LINEARIZING THE GROWTH STANDARD TABLE OF CHILDREN AGING 36 TO 120 MONTHS

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ABSTRACT

Anthropometry at different ages released by the World Health Organization (WHO) as well as the Ministry of Health of Vietnam is using for assessing health, nutrition, and social wellbeing. It is really important for children who are at pre-school, and primary school ages. Data is tabular and applying for a jump of half-year intervals. In the case of a child's age by month is between intervals, the height has to be calculated by deductive method. The linearizing method has been used to convert the table data into the linear equation which can be used for applying in anthropometric assessment to children who have age from 36 to 120 month -old, counting to month-old instead of by half-year jump for ages. The obtained linear equation is $y = 0.49x + 79.97$, whereas *y* is standard height corresponding to *x* months old of boy age. The R^2 is 0.9978. By the same method and calculating procedure, the linear equation for the height of girls aging from 36 months to 120 months is $y = 0.41x + 86,49$. Using these equations when assessing children's height comparing to the WHO's standard is more convenient because the counting intervals are detailed to months instead of hafl-year as WHO's standard table.

Keywords: Linearizing, girl and boy's height, standards of weight and height of children.

1. INTRODUCTION

1.1. Three stages of children growing and education from born to adolescence

There are some theoretical models of human development studied by authors around the world. Each of theories was base on aspect of human characteristics such as maturation, psychoanalytic, psychosocial, behaviorism, ecological system … Among the theories, only maturationist theory of Gravill Stanley Hall mentioned about child growth by emphasizing the importance of genetics and evolution based on premise of growing children would recapitulate evolutionary stages of species development as they grew up. Meanwhile, in Psychosocial Theory, Erikson divided the growing stages of children into some stages such as infant (from born to 1 year old), toddler (1-3) and preschool and school age (4-11) and adolescence (12-18) [1].

In aspect of social and educational context research, growing time of child can be considered as three stages with difference of educational age and the nutritional care. After being born to 3 years old (36 months), young child is supported nutritional source from breast-feed supplementing formula milk, digestible food for babies. During this stage, the child growth is affected by mother and nursing cares at home or baby boarding house.

From 36 to 120 months old, children begin to lead the life in kindergartens and then primary schools. This second stage is considered as the key duration for child developing their bodies and habits. With the good nutritional care at this important stage, a child can develop

his or her body to meet the standards of height and body mass. Every deviation of nutritional status could be corrected in this time before being adolescence and then adults.

In the third stage, from 10 to 18 years old, adolescent children are nearly stable state to grow until to adult. Their bodies developing depend on the dietary and physical activities.

1.2. Child growth standards

As for anthropology, height (H) and mass (M) are the main factors to assess the growth of children while combining in BMI formula calculation (Body Mass Index) [2].

$$BMI = \frac{M}{H^2} \ (kg/m^2)$$

Whereas:

M: mass of body (kg);

H: the height (m).

According to WHO, one being considered as normal body has BMI between 18.5 to 22.99. It means the BMI lower than 18.5 is in malnutritional zone and respectively is overweight for higher than 22.9.

The World Health Organization (WHO) has shown many researching results involved to child growth data and notice the standards for children around the world.

The height and weight are the important factors for assessment of children's growth and their nutritional status. The senior officials of Vietnam's Ministry of Health have shown the table of standard children growth for those ages from 0 to 120 months according to WHO. This table contains 66 data for either height and mass of boys and girls, respectively comparison to their ages, accounting by months for children under 1 year old and by hafl year for those from above 1 year old.

