.07	121.74	127.64	133.46	140.36	147.05	151.96	155.06	156.74
		SD		4.78	5.22	5.49	6.09	6.81	6.72	5.58	5.11	5.17

N: Number of people, SD: Standard Deviation, a: Born in 1994, b: Born in 1995.

In this study, to survey the growth status for height, the Mean and SD for height in the third year of junior high school from among the subjects were calculated, and those with short height of ≤ Mean −2.0SD and those with tall height of ≥ Mean +2.0SD were determined and taken as the subjects for analysis. The number of analysis subjects and the basic statistics are shown in the Results.

2.2. Construction of Longitudinal Evaluation Chart for Height with Age

In this study, we conducted an analysis to show how height trended in people judged to be short or tall at the growth stage from the first year of elementary school to the third year of junior high school. For that, it was necessary to make evaluation charts that could evaluate height at each age. Based on the data obtained in this study (4922 males, 4685 females), the wavelet interpolation model was applied to Mean, Mean ± 0.5SD, and M ± 1.5SD for height in each school year. Wavelet interpolation model can approximately describe true growth curves from obtained growth data without being affected by the degree. Therefore, individual data are interpolated with a wavelet function, and a growth distance curve is drawn. Through these procedures, a longitudinal growth evaluation chart for height with age was constructed. For the evaluation levels, ≥Mean +1.5SD was taken to be "Tall," ≥Mean +0.5SD to <Mean +1.5SD to be "Somewhat tall," ≥Mean −0.5SD to <Mean +0.5SD to be "Average," ≥Mean −1.5SD to <Mean −0.5SD to be "Somewhat short," and <Mean −1.5SD to be "Short." Figures 1 and 2 are the longitudinal growth evaluation charts for height with age for males and females that were constructed in this study. Individual longitudinal data were applied to these constructed evaluation charts, and an analysis was performed of how those data changed the evaluation bands.

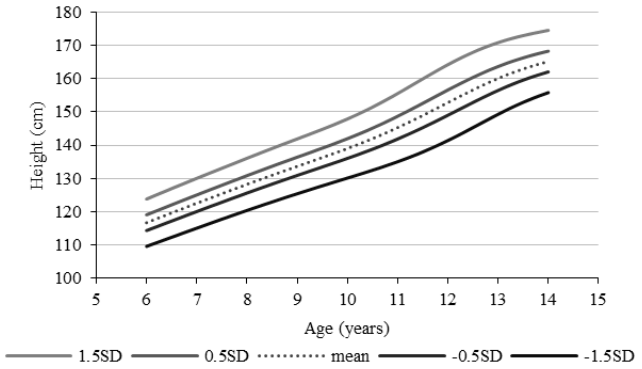

Figure 1. *Evaluation chart of longitudinal height growth in boys by wavelet smoothing method.*

2.3. Analysis Procedure

To classify how the longitudinal data for each of the tall individuals changed the evaluation level, in this study people who were judged to be tall in all years from the first grade of elementary school to the third year of junior high school were classified in the "Tall → Tall" group, those who were judged to be somewhat tall even one time were in the "Somewhat tall → Tall" group, those who were judged to be average even one time were in the "Average → Tall" group, those who were judged to be somewhat short even one time were in the "Somewhat short → Tall" group, and those who were judged to be short even one time were in the "Short → Tall" group.

Similarly, to classify how the longitudinal data for each short individual changed the evaluation level, in this study people who were judged to be short in all years from the first grade of elementary school to the third year of junior high school were classified in the "Short → Short" group, those who were somewhat short even one time were in the "Somewhat short → Short" group, those who were average even one time were in the "Average → Short" group, those who were somewhat tall even one time were in the "Somewhat tall → Short" group, and those who were tall even one time were in the "Tall → Short" group.

3. Results

3.1. Basic Statistics of Short and Tall People

Table 2 shows the number of people judged to be short and tall in this study, and the mean height for each age. First, the number of people judged to be of short height was 149 for males (mean height in the third year of junior high school: 150.31±1.77 cm) and 101 for females (mean height in the third year of junior high school: 143.67±1.37 cm). The number of people judged to be of tall height was 88 for males (mean height in the third year of junior high school: 179.27±1.46 cm) and 93 for females (mean height in the third year of junior high school: 168.52±1.73 cm).

