

# The Secular Growth Changes in Height and Weight of Mongolian Children over the Past 50 Years

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Received: December 26, 2017; Accepted: January 02, 2018; Published: January 22, 2018

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## Abstract

A little information regarding the changes in height and weight among children in Mongolia is available. The purpose of this paper is to report the secular growth changes in height and weight among schoolchildren in Ulaanbaatar city, Mongolia. The main purpose of the study was to determine the secular changes in height and weight of Mongolian children aged 8-17 years over the past 50 years. Height and weight were measured with Physician Beam Scale. Data analysis was made on SPSS-17.0 software. Arithmetical mean with standard deviation for each group ( $M \pm SD$ ) and standard error of the mean were calculated. In order to detect some changes in height and weight of children in different years, meta-analysis was performed (Cohen's d). In 1962-2010, there was an statistically significant increase ( $p < 0.05$ ) in average height of boys at the age of 8, 9 and 13-17 years old whereas there was a decrease of average height of boys aged 10, 11 and 12 years from 1978 to 1992, and 8-10, 14-17 years from 2010 to 2015. An increase in girls' average height occurred throughout all age groups except decrease in girls' height aged 10-12 years and 10, 12, 14-17 years in 1992-2010 and 2010-2015 respectively. There was a statistically significant increase ( $p < 0.05$ ) in average weight for boys and girls throughout all age groups except decrease in weight of children's of both sexes aged 12-17 years old in 2010-2015. In seven out of 10 age groups (8, 9, 10, 14, 15, 16, 17 years old) heights of boys were decreased with medium size effects in 2010-2015. The present study has shown that there were both upward and downward changes in height and weight of schoolchildren in Ulaanbaatar city during 1962-2015.

**Keywords:** Secular growth changes; Height; Weight; Effect size;

## Introduction

The secular trend of growth compares changes in anthropometric parameters that occur from one generation compared to the previous one. Today, it's considered that the term 'secular trend' – suggesting mainly an ascending trend – should be replaced by the secular growth change, as body size

and maturation rate may grow, decline or remain unchanged [1]. With the trend related to height values, at certain ages there occur co-related changes in weight.

As we know, growth of all living being including the children here is determined by gene, though final expression is the summation of a complex interaction of some factors such as nutrition, socio-economic and geo-climatic, which ultimately modify the manifestation of genetic potential to higher and lesser intensity [2-7]. Some reports advocate well documented changes in weight especially, height among adolescents [8-12], but still other studies reported increase of height in a populations [8,13,14], with information of height leveling-off in children in Poland and Germany [15,16]. Information regarding the changes in height and weight among children in Mongolia is meagre. The purpose of this paper is to find out the secular growth changes in respect of height and weight among schoolchildren in Ulaanbaatar city, Mongolia.

## Materials and Methods

The main purpose of the study was to determine the secular changes in height and weight of Mongolian children, in the age group of 8-17 years over the past 50 years. Therefore, 1962, 1978 and 1992 National growth charts data (space) on height and weight of schoolchildren were considered for comparative analysis. In 2010 and 2015, height and weight data of 2000 and 1600 schoolchildren, age group 8-17 years, were collected, respectively. In 2010 and 2015, participated children were enrolled from 13 schools of Ulaanbaatar city. Some 80-100 children from each age and sex were selected, the reason for this was to be able to compare with National charts data which were collected from around 100 children in UB each age and sex.

Height and weight were measured with Physician Beam

Scale (Detecto 339 Balance Beam Scale with Height Rod). Height was measured to the nearest 0.5 cm as each subject stood erect, barefooted with the head held in Frankfort horizontal plane. Weight was measured to the nearest 0.1 kg with light clothing and barefooted.

Data analysis was made on SPSS-17.0 software. Arithmetical mean with standard deviation for each group ( $M \pm SD$ ) and standard error of the mean were calculated.

In order to detect the changes in height and weight of children in different years meta-analysis was performed. Particularly, the effect size (Cohen's  $d$  – standardized differences of means) was calculated using the following equation [17]:

$$\text{Effect size} = \frac{|\bar{X}_1 - \bar{X}_2|}{\text{Average SD } X_1, X_2}$$

Where:

$\bar{X}_1$  – Average of group 1

$\bar{X}_2$  – Average of group 2

SD – Standard deviation

The interpretation of the effect sizes was done using (Table 1).

