Influences of Socioeconomic Status on Short Stature in Childhood

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Objectives: Short stature in childhood is defined to the cases in which the stature is below 3 percentiles of the standard value in accordance with that of those in the same age and gender group. The influence of the socioeconomic status on the short stature in childhood are analyzed.
Methods: 154 children from the community child center in a region of poor socioeconomic status and 78 children in normal socioeconomic status who visited the Busan Medical Center due to the issue of short stature were selected for examination and analysis.
Results: The prevalence rate of short stature at the community child center in 2 municipalities in Busan was confirmed to be 7.3%. In the comparison of the average growth parameters of poor socioeconomic status and normal socioeconomic status in the short stature group, there was no observation of significant difference in terms of the chronological age, midparental height, bone age, bone age/chronological age, height standard deviation score (SDS), body mass index(BMI) percentile and insulin like growth factor binding protein 3 (IGFBP3) SDS. In the short stature suspicious group, there was observation of significant difference in the averages of bone age, weight, BMI percentile , IGFBP3 and IGFBP3 SDS.
Conclusions: Although the prevalence rate of short stature in children belonging to the poor socioeconomic class was observed to be higher than the existing results, there was no significant difference in the growth parameters associated with the growth of the height from those of the children in normal socioeconomic status.

Key Words: Growth, Height, Short stature, Socioeconomic status

It has been reported that the growth of human beings is affected by a diverse range of factors including genetics, race, weight at the time of birth, hormone, nutrition and environment.[1,2] Although genetics is the most important factor as the decisive factor for the growth of height, it is also known that socioeconomic status and diseases also have influence. Globally, there had been increase in the average height of people by 1-3cm for every 10-year interval during the 20th century due mainly to improvement of the health, and advancement of environment and socioeconomic status of the children.[3-6] Although reports of socioeconomic difference affecting the growth of height have declined a lot in recent years, there have been reports that there are still influence.[5,7] Majority of children at the community child centers in Korea are the children of

families subjected to the payment of basic living subsidies under the medical classification, families of lower income class, families of social class in health insurance blind zone and, socially, families of single parent and multi-child family. Therefore, there is a report that the frequency of short stature is high for the children in the community child center since they belong to socioeconomically vulnerable medical class.[8] However, there is insignificant study on the influence of socioeconomic status on short stature and growth of height in Korea. Accordingly, we measured the growth parameters such as height, weight, body mass index (BMI), midparental height, bone age and insulin like growth factor binding protein 3 (IGFBP3) of children with short stature detected during health checkup at the community child center and children visiting the short stature clinic of the pediatrics and adolescents department to determine the effects of socioeconomic status on the height growth and the frequency of short stature through comparison of the forementioned 2 groups.

MATERIALS AND METHODS

Subjects

This was a retrospective study conducted following approval from public institutional review board. Pediatrics and Adolescents Department and Public Medical Service Department of Busan Medical Center executed health examination on 582 children at the community child center in 2 municipalities in Busan Metropolitan

City from January 1, 2014 to August 31, 2019. Among these children, a total of 154 children including 43 children with short stature who corresponds to below 3 percentile values of those in the same gender and age and 111 children who underwent examination at the short stature clinic of the pediatrics and adolescents department with suspicion of short stature by belonging to values from 3 percentile to 20 percentile were selected as the subjects of the study. At the same time, 78 children in the normal socioeconomic status who were treated for the diagnosis of short stature under the same aforementioned standards and due to the suspicion of short stature by belonging to values from 3 percentile to 20 percentile values at the Pediatrics and Adolescents Department of Busan Medical Center over the same period were put in the control group.

