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Research Article

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Establishment of Physical Strength Evaluation Findings on Slim School Age Children: Analysis of Fifth Grade Primary School Students

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Abstract

Hypotheses on physical strength and athletic ability in people with slim body types have yet to be clearly proven. Certainly, several studies have been reported, but none have gone beyond the realm of speculation. This is due to the fact that an amount of data needed to statistically ensure conclusions on the slim body type have not been established. In this study we carefully the examined physique, physical strength and athletic ability over time obtained in a large-scale study conducted over seven years (2013 to 2019) in the Kansai region of Japan, and obtained measurement results for fifth grade elementary school students and second year junior high school students. Specifically, we applied the wavelet interpolation model to the trends over time in mean values and standard deviations for height, physical strength, and athletic ability (grip strength, repeated side jumps, sit and reach, sit-ups, 50 m run, standing long jump, 20 m shuttle run, and softball throw) in fifth grade boys and girls. We then constructed span evaluation charts. The height, physical strength, and athletic ability of fifth grade boys and girls judged from an aging span evaluation chart for BMI devised by Fujii [1] was then applied to this evaluation chart. The result was that the evaluation of physical strength and athletic ability in slim fifth grade elementary school students derived in this study clearly indicated that these students somewhat below average in grip strength and softball throw, which has not been reported from previous estimates. We submit that a physical strength and athletic ability evaluation in fifth grade boys and girls in elementary school with a slim body type has been established in this study.

Keywords: Slim type, Physical strength, Span evaluation chart, Wavelet interpolation model

1. Introduction

There has been a very large number of studies on obesity over the years, but studies on physical abilities in obesity and on slim body types, or studies on physical abilities in slim body types, are admittedly rare. One reason for the small number of studies on slimness is that, compared with obesity, the risk of disease is smaller [2]. At the same time, it is reported that the relative risk of mortality is about two-fold in males and females with a BMI of 18.5 or less, which is classified as underweight, or slimness, from the relationship between BMI and mortality [3]. Incidentally, the relative risk of mortality is about three-fold in people with a BMI of 30 or higher. Thus, similar to obesity, slimness also has a mortality risk, and research findings equal to or above those for obesity are desired. However, there is a tendency for slimness to be more welcome in the society than obesity from a sense of aesthetics. Takimoto et al. [4] reported that from a young age girls have a desire to be slim, and tend to see their own body type as fat, with the desire to become slimmer reaching 94% in high school girls. Kajiwara et al. [5] reported that 97.8% of female university students had a desire to be slim, and that no change or improvement was seen compared with the results of a similar survey conducted ten years earlier by Shiraishi et al. [6]. Kajiwara et al. [5] and Shiraishi et al. [6] reported that girls' desire to be slim increases from the late elementary school years, and that when they reach university they attempt diets that include such things as dietary restrictions, supplements, strength training, and aerobic exercise.

In recent years, young people who appear in the media propagate the myth that slimness is an absolute aesthetic sense. This can be said without exaggeration to be a form of social pressure. Pipher [7] said that women think they are fat because the ideal body weight has been set in a narrow range by society, and that for young women the ideal height is 170 cm and the ideal weight is 53 kg. Shell [8] stated that capitalism itself affirms a slim body type and that obesity is unacceptable in industrial societies constantly seeking greater efficiencies.

In a culture that emphasizes appearance in capitalist economies, obesity has been considered an element that should be eliminated. Ironically, in the USA, which has become one of the most obese nations in the world with its abundance of fast food, commercial interests and government policy have been linked through the provision of diet foods and supplements to reduce that obesity. Thus, both obesity and slimness are distortions of human wisdom.

Here, while disease from obesity is widely known, there are also diseases from slimness, including decreased body temperature (sensitivity to cold), muscular atrophy, low blood pressure, decreased basal metabolism, hypoglycemia, general malaise, fatigability and anemia, decreased immune function, dehydration, osteoporosis, and menstrual disorders in women. These negative aspects of slimness must not be overlooked.

In this way, similar to obesity, slimness also contains many problems that need to be resolved. However, compared with studies on obesity, there are far fewer findings on slimness. In the small number of studies that do exist, the following findings have been reported with regard to height growth in slim people. Tokumura et al. [9] showed that until puberty height is similarly tall to that in obesity, but suggested that one factor is that not only simple slimness but also the symptomatic slimness of Marfan syndrome is included. Therefore, the factors for tall height in slimness are unclear. In addition, Fujii et al. [10] investigated the development of athletic ability in slim people and showed that compared with the middle type (standard body type), height growth in both boys and girls with a slim body type was no different from that of the middle type until puberty, and that athletic ability was not as inferior as that in the obese type. However, that analysis had limitations since it dealt with longitudinal data until the third year of junior high school. In any case, much is unknown about physical growth and development in slim people. Moreover, many things about physical abilities in slim people are also unknown.