Table 1. Standard height and mass of boys and girls aging from 0 to 120 months [3, 4]

Boys		Ages (Months)	Girls	
Weight (kg)	Height (cm)		Weight (kg)	Height (cm)
3.3	49.9	0	3.2	49.1
4.5	54.7	1	4.2	53.7
5.6	58.4	2	5.1	57.1
6.4	61.4	3	5.8	59.8
7	63.9	4	6.4	62.1
7.5	65.9	5	6.9	64.0
7.9	67.6	6	7.3	65.7
8.3	69.2	7	7.6	67.3
8.6	70.6	8	7.9	68.7
8.9	72.0	9	8.2	70.1
9.2	73.3	10	8.5	71.5
9.4	74.5	11	8.7	72.8
9.6	75.7	12	8.9	74.0
10.3	79.1	15	9.6	77.5
10.9	82.3	18	10.2	80.7

Boys		Ages	Girls	
Weight (kg)	Height (cm)	(Months)	Weight (kg)	Height (cm)
11.5	85.1	21	10.9	83.7
12.2	87.1	24	11.5	86.4
13.3	91.9	30	12.7	90.7
14.3	96.1	36	13.9	95.1
15.3	99.9	42	15.0	99.0
16.3	103.3	48	16.1	102.7
17.3	106.7	54	17.2	106.2
18.3	110.0	60	18.2	109.4
19.4	112.9	66	19.1	112.2
20.5	116.0	72	20.2	115.1
21.7	118.9	78	21.2	118.0
22.9	121.7	84	22.4	120.8
24.1	124.5	90	23.6	123.7
25.4	127.3	96	25.0	126.6
26.7	129.9	102	26.6	129.5
28.1	132.6	108	28.2	132.5
29.6	135.2	114	30.0	135.5
32.0	137.8	120	31.9	138.6

Girl and boy heights by ages

Figure 1. Girl and boy's heights by ages

In this article, the data of heights for boys at age from 36 to 120 months, corresponding to the second stage growing, will be converted to the linear function so that the function can be used in nutritional assessment without referring data in the Table 1.

Linearizing the data aims to support a simple way to reference the data without using the standard table when assess the BMI of children who are from 36 months to 120 months old.

For converting those data to function form, the linear least squares method is used. The results calculated by the deductive function will be compared with the interpolation method.

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2. METHOD AND DATABASE

The standard of child's height and weight by age announced by WHO 2007 will be used as the main data, using the boy's height index of personal data who aged from 36 to 120 months of age.

Using the least squares method to convert the data table to the linear equation.

3. RESULTS AND DISCUSSION

In the Figure 1, the data of height for both boys and girls by ages from 36 to 120 months can be approximated in the straight line.

Function: y = ax + b

Whereas:

    y: target function, as height factors.

    x: variant of number of ages from 36 to 120 months

    a and *b*: the constants

Therefore, the display function for those data could be linear after using least squares to have the best results that nearest table data.

It is known that the set of scatter data can be displayed by the straight line using the bellow simultaneous equations. The two constants *a* and *b* can be calculated out after analyzing the set of equations.

$$\begin{cases} a \sum_{n=1}^{n} x_i^2 + b \sum_{n=1}^{n} x_i = \sum_{n=1}^{n} x_i y_i & (1) \\ a \sum_{n=1}^{n} x_i + nb = \sum_{n=1}^{n} y_i & (2) \end{cases}$$

For calculating and set the linear equation of heights by ages of child from 36 to 120 months, referring the data on the Table 1, heights of boys and girls from 36 month to 120 months-old age is to extracted on the Table 2,

whereas:

    x_i: ages by month

    y_i: heights (cm)

    n: number of variants

Table 2. Height of boys and girl aging from 36 to 120 months [3]

n	Boys	Ages (Months)	Girls
1	96.1	36	95.1
2	99.9	42	99
3	103.3	48	102.7
4	106.7	54	106.2
5	110	60	109.4
6	112.9	66	112.2
7	116	72	115.1
8	118.9	78	118
9	121.7	84	120.8

n	Boys	Ages (Months)	Girls
10	124.5	90	123.7
11	127.3	96	126.6
12	129.9	102	129.5
13	132.6	108	132.5
14	135.2	114	135.5
15	137.8	120	138.6

After calculating, the deduced equation is:

$$y = 0.49x + 79.97 \qquad (3)$$

By the equation (3), we can calculate the standard of child at any month old age instead of by half-year jump for ages as standard Table 1.