Cohen's effect size was considered small where  $d \geq 0.2$ , medium as  $d \geq 0.5$  and large effect size where  $d \geq 0.8$ .

An effect size is exactly equivalent to a 'Z-score' of a standard Normal distribution. For example, an effect size of 0.8 means that the score of the average height in the one group is 0.8 standard deviations above the average height in the second group, and hence exceeds the height measurements of 79% of the second group.

**Table 1:** Interpretations of Cohen's  $d$  effect sizes

Effect size, $d$	Percentage of group Y who would be below average A in group X	Probability that person from group Y will be higher than A from group X, if both chosen at random (=CLES)	Effect size, $d$	Percentage of group X who would be below average A in group Y	Probability that person from group Y will be higher than A from group X, if both chosen at random (=CLES)
0	50%	0.5	0.7	76%	0.69
0.1	54%	0.53	0.8	79%	0.71
0.2	58%	0.56	0.9	82%	0.74
0.3	62%	0.58	1	84%	0.76
0.4	66%	0.61	1.2	88%	0.8
0.5	69%	0.64	1.4	92%	0.84
0.6	73%	0.66	1.6	95%	0.87

## Results

Anthropological data covering height and weight and age group of 8-17 were recorded, irrespective of sex. The (Figures 1, 2, 3 and 4) show trends in height and weight in each age group of both sexes for investigated years. Starting with 10 years, the girls catch up boys at their height; in contrary the boys of age group 17 catch up girls at their height and become taller. Present day children are taller than the children of 50 years ago but children's growth leveling-off in the last years, particularly starting from 13 years old (Figure 1, 2).

Dynamics for the body weight is nearly similar to the stature but gender differences occur earlier for weight. Peak weight boost comes around at the age of 13 to 14 years for girls and boys (Figure 3, 4).

In 1962-2010, there was an statistically significant increase ( $p < 0.05$ ) in average height of boys at the age of 8, 9 and 13-17 years old whereas there was a decrease of average height of boys aged 10, 11 and 12 years from 1978 to 1992, and 8-10, 14-17 years from 2010 to 2015 (Table 2).

An increase in girls' average height occurred throughout all age groups except decrease in girls' height aged 10-12 years and 10, 12, 14-17 years in 1992-2010 and 2010-2015 respectively

(Table 2).

There was an statistically significant increase ( $p < 0.05$ ) in average weight for boys and girls throughout all age groups except decrease in weight of children's of both sexes aged 12-17 years old in 2010-2015 (Table 3).

When we compare the statistically significant changes in height and weight over the years in children both sexes using effect sizes, it was revealed that in 1962-1978, there were in general medium effect sizes ( $d=0.7$ ) in boys' height, which means height of boys increased in average of 4.1 cm. In 1978-1992, decrease in height was revealed in three age groups such as 10, 11 and 12 years old with effect size as 0.4, 0.1 and 0.5, which means that 66%, 50% and 69% of boys of those age groups in 1992 were shorter of the same age average height boys in 1978. But in 1998-2010, increase in height was noted in all age groups, and Cohen's  $d$  ranged from 0.3 to 1.3.

The striking results were observed when boy's heights of 2010 and 2015 were compared. In seven out of 10 age groups (8, 9, 10, 14, 15, 16, 17 years old) heights of boys were decreased with medium size effects (Table 4).

Regarding girls' height, the similar changes in effect sizes were observed (Table 4).

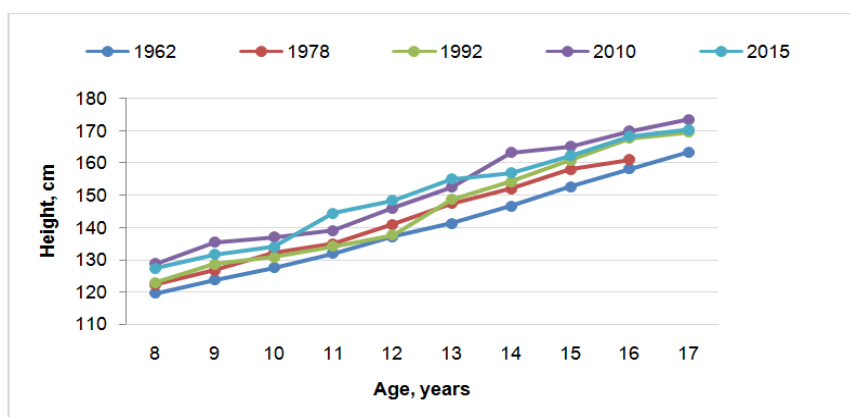


Figure 1: Growth increment in respect to height in boys (1962-2015)