In fact, there are almost no studies on the physical abilities (physical strength and athletic ability) of slim people. As mentioned above, the relationship with disease and the employment risk in the workplace are not as strong as with obesity, and so academic interest in slimness is lacking. However, if slimness is taken to be the opposite of obesity, the body type balance risk and the mortality risk are also shown to be high. Such risks may be said to be affected by the physical problems inherent to slimness. Therefore, if a physical ability evaluation for slimness could be clearly established, the risks associated with being slim could perhaps be avoided. In attempting to clarify the physical abilities of slim people, an amount of data on slim people that can ensure statistical significance needs to be obtained.

Given the above, in this study we closely examined physique, physical strength, and athletic ability over time obtained in a large-scale survey spanning seven years in the Kansai region of Japan, and used the measurement results for fifth grade elementary school students and second year junior high school students. Next, we constructed a span evaluation chart of physical strength and athletic ability from the measurement results for fifth grade elementary school students and second year junior high school students. Specifically, in this study we identified slim children from determination of BMI in fifth grade boys and girls. The physical abilities of slim children were applied to the span evaluation chart, and the physical abilities of these children were evaluated over time. This led to confirmation for the findings of each of the abilities that were derived from the physical ability evaluation. The data obtained in this study were measured in elementary and junior high schools in the Kansai region of Japan, and so a huge volume of data was ensured. In this sense, the findings from the physical ability evaluation of slim children derived here differ from previously estimated findings, and validated findings are provided.

2. Methods

2.1 Subjects and Materials

The subject data were measurements of physique, physical strength, and athletic ability conducted from 2013 to 2019 in fifth grade elementary school and second year junior high school boys and girls in the Kansai region of Japan. Data on fifth grade boys and girls from the results of a Survey of Physical Fitness and Athletic Ability published by the Ministry of Education, Culture, Sports, Science and Technology for that same period were used. The measured items were physique items (height, weight, BMI) and physical fitness items (grip strength, repeated side jumps, sit and reach, sit-ups, endurance running, 50 m run, standing long jump, 20 m shuttle run, and softball throw).

2.2 Construction of Span Evaluation Chart

Means and standard deviations were calculated from the results of physical strength and athletic ability tests of fifth grade boys and girls from the 2013 to 2019 school years, and the wavelet interpolation model was applied to the mean value for each measurement. The wavelet interpolation model was then applied to the mean ± 0.5 SD and mean ± 1.5 SD. Figure 1 shows the trends in height over time to which the wavelet interpolation model was applied, and is also an evaluation chart of the span over time. As is clear from looking at the trend over time in mean height, it tends to be under 140 cm. Tall boys trend around 148 cm, while short boys trend at just below 130 cm. This kind of span evaluation chart was constructed for each item of physical strength and athletic ability.

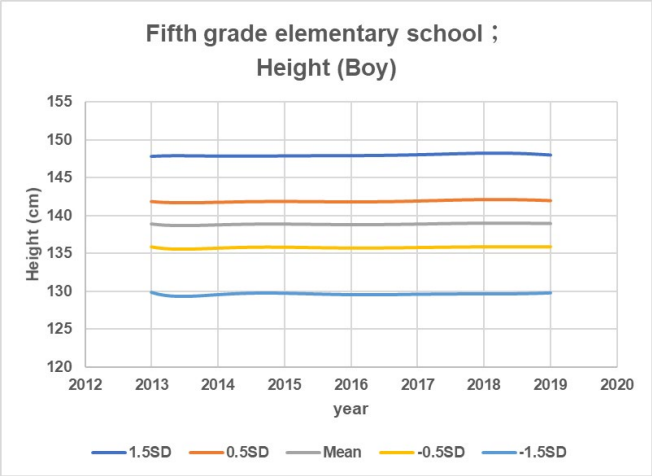

Figure 1: Span evaluation chart for height in fifth grade boys

2.3 Identifying Slim Children

In adults, it is acceptable to define slimness as a BMI of 17 or lower, but the criterion for adults cannot be fit to slimness in fifth grade elementary school students. Fujii [1] constructed an aging span evaluation chart of BMI in findings that verified the tracking of obesity into adulthood, and we applied this evaluation chart to identify slim fifth grade students. Figure 2 is an evaluation chart to determine which children are slim, but mean BMI in fifth grade students was about 18 and if we attempt to determine slimness we can judge slim students to be those in a range exceeding +1.5 SD. However, if we consider ensuring the necessary amount of data for slim children, it would be difficult to ensure that amount if BMI were to be set at 13and under. Therefore, we set BMI for this at 14and under. The criterion for slimness in fifth grade elementary school students in this study was thus set at 14 and under.