3.2. Tracking Characteristics in Short Subjects

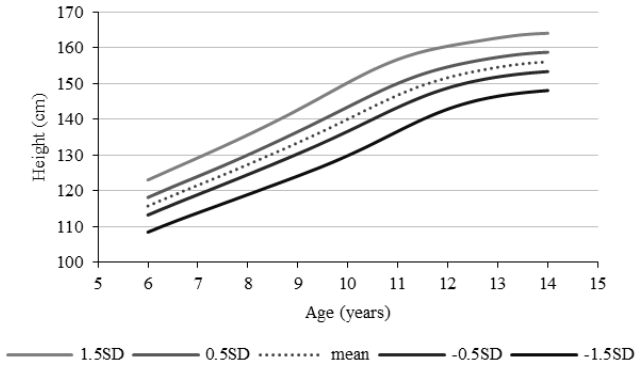

Figure 2. *Evaluation chart of longitudinal height growth in girls by wavelet smoothing method.*

In Figures 3 and 4, the longitudinal mean values at each age in the short group are fit onto the evaluation chart made in this study. From these figures, it is seen that both boys and girls tended to be in the somewhat short evaluation level from the first grade of elementary school to the third year of junior high school. However, although these are

longitudinal trends they are trends in the mean level, and so individual longitudinal trends need to be evaluated. We then analyzed the longitudinal tracking status for each individual, investigated the status of changes of the evaluation level in the evaluation chart, and showed the frequency distribution of the changes.

Figures 5 and 6 show the frequency distributions of changes in males and females. The results show that in males the "Short → Short" group accounted for 36.91% (55/149), the "Somewhat short → Short" group 51.68% (77/149), the "Average → Short" group 10.74% (16/149), the "Somewhat tall → Short" group 0.67% (1/149), and the "Tall → Short" group 0.00% (0/149). About 90% tracked in the range of heights shorter than Mean −0.5SD. In females, the "Short → Short" group accounted for 48.51% (49/101), the "Somewhat short → Short" group 38.61% (39/101), the "Average → Short" group 10.89% (11/101), the "Somewhat tall → Short" group 1.98% (2/101), and the "Tall → Short" group 0.00% (0/101). As in males, about 90% tracked in the range of heights shorter than Mean −0.5SD.

3.3. Tracking Characteristics in Tall Subjects

In Figures 7 and 8, as in the case of the short group, the longitudinal mean values at each age in the tall group are fit onto the evaluation chart made in this study. From these figures, it is seen that both boys and girls tended to be in the somewhat tall evaluation band from the first grade of elementary school to the third year of junior high school. With regard to these findings, similar to the short group, although these are longitudinal trends they are trends in the mean level, and so individual longitudinal trends need to be evaluated. We then analyzed the longitudinal tracking status for each individual, investigated the status of changes of the evaluation level in the evaluation chart, and showed the frequency distribution of the changes.

Figures 9 and 10 show the frequency distribution of changes for males and females. The results show that in males the "Tall → Tall" group accounted for 61.36% (54/88), the "Somewhat tall → Tall" group 32.95% (29/88), the "Average → Tall" group 4.55% (4/88), the "Somewhat short → Tall" group 1.14% (1/88), and the "Short → Tall" group 0.00% (0/88). About 90% tracked in the range of heights taller than Mean +0.5SD. In females, the "Tall → Tall" group accounted for 30.11% (28/93), the "Somewhat tall → Tall" group 49.46% (46/93), the "Average → Tall" group 16.13% (15/93), the "Somewhat short → Tall" group 4.30% (4/93), and the "Short → Tall" group 0.00% (0/93). About 80% tracked in the range of heights taller than Mean +0.5SD.

Table 2. *Mean height and standard deviation of each age in tall and short height group.*

				Age (years)								
				6	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Short Height	Boys (N = 149)	Mean	cm	109.97	115.01	120.10	125.03	129.51	134.16	138.89	144.65	150.31
		SD		3.21	2.90	2.97	3.02	3.04	2.96	3.09	3.30	1.77
	Girls (N = 101)	Mean	cm	107.28	112.62	117.66	123.30	129.11	134.82	139.40	142.12	143.67
		SD		3.43	3.62	3.91	4.74	5.23	4.73	3.31	2.10	1.37
Tall Height	Boys (N = 88)	Mean	cm	125.90	132.43	138.90	144.92	150.82	158.65	167.70	174.95	179.27
		SD		3.53	3.51	3.61	3.69	3.73	4.27	4.46	2.82	1.46
	Girls (N = 93)	Mean	cm	122.96	129.52	135.72	142.12	149.00	156.59	162.81	166.50	168.52
		SD		3.71	3.33	3.52	3.78	4.52	4.32	3.00	1.90	1.73

N: Number of people, SD: Standard Deviation.