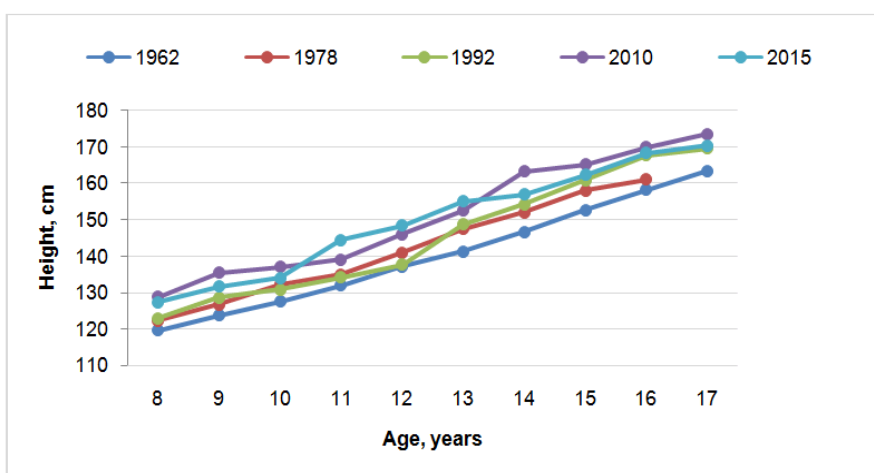


Figure 2: Growth increment in terms of height in girls (1962-2015)

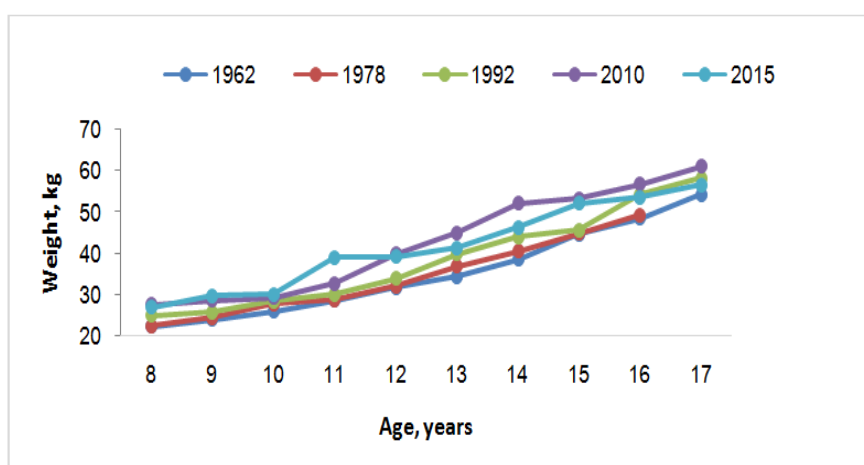


Figure 3: Growth increment in terms of weight in boys (1962-2015)

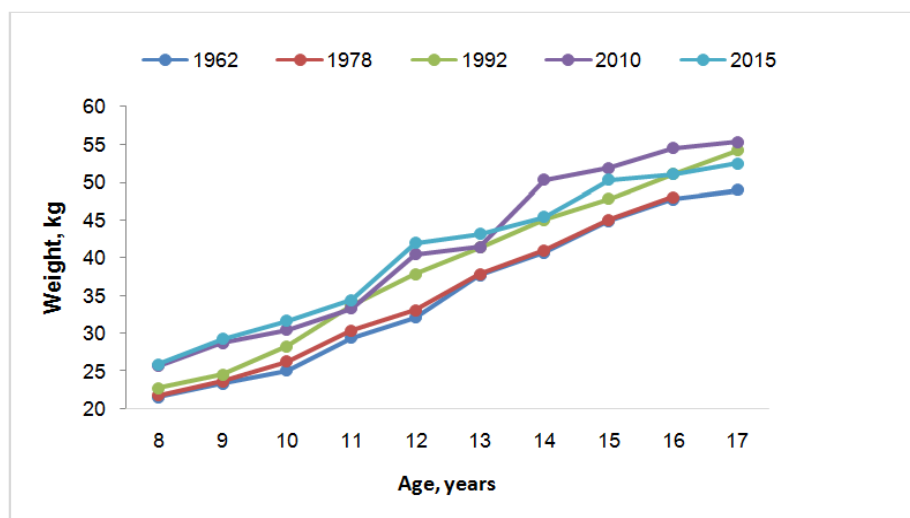


Figure 4: Growth increment in terms of weight in girls (1962-2015)