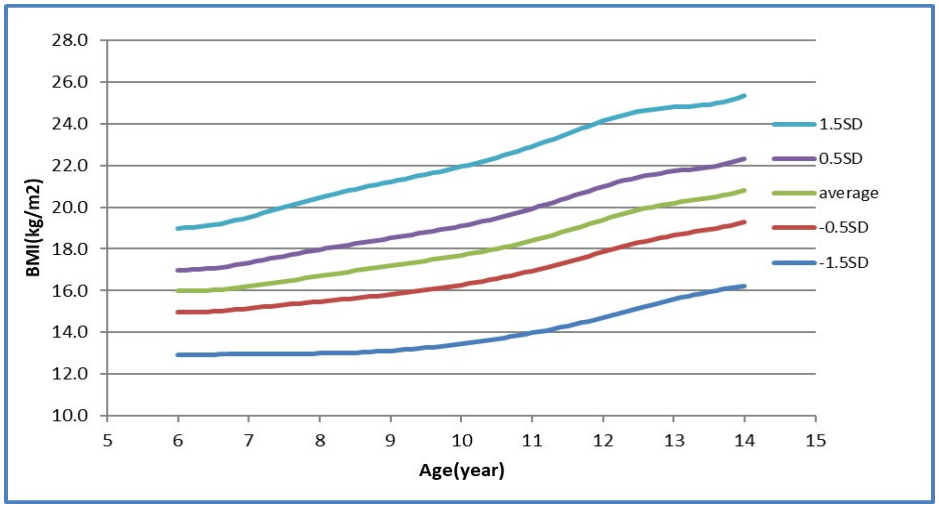

Figure 2: Obesity determination chart based on changes with age in BMI

2.4 Wavelet Interpolation Model

The wavelet interpolation method (WIM) is a method of examining growth distance values at times such as the pubertal peak or the age of menarche. Interpolation with a wavelet function (the basis function is Meyer's mother wavelet) is done between data to approximately describe the true growth curve from given growth data, a growth distance curve is drawn, and that drawn distance curve is differentiated to derive a growth velocity curve. A feature of the wavelet interpolation method is that local phenomena are sensitively read, and it has a very high approximation accuracy. The detailed theoretical background and basis of its efficacy have been described in previous studies by Fujii [10-12], and so the data analysis algorithm with the wavelet interpolation method will be omitted here.

3. Results

3.1 Statistics Over Time for Height and Physical Ability in Slim People

A one-way analysis of variance was performed for the height and physical ability items of slim people shown in Table 1 from 2013 to 2019. No significant differences were seen in any of the items. This shows that there were no changes in the physical abilities of

slim people over seven recent years. Since there were no changes in the physical abilities of fifth grade elementary school students over these seven recent years, we considered constructing a span evaluation chart of physical strength and athletic ability not for single years but for the seven year span. We attempted to grasp the recent physical abilities of slim school age children (fifth year of elementary school) by devising this span evaluation chart. We constructed the span evaluation chart for the physical ability items of grip strength, repeated side jumps, sit and reach, sit-ups, 50 m run, standing long jump, 20 m shuttle run, and softball throw, and applied each physical ability of slim people to that evaluation chart.

Fifthgrade elementary school; slim boys		Height (cm)	Weight (kg)	Grip strength (kg)	Sit-ups (times)	Sit and reach test (cm)	Repeated side jump (times)	20m shuttle run (times)	50m run (second)	Standing long jump (cm)	Soft-ball Throwing (m)
2013	Mean	135.2	24.9	13.2	17.2	29.6	36.8	50.5	9.5	148.3	19.2
(N=188)	SD	5.16	1.98	2.74	5.30	8.34	7.73	18.90	0.75	21.61	7.01
2014	Mean	135.9	25.0	13.4	17.1	29.8	38.3	49.0	9.5	146.9	18.8
(N=230)	SD	5.84	2.21	2.58	5.95	6.89	8.17	19.44	0.98	20.94	6.60
2015	Mean	135.9	25.2	13.6	13.6	17.1	30.8	37.9	50.4	9.5	146.9
(N=167)	SD	5.27	2.00	0.32	2.98	6.46	6.78	7.73	18.81	0.89	21.59
2016	Mean	135.8	25.1	13.6	14.0	18.3	31.1	39.1	52.1	9.4	146.8
(N=198)	SD	5.59	2.10	0.41	2.93	5.91	7.62	8.35	19.27	0.75	21.56
2017	Mean	136.5	25.2	13.5	13.5	17.0	30.8	37.6	48.3	9.6	147.2
(N=229)	SD	5.40	2.11	0.48	3.00	6.07	7.39	8.13	18.77	1.05	20.43
2018	Mean	136.7	25.4	13.6	13.6	17.9	31.3	38.7	49.9	9.5	149.0
(N=212)	SD	5.66	2.17	0.36	3.21	5.44	8.05	8.98	18.76	0.94	22.36
2019	Mean	136.6	25.2	13.5	13.5	17.9	30.3	38.6	50.5	9.4	148.4
(N=226)	SD	6.01	2.29	0.49	2.82	5.94	8.22	8.22	19.45	0.84	22.04

Table 1: Statistics over time for physique and physical strength of slim fifth grade students