Methods

Same personnel training on the method of measuring the height of the children measured the height and weight of the subject children and Korean National Growth Chart of children in 2007 was used as the standard for computation of height percentile value while the Korean National Growth Chart for children in Korea in 2018 was applied as the standard for children born in 2019. X-ray was taken on the non-dominant wrist and hand to measure bone age with the TW3 (Tanner-Whitehouse 3) method as the standard. BMI was computed by using the formula, weight(kg)/[height(m)]^2. Percentile for BMI was computed by using the Korean National Growth Chart of children in 2007. Mid-

parental height SDS was calculated based on the data corresponding to the age of 18.0, which is nealy closet to adult height. Blood test was executed to measure IGFBP3. IGFBP3 standard deviation score (SDS) was computed by making reference to the reference values for children and adolescents of Korea in 2012.[9] The heights of children actually measured were compared by computing their SDS by dividing the value obtained by subtracting the average value of the height of children in the same age and gender from the actually measured height of each child by the standard deviation (SD).

SAS statistics program was used for statistical processing of data obtained. Wilcoxon/Mann-Whitney test (normal approximation two-sided) and two sample t-test were used to compare the average values while multiple logistic regression analysis was used for analysis of growth factor related analysis in accordance with low socioeconomic status. All statistically data are determined to be significant if the *P*-value is less than 0.05.

RESULTS

Characteristics of subject children and prevalence rate of short stature in children of low socioeconomic status

A total of 232 children were composed of 121 boys and 111 girls. Among these, there were 154 children from the community child center with poor socioeconomic status while 78 children were from normal socioeconomic status. There were 58 children with short stature belong to below 3 percentile values accounting for 25% of the total, while 174 children had suspicion of short stature belonging to values from 3 percentile to 20 percentile accounting for 75 % of the total. The average age of male and female on the subject children was 10.52 ± 2.83 years and 10.2 ± 2.55 years. The prevalence rate of short stature in childhood at the community child center in the 2 municipalities of Busan was confirmed to be 7.3% during the study period, which is substantially higher than the prevalence rates of 0.9% and 1.4% indicated in the Korean national growth chart of children in 2007 and 2017, respectively (Table 1) (Table 2) (Fig. 1).

Comparison of growth parameters in accordance with presence of short stature

Independent sample t-test was used for comparison of the average of the short stature group and short stature suspected group in all the subject children of the study. Short stature group displayed statistically significant lower height, height SDS, midparental height SDS, bone age, weight, BMI percentile and IGFBP3 (Table 3).

Comparison of growth parameters in accordance with the socioeconomic status

The proportion of children with short stature group among the children of poor scocioeconomic status was higher than that of normal socioeconomic status (27.9 % vs. 19.2 %). However, there was no significant difference in the chi-square test (*P*-value = 0.149). Wilcoxon/Mann-Whitney test (normal approximation two-sided)

Table 1. Clinical characteristics of subjects

Charaoteristios	Mean values	
	Male	Female
Total Patients (n)	121	111
Age (yr)	10.52 ± 2.83	10.20 ± 2.55
Bone age (yr)	10.59 ± 2.49	9.74 ± 2.32
Bone age/Chronologioal age	0.98 ± 0.11	0.91 ± 0.09
Midparental height (om)	170.8 ± 4.1	158.5 ± 3.58
Midparental height SDS	-0.3 ± 0.5	-0.3 ± 0.48
Height (om)	135.0 ± 15.54	133.0 ± 12.79
Height SDS	-0.81 ± 0.5	-0.7 ± 0.45
BMI (kg/m^2)	18.03 ± 3.19	16.84 ± 2.68
BMI peroentile (%)	42.71 ± 27.68	33.52 ± 24.41
IGFBP3 (ng/ml)	4347.26 ± 1063.8	4459.0 ± 975.8
IGFBP3 SDS	0.41 ± 0.29	0.36 ± 0.26