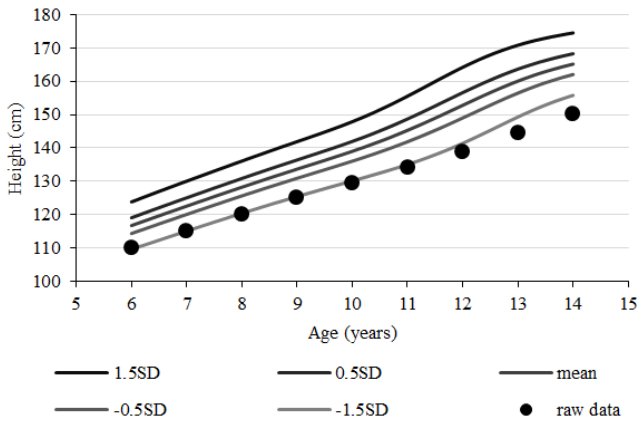

Figure 3. *Tracking status of short height group in boys.*

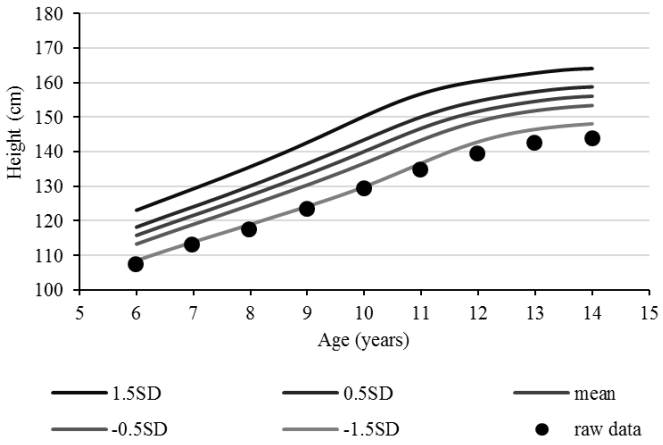

Figure 4. *Tracking status of short height group in girls.*

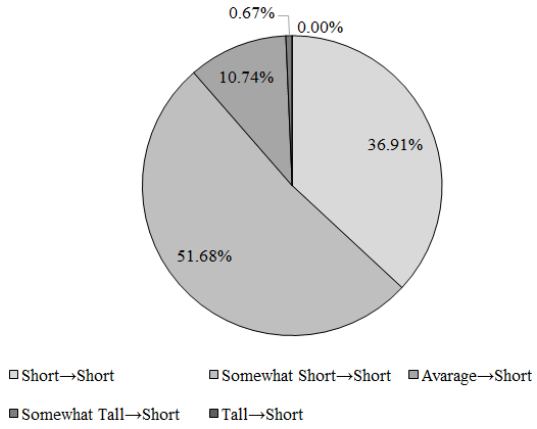

Figure 5. *Percentage of tracking status for each group in short height boys.*

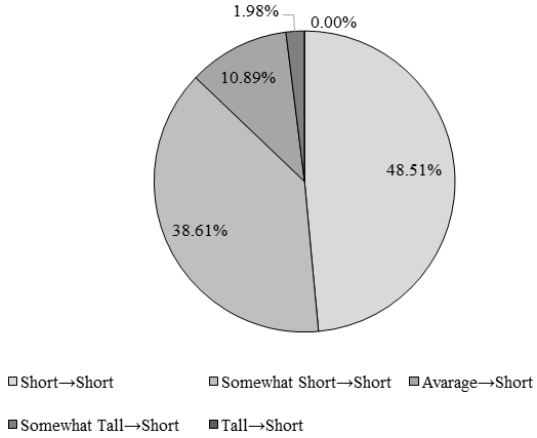

Figure 6. *Percentage of tracking status for each group in short height girls.*

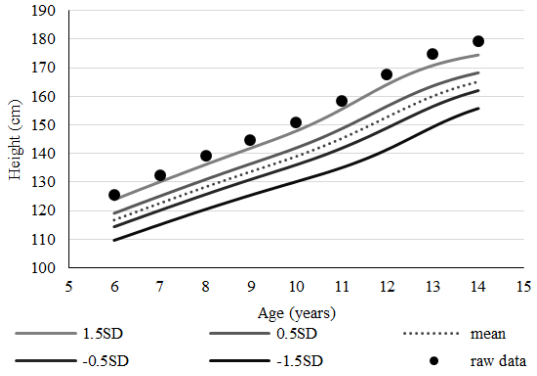

Figure 7. *Tracking status of tall height group in boys.*

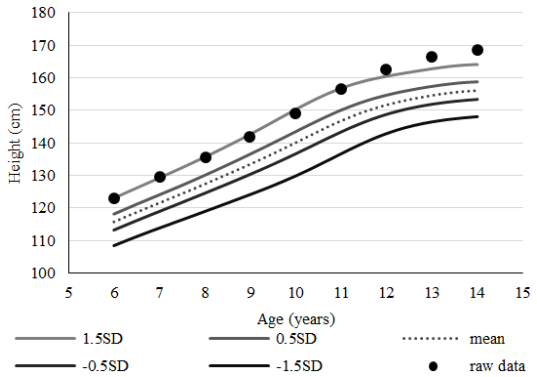

Figure 8. *Tracking status of tall height group in girls.*

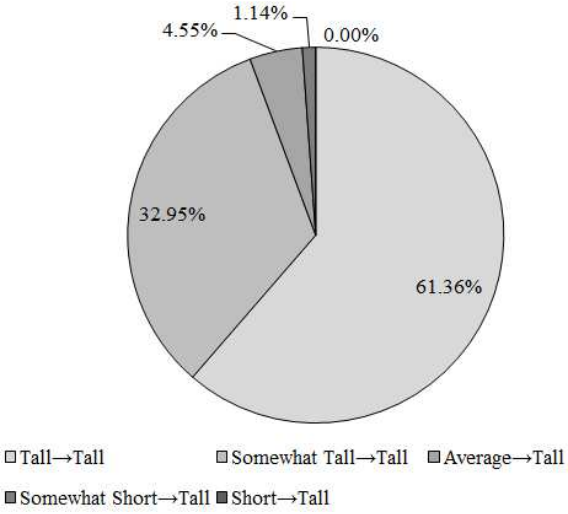

Figure 9. *Percentage of tracking status for each group in tall height boys.*

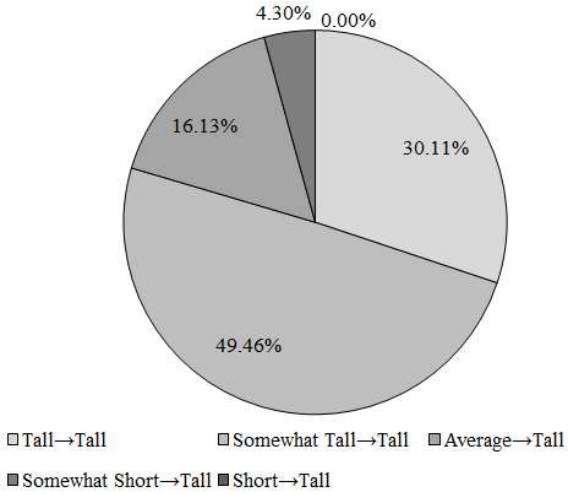

Figure 10. *Percentage of tracking status for each group in tall height girls.*

4. Discussion

This study explored the point of contact with sports talent identification by analyzing the tracking status of height using the wavelet interpolation model and verifying the change process in height rankings with changes in age. The results were that those who moved within the "Short" evaluation level and those who were evaluated as "Somewhat short" even once up to the third year of junior high school and afterward transitioned to "Short" accounted together for 132 of 149 males (88.59%) and 88 of 101 females (87.12%). The results of a verification of tall height tracking were that those who moved within the "Tall" evaluation level and those who were evaluated as "Somewhat tall" even once up to the third year of junior high school, and afterward transitioned to "Tall" accounted together for 83 of 88 males (94.31%) and 74 of 93 females (79.57%).