3.2 Application of Span Evaluation Chart to Physical Ability Items of Young People

The height trend for slim fifth grade boys followed a somewhat short evaluation line even though it was in the standard range (Figure 3). In girls, however, a somewhat short evaluation is probably valid (Figure 4). For the physical items of slim children, first both fifth grade boys and girls showed a grip strength trend over time of near 14, which made clear that they were in the somewhat low assessment band and grip strength was determined to be somewhat low (Figures 5, 6). In sit-ups, fifth grade boys showed a trend over time for about 16 sit-ups, which was in the standard range, and in sit-ups they were judged to be standard. Fifth grade girls showed a trend over time for about 16 sit-ups, which was in the standard range, and in sit-ups they were judged to be standard (Figures. 7, 8). In the sit and reach, fifth grade boys showed a trend over time for around 30 cm, which was in the standard range, and in the sit and reach they were judged to be standard. Fifth grade girls showed a trend over time for around 35 cm, which was in the standard range, and in the sit and reach they were judged to be standard (Fig. 9, 10). In the repeated side jumps, both fifth grade boys and girls showed a trend over time for about 37 jumps, which was in the standard range, and in repeated side jumps they were judged to be standard (Figures. 11, 12). In the 50 m run, fifth grade boys and girls showed a trend over time for about 9.5 sec, which was in the standard range, and in the 50 m run they were judged to be standard (Figures. 13, 14). In the 20 m shuttle run, fifth grade boys showed a trend over time for around 50 times, which was in the standard range, and in the 20 m shuttle run they were judged to be standard. Fifth grade girls showed a trend over time for around 40 times, which was in the standard range, and in the 20 m shuttle run they were judged to be standard (Figures. 15, 16). In the standing long jump, fifth grade boys showed a trend over time for around 150 cm, which was in the standard range, and in the standing long jump they were judged to be standard. Fifth grade girls showed a trend over time of around 140 cm, which was in the standard range, and in the standing long jump they were judged to be standard (Figures. 17, 18). In the softball throw, fifth grade boys showed a trend over time for around 18 m, which was in the somewhat short evaluation range, and in the softball throw they judged to be somewhat below average. Fifth grade girls showed a trend over time for around 12 m, which was in the standard range, and in the softball throw they judged to be standard (Figures. 19, 20). Finally, it is worth noting that in the softball throw both boys and girls showed a decreasing trend over time. This shows that even in slim children, there has been a clear decline in throwing ability in recent years.

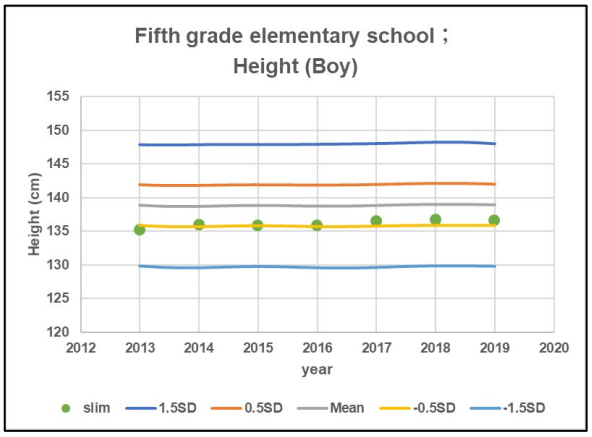

Figure 3: Application to span evaluation chart in slim fifth grade boys (height)

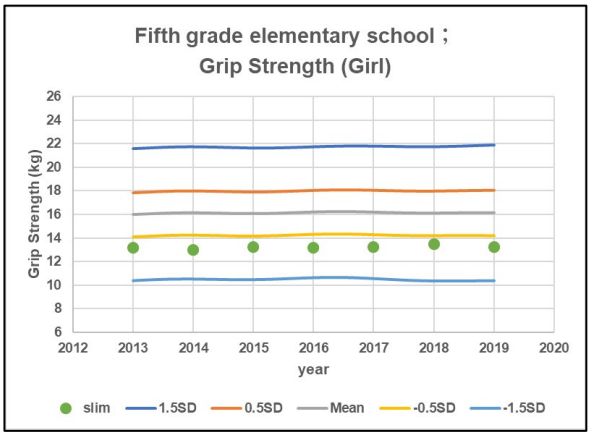

Figure 6: Application to span evaluation chart in slim fifth grade girls (grip strength)

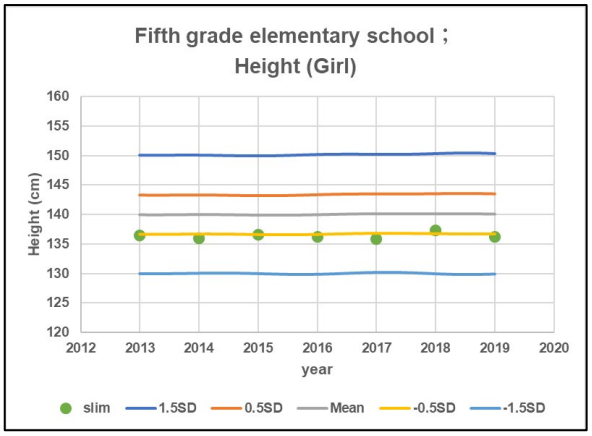

Figure 4: Application to span evaluation chart in slim fifth grade girls (height)