Data expressed means ± standard deviation
SDS, standard deviation score; BMI, body mass index; IGFBP3, insulin like growth factor binding protein 3
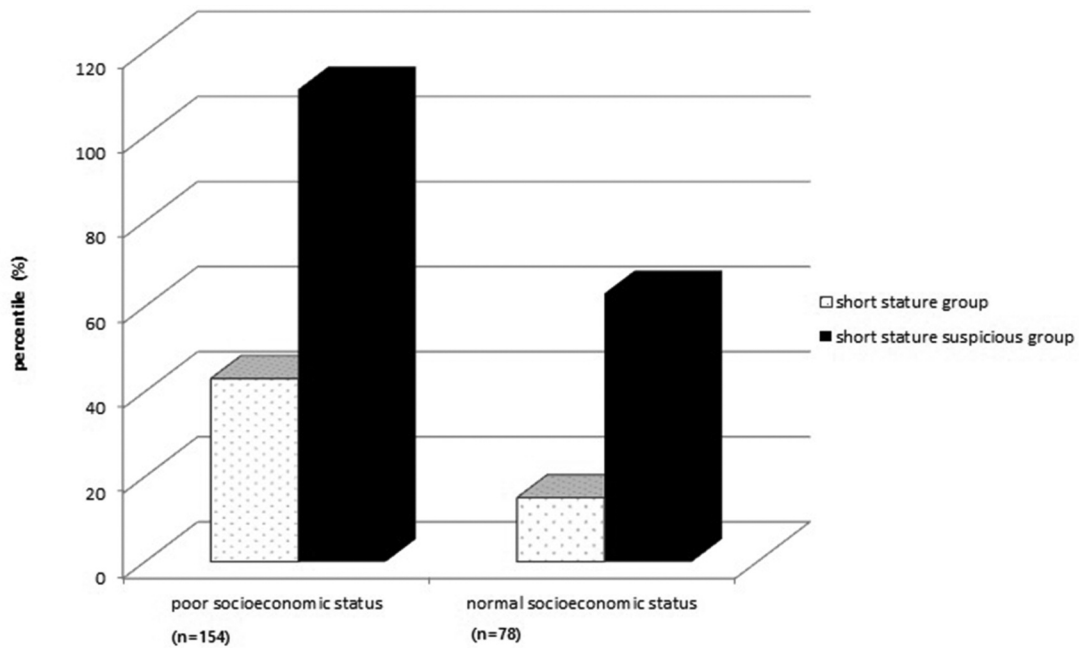
Table 2. Prevalence of short stature in low socioeconomic status children - comparison with Korean National Growth Charts

Short stature	Our result	KNGC2007	KNGC2017
Year	2014.1-2019.8	2007	2017
Age (yr)	5-17	2-18	2-18
Location	Busan (yeon-je gu, busan-jin gu)	Whole country	Whole country
Number/Total number	43/582	68/7606	106/7606
Prevalence rate	7.3%	0.9%	1.4%

KNGC, Korean National Growth Charts

was applied for the comparison of children with short stature between the children from poor socioeconomic status and children from normal socioeconomic status since the number of normal children is small, while independent sample t-test was applied for the children with suspicion of short stature. Children with short stature showed no difference in growth parameters in accordance with the socioeconomic status. In children with suspicion of short stature belonging to values from the 3 percentile to 20 percentile, significant differences in the averages of weight (32.5 ± 10.6 vs. 36.1 ± 12.9, $P = 0.045$), bone age (10.1 ± 2.3 vs. 10.9 ± 2.28, $P = 0.017$), bone age/chronological age (0.93 ± 0.1 vs. 0.99 ± 0.1, $P = 0.001$), BMI percentile (36.6 ± 24.2 vs. 47.3 ± 29.7, $P = 0.010$), IGFBP3 (4661.4 ± 914.7 vs. 4238.9 ± 989.4, $P = 0.005$) and IGFBP3 SDS (0.5 ± 0.2 vs. 0.3 ± 0.3, $P = 0.008$) were observed (Table 4) (Fig. 1).