Takahashi et al. [14] investigated the changes with age in height ranking with longitudinal height growth data from 6 to 19 years old in 163 male students. They reported that of those judged to be of short height in the first grade of elementary

school, 57.6% were judged to be of short height even in the third year of junior high school, and the those judged to be of tall height in the first grade of elementary school, 51.5% were judged to be of tall height even in the third year of junior high school. Muramatsu et al. [15] divided height rank into a large group, middle group, and small group by the percentile method, and analyzed the changes in height rank with age. They reported that in both the first grade of elementary school and the third year of junior high school, the percentage judged to be in the small group was 77.7% in males and 75.5% in females. The percentage judged to be in the large group was 70.3% in males and 66.1% in females. Although a comprehensive comparison with these earlier studies cannot be made, the significance of constructing a span evaluation chart for height with age using the wavelet interpolation model, and clarifying the tracking of height ranks based on the establishment of this chart in this study, is that the findings from earlier studies were verified. In other words, individuals ranked as short or tall moved within those ranks without change until adulthood. This finding suggests a strong effect for the contribution of heritability in height growth, similar to the heritability of height in twin studies.

From the findings in this study, it is thought that analyzing how inherited traits transition after birth is also important in discussing the heritability of height. For example, even among traits expressed after birth individual differences are seen at in a relatively early period. As also seen from the infant physical growth curves recorded in mother and child health handbooks, sex differences can be clearly judged from infancy, and children grow with those male-female differences unchanged. Even in people of the same sex, the rate of maturity, physical size, and level of athletic ability is expressed in the growth process after birth [16, 17]. In other words, it is thought that genetic traits developed not just in a single generation but between multiple generations are already carried by an individual at birth. Analyzing the expression process of these traits may also be considered a methodology that can verify heritability.

The longitudinal span evaluation chart for height with age constructed in this study evaluates height rank based on aging. Individual height ranking is therefore possible throughout the growth period and the expression status of the genetic trait of height can be grasped. If the individual difference of height differences moves together with age like sex differences, it is evidence that genetic factors have a large influence. Conversely, if these height differences do not follow the same lines, it would seem to suggest a greater influence from environmental factors after birth than from genetic factors. Considering this, demonstrating that people ranked as having short or tall height continue to track at the same level as in this study may be considered a finding that strongly suggests the heritability of height. While the heritability of height has been recognized previously [6], it can be said that this study clarified the fact that the individual difference of height differences is already expressed from the first grade of elementary school. The major significance of this study is thought to be that, by verifying the tracking phenomenon for height, it paradoxically revealed a potential methodology for discussing heritability.

By elucidating the tracking of height ranking, a logical system for the perspective of identifying sports talent based on the genetic contribution to height after birth could be seen in this study. Thus, if people with superior athletic ability and tall height could be identified from a very young age, it would lead to the identification of future talent in sports where height is an advantage. In sports where short height is an advantage, identifying individuals with superior athletic ability and short height would be beneficial. Therefore, a logical system for sports talent identification may have been established in this study by establishing a tracking analysis for tall and short height rank. In particular, tracking of short height may be a useful finding in the identification of talent in gymnastics.

In the future, it will be necessary to analyze not only the tracking status of height but also that of various motor fitness. So, based on the present study, it is important to build a system for effective sports talent identification.

5. Conclusion

In this study, by analyzing the tracking status in people of short and tall height and verifying the changes in the rank level with changes with age in height, we verified a logical system for the viewpoint of sports talent identification based on the genetic contribution to height after birth. The result was that the tracking of short and tall height ranking was clarified by establishing a span evaluation chart for height with age using the wavelet interpolation model. In other words, individuals ranked as having short or tall height moved within that rank without change until adulthood. This finding suggests a strong effect for the contribution of heritability in height growth, similar to the heritability of height in twin studies. The major significance of this study is thought to be that, by verifying the tracking phenomenon for height, it paradoxically revealed a potential methodology for discussing heritability.

By elucidating the tracking of height ranking, a logical system for the perspective of identifying sports talent based on the genetic contribution to height after birth could be seen in this study. Thus, if people with superior athletic ability and tall height could be identified from a very young age, it would lead to the identification of future talent in sports where height is an advantage. In sports where short height is an advantage, identifying individuals with superior athletic ability and short height would be beneficial. Therefore, a logical system for sports talent identification may have been established in this study by establishing a tracking analysis for tall and short height rank.

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