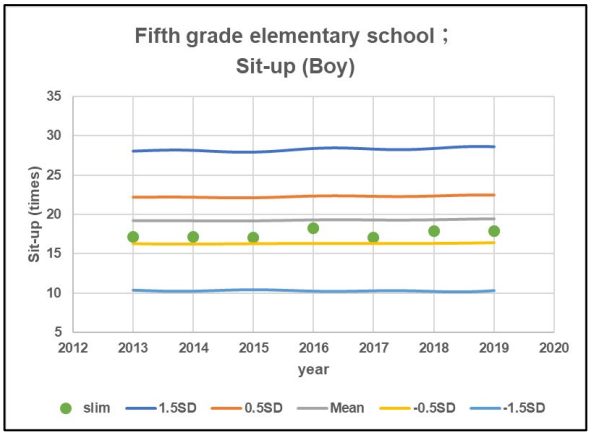

Figure 7: Application to span evaluation chart in slim fifth grade boys (sit-ups)

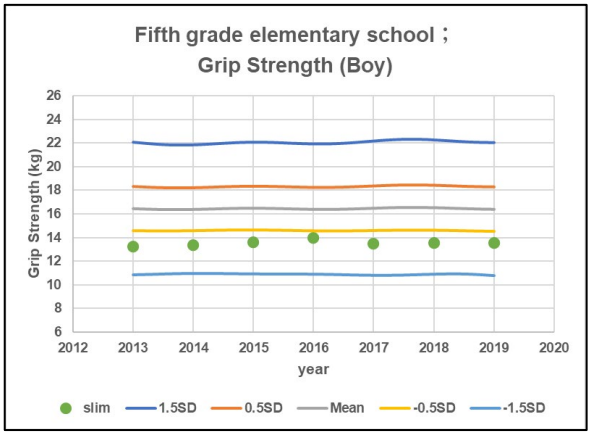

Figure 5: Application to span evaluation chart in slim fifth grade boys (grip strength)

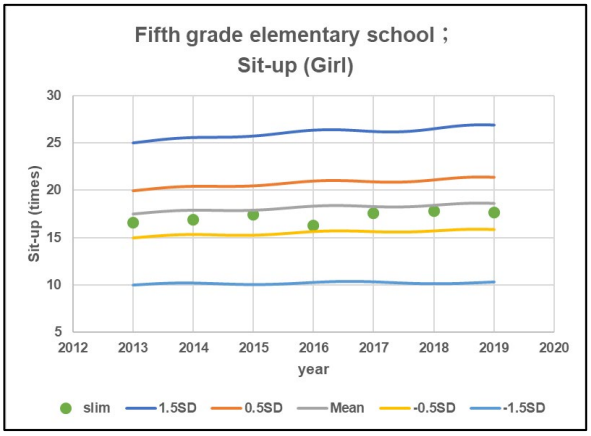

Figure 8: Application to span evaluation chart in slim fifth grade girls (sit-ups)

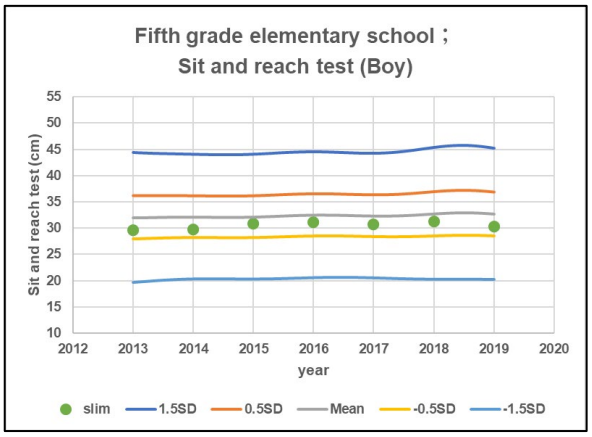

Figure 9: Application to span evaluation chart in slim fifth grade boys (sit and reach)

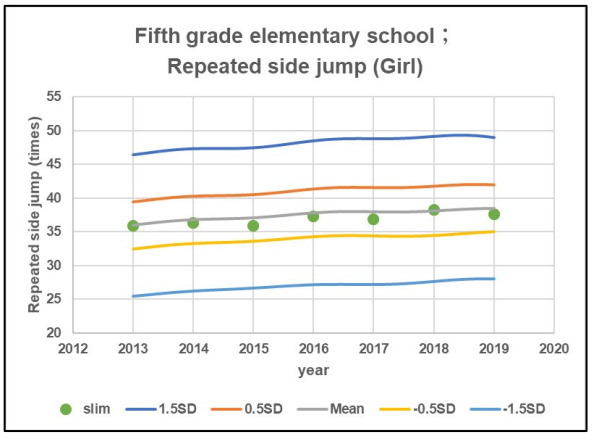

Figure 12: Application to span evaluation chart in slim fifth grade girls (repeated side jumps)