Fig. 1. Comparison between short stature group and short stature suspicious group according to socioeconomic status (chi-square *P*-value = 0.149)

Table 3. Comparison of clinical characteristics between short stature group and suspicious short stature group

variable	Short stature children(n = 58)	Suspicious short stature children(n = 174)	*P*-value
Chronological age (yr)	10.5 ± 3.1	11 ± 2.5	0.248
Bone age (yr)	9.6 ± 2.7	10.38 ± 2.33	0.031
Bone age/Chronological age	0.93 ± 0.1	0.95 ± 0.1	0.310
Midparnetal height (cm)	164.6 ± 7.5	165.0 ± 7.2	0.728
MPH SDS	-0.42 ± 0.58	-0.27 ± 0.46	0.045
Height (cm)	126.8 ± 15.1	136.5 ± 13.2	0.000
Height SDS	-1.4 ± 0.4	-0.6 ± 0.3	0.000
Weight (kg)	28.4 ± 12.2	33.8 ± 11.6	0.003
BMI (kg/m^2)	16.9 ± 3.2	17.7 ± 2.9	0.089
BMI percentile	31.9 ± 24.9	40.5 ± 26.8	0.033
IGFBP3 (ng/mL)	4077.7 ± 1134	4508.5 ± 961.4	0.005
IGFBP3 SDS	0.3 ± 0.3	0.4 ± 0.3	0.051

Short stature, defined as height ≦ 3 percentile; Suspicious short stature children, defined as 3 percentile 〈 height ≦ 20 percentile
Data expressed means±standard deviation
MPH, midparental height; SDS, standard deviation score; BMI, body mass index; IGFBP3, insulin like growth factor binding protein 3

Multiple logistic regression analysis of factors associated with the diagnosis of short stature in accordance with the low socioeconomic status

Multiple logistic regression analysis was exe-cuted to confirm the growth parameters associ-ated with the diagnosis of short stature in accor-dance with the low socioeconomic status. As the results, it was observed that BMI persentile (odds

Table 4. Comparison of clinical characteristics between poor socioeconomic status group and normal socioeconomic status group (in short stature children and suspicious short stature children)

variable	Short stature children			Suspicious short stature children		
	low socioeconomic status group (n = 43)	Normal socioeconomic status group (n = 15)	P-value	low socioeconomic status group (n = 111)	Normal socioeconomic status group (n = 63)	P-value
CA (years)	10.6 ± 2.7	10.1 ± 4	0.704	10.9 ± 2.5	11.2 ± 2.5	0.361
BA (years)	9.5 ± 2.5	9.8 ± 3.2	0.972	10.1 ± 2.3	10.9 ± 2.26	0.017
BA/CA	0.9 ± 0.1	1 ± 0.2	0.084	0.93 ± 0.1	0.99 ± 0.1	0.001
MPH (cm)	164.1 ± 7.78	166.13 ± 6.84	0.397	164.32 ± 7.45	166.28 ± 6.6	0.086
MPH SDS	-0.43 ± 0.62	-0.38 ± 0.4	0.846	-0.27 ± 0.46	-0.26 ± 0.46	0.846
Height (cm)	127.14 ± 13.26	125.85 ± 19.97	0.764	135.15 ± 12.56	138.8 ± 14.1	0.080
Height SDS	-1.4 ± 0.5	-1.3 ± 0.2	0.633	-0.7 ± 0.3	-0.6 ± 0.4	0.080
Weight (kg)	28 ± 9.6	29.4 ± 18.2	0.566	32.5 ± 10.6	36.1 ± 12.9	0.045
BMI (kg/m²)	16.8 ± 2.7	17.3 ± 4.6	0.805	17.4 ± 2.8	18.1 ± 3.1	0.101
BMI percentile	29.7 ± 23.9	38.2 ± 27.3	0.253	36.6 ± 24.2	47.3 ± 29.7	0.010
IGFBP3	4176.1 ± 1047.5	3795.9 ± 1352.7	0.307	4661.4 ± 914.7	4238.9 ± 989.4	0.005
IGFBP3 SDS	0.3 ± 0.3	0.3 ± 0.4	0.602	0.5 ± 0.2	0.3 ± 0.3	0.008

Suspicious short stature children, defined as 3 percentile 〈 height ≦ 20 percentile
Data expressed means ± standard deviation
MPH, midparental height; SDS, standard deviation score; BMI, body mass index; IGFBP3, insulin like growth factor binding protein 3

ratio, 0.982; 95% confidence interval, 0.97-0.995; $P = 0.005$), IGFBP3 (odds ratio, 1.001; 95% confidence interval, 1-1.001; $P = 0.0002$) and bone age/chronological age (odds ratio, 0.005; 95% confidence interval, < 0.001 - 0.118; $P = 0.001$) are associated with the possibility that all the subjected children would have low socioeconomic status (Table 5).