For example, a boy at 57 month-old age, the standard of height can be calculated by the equation (3) as following:

$$SD\ (57) = 0.49.57 + 79.97 = 107{,}9 \approx 108\ (cm) \qquad (4)$$

Comparing to the result calculated by the interpolation method for 54 and 60 month data, with result below.

$$X_{mean} = \frac{H_{60} - H_{54}}{N} = \frac{110 - 106.7}{6} = 0.55$$

Whereas,

- X_{mean}: the height increase for each year from 54 months to 60 months.
- H_{60}: the data for height at 60 month-old
- H_{54}: the data for height at 54 month-old.
- N: the number of month between 54 to 60.

That can be calculated the height by mean of boy at 57 month - old by interpolation

$$H_{57} = 106.7 + 0.55 \times 3 = 108.35 \qquad (5)$$

Comparing the results by equation (4) and (5), the error calculated is acceptable

$108.35 - 108 = 0.35$;

$0.35/108 = 0.0032$, that mean the error is 0.32%, less than 1%.

Overall comparing the result by equation and the basal data are displayed in the Table 3 bellow, whereas:

y_i: heights by ages given by basal data Table 2

ycl: heights by calculating following the deduced equation

yi - ycl: differences between calculated heights by deduced equation and height by basal data.

Table 3. Comparing the result between equation and the basal data

Ages by months	Heights (y_i)	y_{cl} (calculated formula)	yi - ycl (2) - (3)
(1)	*(2)*	*(3)*	*(4)*
36	96.1	97.6	-1.5
42	99.9	100.5	-0.6
48	103.3	103.5	-0.2
54	106.7	106.4	0.3
60	110	109.37	0.63
66	112.9	112.31	0.59
72	116	115.25	0.75
78	118.9	118.19	0.71
84	121.7	121.13	0.57
90	124.5	124.07	0.43
96	127.3	127.01	0.29
102	129.9	129.95	-0.05
108	132.6	132.89	-0.29
114	135.2	135.83	-0.63
120	137.8	138.77	-0.97

By the table 3, R- Square can be calculated by formula

$$R^2 = 1 - (SSR/TSS)$$

Whereas:

SSR: Residual Sum of Square = 6.5699

TSS: Total Sum of Square = 2422.798

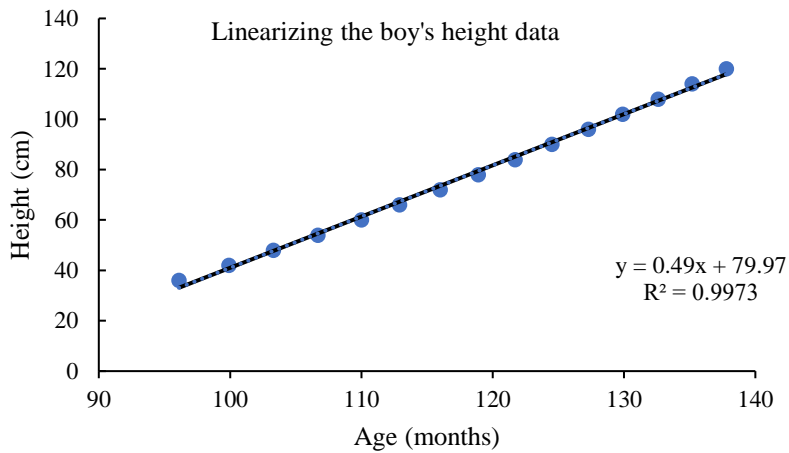$$R^2 = 1 - (6.57/2422.798) = 0,99728 \approx 0.9973$$

Figure 2. Linearizing the boy's height data

By the similar way, we can obtain the equation for the height of girls from 36 months to 120 months old.