Table 2: Comparison of children's height over last 50 years, cm

Years		1962	1978	1992	2010	2015
Age	Sex	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
8	Boys	119.6 ± 4.7	122.3 ± 5.1	123.0 ± 6.2	128.8 ± 6.0	127.4 ± 4.9*
	Girls	118.6 ± 4.8	120.4 ± 5.4	123.0 ± 6.4	126.3 ± 4.5	126.6 ± 4.1
9	Boys	123.8 ± 5.3	126.7 ± 5.1	128.7 ± 5.6	135.4 ± 6.3	131.7 ± 4.6*
	Girls	122.7 ± 5.0	125.4 ± 4.3	130.9 ± 4.9	132.1 ± 6.8	132.6 ± 4.9
10	Boys	127.6 ± 5.8	132.3 ± 3.9*	130.8 ± 4.2*	137.0 ± 5.6	134.0 ± 5.7*
	Girls	126.3 ± 4.8	130.7 ± 6.7	133.0 ± 5.1	137.6 ± 6.96	137.6 ± 4.9
11	Boys	132.0 ± 5.4	134.9 ± 5.2	134.2 ± 6.1	139.1 ± 5.9	144.1 ± 7.5
	Girls	133.1 ± 6.2	137.6 ± 5.3	142.2 ± 7.7	139.4 ± 5.2	142.5 ± 5.5
12	Boys	137.2 ± 7.0	141.0 ± 5.1*	137.7 ± 7.0*	146.1 ± 7.4	148.5 ± 7.0
	Girls	138.1 ± 6.6	141.4 ± 5.7	148.0 ± 7.4	146.2 ± 6.2*	144.8 ± 6.7
13	Boys	141.3 ± 6.2	147.4 ± 8.6	148.8 ± 7.6	152.6 ± 7.9	155.0 ± 6.3
	Girls	142.9 ± 5.2	147.3 ± 6.3	152.6 ± 7.9	150.4 ± 5.8	151.7 ± 6.1
14	Boys	146.7 ± 7.5	152.0 ± 6.5	154.2 ± 8.2	163.3 ± 7.7	157.0 ± 7.2*
	Girls	147.2 ± 6.3	149.5 ± 3.4	156.1 ± 6.6	160.4 ± 5.1	153.8 ± 5.5
15	Boys	152.7 ± 7.5	158.1 ± 6.1	161.0 ± 7.2	165.2 ± 6.6	162.4 ± 6.8*
	Girls	150.4 ± 5.6	152.2 ± 3.9	159.6 ± 5.8	160.8 ± 5.4	159.7 ± 4.0
16	Boys	158.2 ± 6.0	161.1 ± 6.9	167.8 ± 6.6	169.9 ± 6.4	168.3 ± 5.6*
	Girls	152.1 ± 5.2	155.4 ± 2.4	161.1 ± 6.7	163.9 ± 5.7	160.0 ± 5.8
17	Boys	163.4 ± 6.3	0	169.7 ± 6.1	173.7 ± 5.4	170.4 ± 5.6
	Girls	152.7 ± 5.0	0	162.0 ± 4.1	164.1 ± 5.8	163.5 ± 5.1