DISCUSSION

Although the height growth of child is generally determined genetically, it is also known to be influenced substantially by the daily life environment during early childhood. Factors that affect growth include nutrition, disease, psychosocial stress, residential conditions and physical damages during childhood that are difficult to bear with.[3,10,11] Such socioeconomic inequalities in height growth are observed consistently within variously different environments and there is the tendency of the finally predicted height becoming even smaller depending on the extent of the environmental damages confronted with such as malnutrition or aggravation of health by children with socioeconomic disadvantages. Final predictable height reflects not only genetic possibilities but also the daily life status during childhood.[3,5] In spite of the improvement in the standard of living and general increase in the height, there is a trend of children with poorer background displaying slower height growth and it is known that the difference in height continues

Table 5. Stepwise multivariate logistic analysis of factors associated with poor socioeconomic status

variable	P-value	Odd ratio (95%CI)
BMI percentile	0.005	0.982(0.97 - 0.995)
IGFBP3	0.0002	1.001(1 - 1.001)
Bone age/Chronological age	0.001	0.004(< 0.001 - 0.118)
Midparental SDS	0.684	0.872(0.45 - 1.68)
Height SDS	0.564	0.768(0.314 - 1.87)
short stature group vs. suspicious short stature group	0.498	1.396(0.533 - 3.657)

BMI, body mass index; SDS, standard deviation score

due to socioeconomic inequality.[12] In the researches that have been reported thus far, the effects of environmental factors on the height growth is decreasing in the recent years and similar research results are being reported for various other population groups. It is asserted that this is due to improvement in the socioeconomic situation.[13-15] Therefore, it is claimed that the correlation between the socioeconomic status and height growth of children is weakening and the social inequality in height is increasingly decreasing.[3,14] However, in the survey made in France over the last 30 years in another study, it is reported that there continues to exist social inequalities in the height growth and the final adult height due to factors such as education and income.[7] In domestic research, although the study was limited to the Seoul area, no significant difference was found in studies examining the height of high school students according to parent income.[16] But there was a report of 13% with short stature prevalence rate in children of married immigrant women in rural areas.[17] Influence of socioeconomic status on short stature is not yet consistent.

This study aimed to examine whether socioeconomic status influences the height growth of children by comparing the recent prevalence rate of short stature in the children of the community child center, who belong to the medically vulnerable status, and that of the children in normal socioeconomic status in Korea. During the period of this study, the prevalence rate of short stature in childhood at the community child center in 2 municipalities of Busan was observed to be 7.3%, which is substantially higher than the prevalence rates of short stature of 0.9% and 1.4% reported in the Korean National Growth Chart of children in 2007 and Korean National Growth Chart of children and adolescents in 2017, respectively.[18] The reason for the difference in prevalence rate may be because the Busanjin-gu and Yeonje-gu districts in Busan, which are the study areas, have high health deprivation indices in Busan.[19] Also, it is thought that the results of this study may be possible because there is also report of high prevalence rate of short stature in certain vulnerable groups.[17]

Although there could be limitations in reflecting the prevalence rate of short stature of children in all the community child center since it is based only on 2 specific municipalities in Busan, it nonetheless illustrates that socioeconomic status imparts influence on the height growth of children.