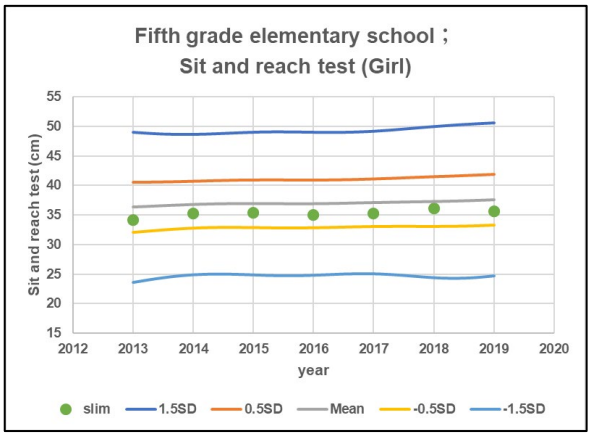

Figure 10: Application to span evaluation chart in slim fifth grade girls (sit and reach)

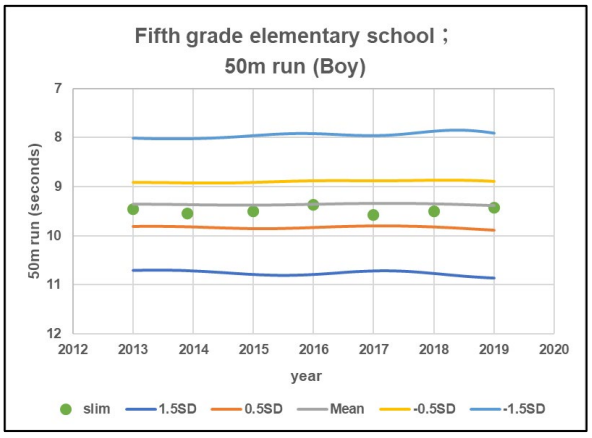

Figure 13: Application to span evaluation chart in slim fifth grade boys (50 m run)

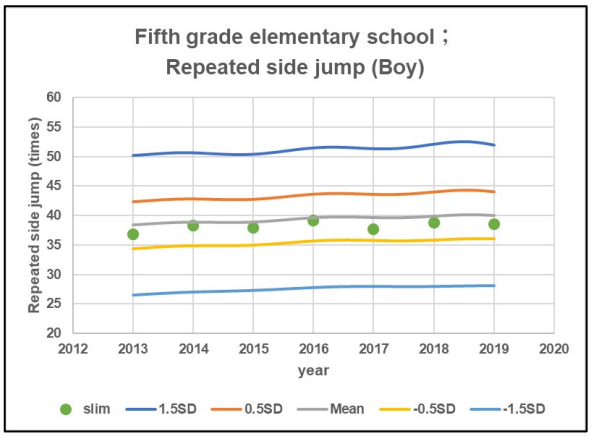

Figure 11: Application to span evaluation chart in slim fifth grade boys (repeated side jumps)

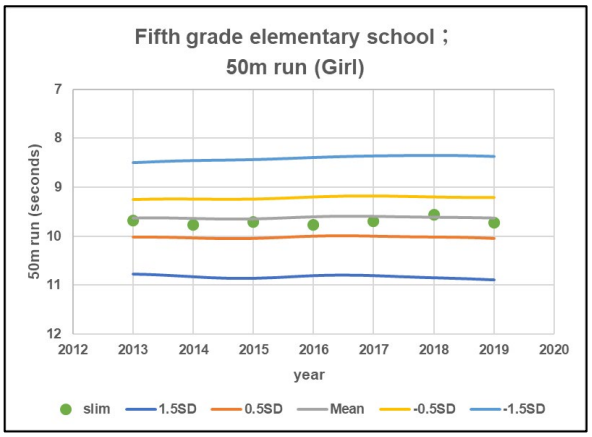

Figure 14: Application to span evaluation chart in slim fifth grade girls (50 m run)

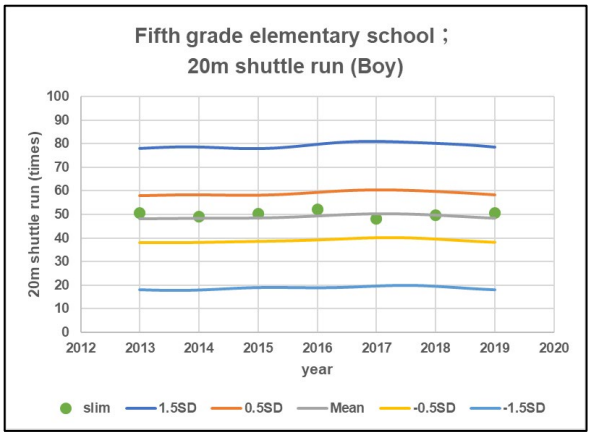

Figure 15: Application to span evaluation chart in slim fifth grade boys (20 m shuttle run)