\*p < 0.05

**Table 3:** Comparison of children's weight over last 50 years, kg

Years		1962	1978	1992	2010	2015
Age	Sex	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
8	Boys	22.4 ± 2.4	22.6 ± 2.4	25.1 ± 3.6	27.7 ± 4.8	27.1 ± 4.6
	Girls	21.6 ± 2.3	21.8 ± 2.5	22.8 ± 3.6	25.7 ± 3.8	25.9 ± 4.2
9	Boys	24.1 ± 2.6	24.5 ± 2.7	25.9 ± 2.6	28.6 ± 5.6	29.9 ± 4.1
	Girls	23.4 ± 2.6	23.7 ± 2.4	24.6 ± 3.5	28.8 ± 5	29.3 ± 5.4
10	Boys	26.1 ± 3.2	27.9 ± 2.2	28.5 ± 3.5	29.4 ± 6.2	30.1 ± 5.4
	Girls	25.1 ± 3.2	26.3 ± 3.6	28.3 ± 3.8	30.5 ± 5.3	31.7 ± 7.0
11	Boys	28.6 ± 3.4	28.9 ± 2.8	30.2 ± 4.8	32.8 ± 6.0	39.1 ± 6.1
	Girls	29.4 ± 4.3	30.4 ± 4.3	33.8 ± 5.6	33.3 ± 5.5	34.4 ± 7.0
12	Boys	31.9 ± 3.6	32.1 ± 3.5	33.9 ± 4.0	39.9 ± 7.9	39.3 ± 6.5
	Girls	32.1 ± 4.8	33.1 ± 3.9	37.9 ± 5.5	40.5 ± 7.4	42.0 ± 6.7
13	Boys	34.4 ± 4.7	36.9 ± 5.5	39.9 ± 6.8	45.1 ± 8.6	41.4 ± 4.2
	Girls	37.7 ± 5.4	37.9 ± 5.4	41.41 ± 6.2	41.45 ± 7.4	43.2 ± 6.2
14	Boys	38.6 ± 5.6	40.6 ± 7.1	44.0 ± 5.8	52.2 ± 6.8	46.4 ± 3.9
	Girls	40.7 ± 6.2	41.0 ± 5.1	45.0 ± 6.3	50.3 ± 6.0	45.4 ± 6.5
15	Boys	44.8 ± 7.2	44.9 ± 5.6	45.8 ± 6.9	53.4 ± 5.9	52.2 ± 8.1
	Girls	44.9 ± 5.9	45.0 ± 4.4	47.8 ± 5.3	51.9 ± 8.2	50.3 ± 7.4
16	Boys	48.6 ± 6.3	49.4 ± 6.6	54.4 ± 6.7	56.8 ± 7.6	53.7 ± 6.7
	Girls	47.7 ± 5.5	48.0 ± 2.9	51.1 ± 5.7	54.5 ± 6.1	51.1 ± 3.7
17	Boys	54.4 ± 6.3	0	58.3 ± 6.2	61.1 ± 8.3	56.7 ± 6.1
	Girls	49.0 ± 5.5	0	54.2 ± 5.6	55.3 ± 5.7	52.5 ± 2.8

\*p < 0.05

**Table 4:** Children's height decrease and their effect sizes

Boys	2010	2015	2010/2015			Girls	2010	2015	2010/2015		
	Age, years	Average ± SD	Average ± SD	Average height difference	SD, Average		Effect size, d	Age, years	Average ± SD	Average ± SD	Average height difference
8	128.8 ± 6.0	127.4 ± 4.9	-1.4	5.5	-0.3	8	126.3 ± 4.5	126.6 ± 4.1	0.3	4.3	0.1
9	135.0 ± 6.3	131.7 ± 4.6	-3.7	5.5	-0.7	9	132.1 ± 6.8	132.6 ± 4.9	0.5	5.85	0.1
10	137 ± 5.6	134 ± 5.7	-3	5.5	-0.5	10	137.6 ± 7.0	137.6 ± 4.9	0	5.95	0
11	139.1 ± 5.9	144.1 ± 7.5	5	6.7	0.7	11	139.4 ± 5.2	142.5 ± 5.5	3.1	5.35	0.6
12	146.1 ± 7.4	148.5 ± 7.0	2.4	7.2	0.3	12	146.2 ± 6.2	144.8 ± 6.7	-1.4	6.45	-0.2
13	152.6 ± 7.9	155 ± 6.3	2.4	7.1	0.3	11	150.4 ± 5.8	151.7 ± 6.1	1.3	5.95	0.2
14	163.3 ± 7.7	157 ± 7.2	-6.3	7.5	-0.8	14	160.4 ± 5.1	153.8 ± 5.5	-6.6	5.3	-1.2
15	165.2 ± 6.6	162.4 ± 6.8	-2.8	6.7	-0.4	15	160.8 ± 5.4	159.7 ± 4.0	-1.1	4.7	-0.2
16	169.9 ± 6.4	168.3 ± 5.6	-1.6	6	-0.3	16	163.9 ± 5.7	160 ± 5.8	-3.9	5.75	-0.7
17	173.65 ± 5.4	170.4 ± 5.6	-3.25	5.5	-0.6	17	164.1 ± 5.8	163.5 ± 5.1	-0.6	5.45	-0.1

Decrease in children's weight was observed between average weight in 2010 and 2015 for both sexes. In (Table 5), differences in average weight, average SD and their effect sizes are given.