Although there are various factors that affect the growth status evaluation or growth velocity in children,[20] this study utilized midparental height, bone age, BMI and IGFBP3 for which confirmation of the results was possible. Midparental height is important for predicting the final height of children and is important for explaining the genetic factors of height growth. Midparental height is calculated by adding 6.5 cm from average height of parent in boys and subtracting 6.5 cm from average height of parent in girls.[16] Bone age is used for growth evaluation or predicting the final adult height of normal children. Bone age increases with the age and the height increase with the bone age.[21] BMI is known to impart different effects depending on the time and extent of height growth. Although it is known that the BMI and height growth has positive correlation within a period of less than 1 year, they are known to have negative correlation over a period of more than 1 year. In particular, it is asserted that BMI has negative effect on height growth in children with relatively short height.[22,23]

IGFBP3, which could be conducted in this study, is a test method capable of reflecting the concentration of blood growth hormone as an independent test and is used as a screening test at the time of growth evaluation of children. Although IGFBP3 is known to be less affected by external factors in comparison to IGF1 and is not affected by BMI, its normal value differs depending on the age and gender. As such, IGFBP3 SDS was applied in this study.[24-27]

For the comparison of the average of growth parameters between the short stature group and 3-20 percentile short stature suspected group among all the subject children in this study, it was confirmed that the short stature suspected group had higher bone age/chronological age, midparental height, midparental height SDS, BMI, and IGFBP3 SDS with no significant difference. Also, other growth parameters, the average values of bone age, height, height SDS, weight, BMI percentile, and IGFBP3, showed statistically significant high results in short stature suspected group. These results were consistent with previous reports.[27] In the comparison between the short stature group belonging to the below 3 percentile values who have poor socioeconomic status and the short stature group of the normal socioeconomic status, there was no statistically significant difference in the average values of all growth parameters between the 2 groups. In addition, in the results of comparison between the short stature suspected group children who have poor socioeconomic status belonging to values from 3 percentile to 20 percentile and the short stature suspected group of children from normal socioeconomic status, there was no observation of statistically significant difference in the average values of the growth parameters with the exclusion of bone age, bone age/chronological age, weight,

BMI percentile, IGFBP3 and IGFBP3 SDS. In the comparison of the socioeconomic differences both short stature group and short stature suspected group, there was no difference in midparental height and midparental height SDS.

Therefore the difference in height due to genetic factors could be excluded. On the contrary, IGFBP3 and IGFBP3 SDS were observed to be statistically significantly higher in the short stature suspected children from poor socioeconomic status childhood. This appears to be the result of greater number of girls at 61 in comparison to the boys at 50 in the children as well as the higher average age of children in the short stature suspected group with poor socioeconomic status belonging to values from 3 percentile to 20 percentile. Based on these results, it can be presumed that difference in the socioeconomic status does not impart any significant influence on the growth parameters of height growth except bone age and bone age/ chronological age in the short stature suspected group. In this study, factors related to the diagnosis of short stature in accordance with the socioeconomic difference were examined through multiple logistic regression analysis. As the results, BMI persentile and bone age/chronological age were found to have influence on the socioeconomic status, and IGFBP3 was also found to be a factor that imparts influence due to the difference in the normal value according to the age and gender. Although BMI persentile is associated with the growth velocity of height, it is presumed that this study has limitations in

concluding that it affects socioeconomic status due to too large difference in accordance with the period of observation of sexual maturity and growth velocity of the height. In addition, it was found that other factors such as height SDS, midparental SDS and presence of short stature do not impart significant effect on the socioeconomic status. These results are in agreement of the results of numerous recent researches that the influence of the difference in the socioeconomic status on the height growth of children is declining.

As the results of this study, it was presumed that there is no significant difference in the growth parameters between the short stature children from poor socioeconomic status and from normal socioeconomic status. However, the prevalence rate of short stature children from poor socioeconomic status was confirmed to be higher than that of the Korean National Growth Chart for children, although limited to specific areas. Therefore, there is a need to check prevalence rate of short stature in children from the community child center in a broader range of areas. Also, this study has additional limitations. First, there were no growth parameters of height velocity over a specific period in the compared growth parameters. Second, there was no analysis of lifestyle habits, dietary habits and sleep habits that affect height growth. There is a need to conduct more extensive range of studies on greater groups for more diversified factors in order to discern the influence of socioeconomic status on the height growth of children.

ACKNOWLEDGEMENT

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