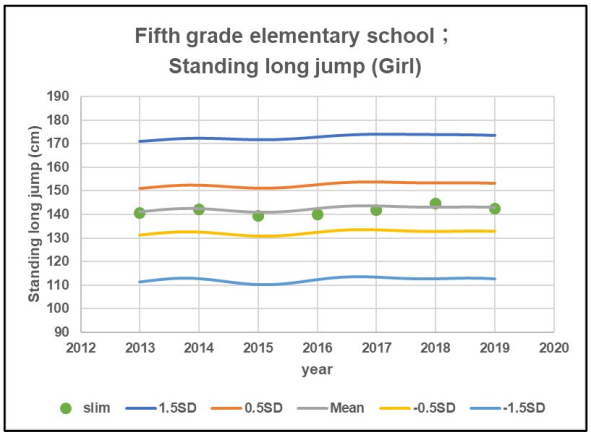

Figure 18: Application to span evaluation chart in slim fifth grade girls (standing long jump)

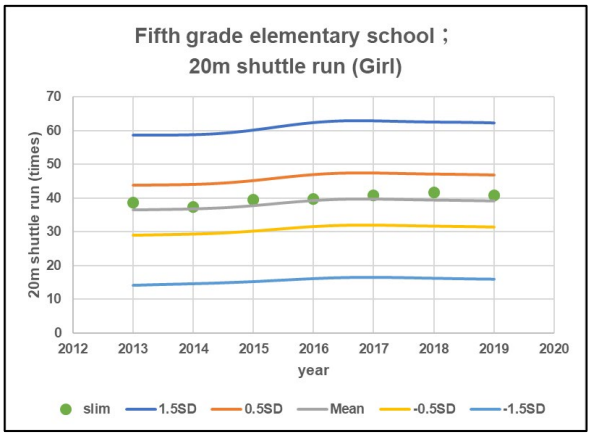

Figure 16: Application to span evaluation chart in slim fifth grade girls (20 m shuttle run)

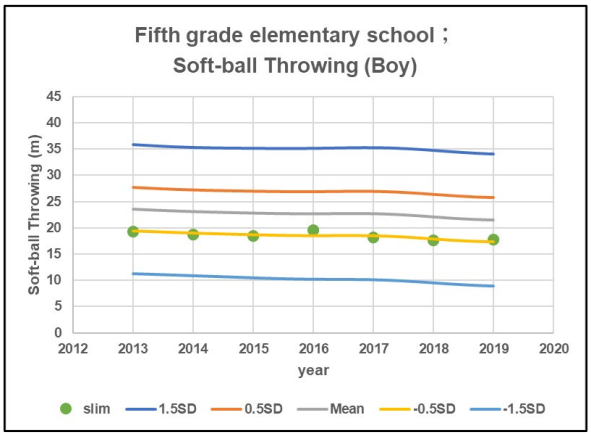

Figure 19: Application to span evaluation chart in slim fifth grade boys (softball throw)

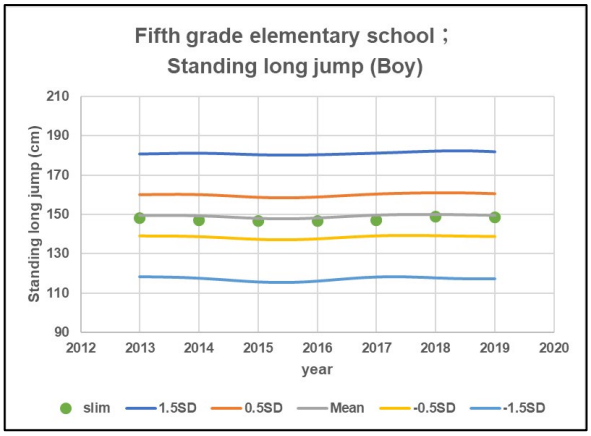

Figure 17: Application to span evaluation chart in slim fifth grade boys (standing long jump)

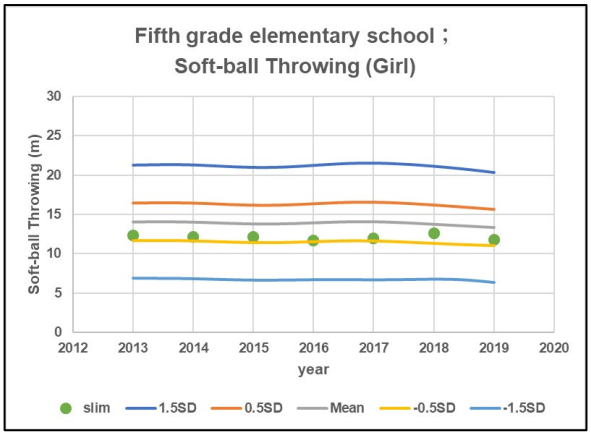

Figure 20: Application to span evaluation chart in slim fifth grade girls (softball throw)