## Discussion

In the study the average height and weight of schoolchildren aged 8-17 years old were compared to reveal secular growth changes over 50 years period. A secular upward and downward change for height and weight of schoolchildren in Ulaanbaatar city Height and weight had upward changes in children of both sexes during 1962 to 2010, and then from 2010 to 2015,

there were leveling-off height and weight in most age groups of schoolchildren. For instance, at age 11 years, girls/boys were on average 2.1 cm taller in 1962-2015 and respectively at age 11, 12, 13, 14 and 15 years girls/boys on average 0.5, 0.3, 0.5, 0.4 and 0.1 kg heavier in 1962-2015. The height and weight levelling-off effect was obvious in boys and girls between 2010-2015 in most age groups. In regard to the observed diminishment in height and weight of children it would be interesting to determine the status of the developmental tempo, measuring bone age and pubertal stage, in other worlds measuring the rate of children maturity (Cole, 2000).

**Table 5:** Children's weight decrease and their effect sizes

Boys			2010/2015			Girls			2010/2015		
Age, years	Average ± SD	Average ± SD	Average height difference	SD, Average	Effect size, d	Age, years	Average ± SD	Average ± SD	Average height difference	SD, Average	Effect size, d
8	128.8 ± 6.0	127.4 ± 4.9	-1.4	5.5	-0.3	8	126.3 ± 4.5	126.6 ± 4.1	0.3	4.3	0.1
9	135.0 ± 6.3	131.7 ± 4.6	-3.7	5.5	-0.7	9	132.1 ± 6.8	132.6 ± 4.9	0.5	5.85	0.1
10	137 ± 5.6	134 ± 5.7	-3	5.5	-0.5	10	137.6 ± 7.0	137.6 ± 4.9	0	5.95	0
11	139.1 ± 5.9	144.1 ± 7.5	5	6.7	0.7	11	139.4 ± 5.2	142.5 ± 5.5	3.1	5.35	0.6
12	146.1 ± 7.4	148.5 ± 7.0	2.4	7.2	0.3	12	146.2 ± 6.2	144.8 ± 6.7	-1.4	6.45	-0.2
13	152.6 ± 7.9	155 ± 6.3	2.4	7.1	0.3	11	150.4 ± 5.8	151.7 ± 6.1	1.3	5.95	0.2
14	163.3 ± 7.7	157 ± 7.2	-6.3	7.5	-0.8	14	160.4 ± 5.1	153.8 ± 5.5	-6.6	5.3	-1.2
15	165.2 ± 6.6	162.4 ± 6.8	-2.8	6.7	-0.4	15	160.8 ± 5.4	159.7 ± 4.0	-1.1	4.7	-0.2
16	169.9 ± 6.4	168.3 ± 5.6	-1.6	6	-0.3	16	163.9 ± 5.7	160 ± 5.8	-3.9	5.75	-0.7
17	173.65 ± 5.4	170.4 ± 5.6	-3.25	5.5	-0.6	17	164.1 ± 5.8	163.5 ± 5.1	-0.6	5.45	-0.1

Our findings of the leveling-off of the average height in school children is consistent with the study carried out by Uuganbayar et al that there was a diminished both height and weight trends between 2003 and 2014. They were looking at cardiovascular function of children in relation with physical development, and measured height and weight of schoolchildren. At this study there was a significant decrease in height in children of both sexes in the period between 2003 and 2014 [18]. A secular increase has been noted in some countries [19-22] although some countries reported on stabilization [14,15] and downward change in height and weight [23]. The results of these studies do not necessarily match in all details because of the different geographical regions, different socio-economic situations, different age groups, and different sample sizes and so on, but the general conclusion appears to be consistent.

In conclusion, the present study has shown that there were both upward and downward changes in height and weight of schoolchildren in Ulaanbaatar city during 1962-2015. An upward change in height and weight were during period of 1962-2010, and then in 2010-2015 downward change was observed in most age groups. Future study is aimed to determine if these secular changes are continuing and to examine possible explanations for and consequences of these changes.

## Acknowledgement

We thank school children and teachers of those schools in Ulaanbaatar city who cooperated with this study.

## Declarations

The Ethics Committee of the Mongolian National University of Medical Sciences approved the study in June 2015.

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