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$$y = 0.5x + 78.7 \ (6)$$

$$R^2 = 0.99826 \approx 0.9983$$

For example, one girl at age of 40 months, it is between 36 and 42 intervals. So her standard height is calculated by equation (*6*), equal 97.6 cm.
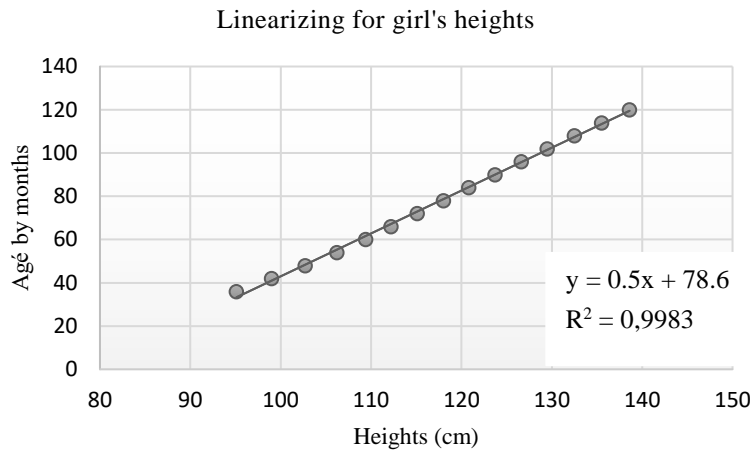
Linearizing for girl's heights

Figure 3. Linearizing for girl's heights

4. CONCLUSION

The standard height of boy whose age of 36 to 120 months old which is announced by WHO can be linearized by the equation $y = 0.49x + 79.97$ with $R^2 = 0.9973$.

Using the same method and calculating procedure, the linear equation for the height of girl aging from 36 months to 120 months is $y = 0.5x + 78.7$; $R^2 = 0.9983$.

Using this equation for the nutritional assessment of children who are at primary school is more convenient than the data table because of counting age by month, not by half-year intervals.

REFERENCES

1. Wong D.W., Hall K.R., Justice C.A., Hernandez L.W. - Counseling individuals through the lifespan, Chapter 2: Theories of human development, SAGE Publication (2015) 23-46.

2. Food and Nutrition Technical Assistance III Project (FANTA) - Nutrition Assessment, Counseling, and Support (NACS): A User's Guide - Module 2: Nutrition Assessment and Classification, Version 2. Washington, DC: FHI 360/FANTA2 (2016).

3. WHO child growth standards: length/height-for-age, weight-for-age, weight-for-length, weight-for height and body mass index-for-age: methods and development, WHO (2006).

4. Improving early childhood development: WHO Guideline 2020.

TÓM TẮT

TUYẾN TÍNH HÓA BẢNG CHIỀU CAO CỦA TRẺ TỪ 36 ĐẾN 120 THÁNG TUỔI

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Tiêu chuẩn chiều cao của trẻ em được Tổ chức Y tế thế giới (WHO) và Bộ Y tế Việt Nam công bố được sử dụng làm cơ sở đánh giá dinh dưỡng cho trẻ, nó đặc biệt quan trọng với trẻ ở lứa tuổi đang học mẫu giáo và tiểu học. Các số liệu được trình bày ở dạng bảng và tính cho tuổi tròn theo bước nửa năm. Trong trường hợp trẻ có số tháng tuổi ở khoảng giữa nửa năm theo mốc số liệu của WHO sẽ phải dùng phép nội suy. Bài báo này công bố kết quả chuyển đổi số liệu bảng thành phương trình tuyến tính áp dụng cho đánh giá nhân trắc cho bé trai từ 36 đến 120 tháng tuổi, tính theo tháng thay vì theo bước nhảy nửa năm bằng phương trình tuyến tính y = 0,49x + 79,97; trong đó, y là tiêu chuẩn chiều cao tương ứng với x là số tháng tuổi, hệ số R^2 là 0,9978. Với cách tính tương tự, phương trình tuyến tính cho số liệu chiều cao chuẩn của bé gái từ 36 đến 12 tháng tuổi là y = 0,5x + 78,7. Sử dụng các phương trình tính toán được sẽ thuận lợi hơn cho việc đối chiếu chiều cao của trẻ từ 36 đến 120 tháng tuổi với tiêu chuẩn của WHO bởi có thể đối chiếu chi tiết đến từng tháng tuổi thay vì bước nhảy nửa năm như bảng số liệu của WHO.

Từ khóa: Tuyến tính hóa, chiều cao của bé trai và bé gái, tiêu chuẩn về chiều cao và cân nặng của trẻ.