4. Discussion

The reason there is not as much research on slimness as there is on obesity is thought to be because the relationship of slimness to disease is not as deep as it is with obesity. For the mortality rate, for example, BMI of 22 is the minimum and the mortality risk becomes higher with BMI below 22 in the direction of slimness. However, it is clear that this is not as much as with obesity. In the findings of Fujii et al. [10], the only study to have examined physical strength in slim school age children, it was shown that there is not such a big difference between slim children and standard weight children in physical strength and athletic ability. However, since there is little data on slim children in previous

studies, a physical ability evaluation of slim children has not been clearly established. In this study, we succeeded in obtaining a large volume of measurements of physique, physical strength, and athletic ability in children in the Kansai region of Japan. Specifically, since the data handled in this study were longitudinal data over seven years, we were able to construct a span evaluation chart using the wavelet interpolation model rather than evaluation charts for single years. This evaluation is an evaluation chart that considers the trends over time, and is thought to be the best for assessing physical abilities (physical strength and athletic ability) in recent years.

When constructing a span evaluation chart, one important thing is the creation of the evaluation lines that differentiate the evaluation bands. A previous analysis method devised by Fujii [13] applied least squares polynomials for trends over time, but it had the problem of not passing through the observation points. While it was adequate to view simple trends, this study looks at the relatively short period of seven years, and so we applied the wavelet interpolation model, which can pass through observation points, rather than apply least squares approximation. The reason for applying the wavelet interpolation model is that it is a mathematical function that has the feature of not depending on degree; that is, the linear trend of first-degree functions or the simple upwardly increasing trend of second-degree functions. Thus, when attempting to understand the changing trends over time in physical abilities, they can be understood as a model of the true changes over time that does not depend on the degree of the polynomial. Fujii [12] has explained the effectiveness of this wavelet interpolation model.

In this study, the wavelet interpolation model was applied to trends over time in height, physical strength, and athletic ability in fifth grade elementary school boys and girls. The wavelet interpolation model was applied to the reference value of a 5-step evaluation from the mean value and standard deviation for height, physical strength, and athletic ability in each school year, and a span evaluation chart was constructed. The height, physical strength and athletic ability (grip strength, repeated side jumps, sit and reach, sit-ups, 50 m run, standing long jump, 20 m shuttle run, and softball throw) of slim fifth grade boys and girls determined by the aging span evaluation chart for BMI devised by Fujii [1] was applied to this evaluation chart. As a result, the height of these slim students was judged to be “standard (somewhat short)” for boys and “somewhat short” for girls. Among physical strength and athletic ability, sit-ups, sit and reach, repeated side jumps, 20 m shuttle run, 50 m run, and standing long jump were judged to be “standard” for both boys and girls. Notably, grip strength was “somewhat low” for both boys and girls, and the softball throw was “somewhat low” for boys.

The evaluation of physical strength and athletic ability of slim fifth grade students derived in this study is not reported based on previous estimates, and clear judgments of “somewhat below average” were derived in grip strength and softball throw. These judgments may be important findings in understanding the physical strength and athletic ability of slim fifth grade elementary school students. We would like to suggest that an evaluation of physical strength and athletic ability of slim fifth grade elementary school students was established in this study.

5. Conclusion

In this study we closely examined physique, physical strength, and athletic ability over time, using data obtained in a large-scale study over seven years (from the 2013 to 2019 fiscal years) in the Kansai region of Japan, and used the measurement results for fifth grade elementary school students and the second year of junior high school. Specifically, the wavelet interpolation model was applied to the mean values and standard deviations for height, physical strength, and athletic ability in fifth grade boys and girls. The wavelet interpolation method was then applied to the standard values in 5-step evaluations from mean values and standard deviations of height and physical abilities in each school year, and a span evaluation chart was constructed. The height, physical strength and athletic ability (grip strength, repeated side jumps, sit and reach, sit-ups, 50 m run, standing long jump, 20 m shuttle run, and softball throw) of slim fifth grade boys and girls determined by the aging span evaluation chart for BMI devised by Fujii (2018) was applied to this evaluation chart. As a result, the height of these slim students was judged to be “standard (somewhat short)” for boys and “somewhat short” for girls. Among physical strength and athletic ability, sit-ups, sit and reach, repeated side jumps, 20 m shuttle run, 50 m run, and standing long jump were judged to be “standard” for both boys and girls. Notably, grip strength was “somewhat low” for both boys and girls, and the softball throw was “somewhat low” for boys. The evaluation of physical strength and athletic ability of slim fifth grade students derived in this study is not a report based on previous estimates, and clear judgments of “somewhat below average” were derived in grip strength and softball throw. We would suggest that an evaluation of physical strength and athletic ability of slim fifth grade elementary school students was established in this study.

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