An Estimation of Grip Strength during Puberty

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Objective: *Find the correlation of grip strength in puberty with chronological age, height, weight, and percentage of body fat.*
Material and Method: *One thousand one hundred and five volunteer students between 11 and 14 years of age in Central Thailand participated in the study. The body weight and height were measured with standard balance and stadiometer. The percentage of body fat was measured with Near Infrared interactance device. The grip strength was measured with Digital Handgrip Dynamometer. The results were statistically analyzed by multiple linear regression.*
Results: *It was found that grip strength has a significant correlation with age, height, and weight but not with percentage of body fat. The prediction of grip strength in puberty can be estimated with the following equations: a) For boys, Grip strength (kg) = -59.797 + 2.493 Age (yr) +0.308 Height (cm) +0.147Weight (kg), and b) For girls, Grip strength (kg) = -32.887 + 0.926Age (yr) +0.236Height (cm) +0.155Weight (kg).*
Conclusion: *The predictive value of an age, height, and weight equation is more precise than that of solely chronological age.*

Keywords *: Puberty, Grip strength, Estimation*

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Grip strength is crucial in several daily activities. The ease and reliability of grip strength assessment[1] make it a useful indicator of clinical outcome after hand treatment[2,3]. Grip strength also reflects the overall physical, health, and nutritional status[4,5]. It is influenced by a number of factors including age, gender, handedness, motivation, and position of extremity during test[6-10]. Despite grip strength's importance, most of the previous studies emphasized only adults' grip strength[6,7,11,12]. Unfortunately, a very limited number of researches concentrated on pubertal period. Past research merely gave reference to value of grip strength in chronological age and pubertal stage[13-15]. Because puberty is an important and dynamic period of development marked by rapid changes in body size, shape and composition, and sexually dimorphic[16-18], there is a considerable change in physical performance and body shape.

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In this period, the percentage of body fat also changes[17] and the percentage of body fat may have an inverse correlation with performance[19]. The authors' questioned whether a physiological change of percentage body fat might influence grip strength or not.

The time of entering into puberty is different for each child[17]. It stems from a host of factors, such as race, socioeconomic, nutrition, and types of exercise[17]. Chronological age alone does not reflect the pubertal stage that leads to different physical performance. To be specific, chronological age, as a single factor, may not give an accurate prediction of grip strength during the pubertal period. Using the pubertal stage to estimate the grip strength seems to give a more precise value. However, this poses one practical problem for both the examiner and subject with body privacy as pubertal age is estimated from private body parts.

The objectives of the present study are (1) to study the correlation of grip strength with chronological age, body structure, and percentage of body fat;

and, (2) to use the simple anthropometric value to estimate the grip strength in the puberty period (11-14 yrs).

Material and Method

Subjects

The study group comprised 1,105 healthy students aged 11 to 14 years old (544 boys, 561 girls,) from six schools in Central Thailand. Each school had different sports programs and parents' socioeconomic status. All of the students, parents, and teachers were briefly told the objectives and the methods of the present study.

Anthropometric measurement

The subjects' names, birth dates and sports activities were recorded. Subsequently, their body height (to the nearest 0.1 cm) was measured with a standard stadiometer. The weight (to the nearest 0.1 kg) was determined by a digital electronic scale. The grip strength of both the dominant hand and non-dominant hand was measured by the digital hand grip dynamometer (Takei Tokyo Japan) in the position of shoulder adduction, 90-degree elbow flexion, and 30-degree wrist flexion. The dynamometer handle was adjusted so that the line of the subject's proximal interphalangeal joints rested exactly on top of the adjustable handle. The subjects were asked to put maximal force on the dynamometer twice from both sides of the hand. The maximal force was recorded in kilograms and used as grip strength value[20,21].

The percentage of body fat was measured with the Near Infrared interactance device (Fultrex-5000A/XL). The authors opted for this method instead of skin fold thickness measured by standard techniques because this equipment is portable and non invasive. In addition, the test protocol is simple, requiring minimal skills from the practitioner, and it gives an immediate result of percentage of body fat[22,23]. The reliability of NIR device in children and adolescents has been reported[24]. The main body of NIR (Fultrex 5000A/XL) is connected via a light cable to a light-emitting sensor. The NIR sensor window is equipped with a light shield to ensure that no external light interferes with the estimation of percentage body fat. The value of percentage body fat was then measured and recorded.

Statistical analysis

Throughout the present study, a p-value < 0.05 was considered significant. For comparison between the two groups, the t-test was utilized. The significance of differences among three or more groups was calcu-

Table 1. Anthropometric measurements and grip strength of the subjects classified by age and gender

Age (year)	11		12		13		14	
Sex	Boys (n = 38) Mean (SD)	Girls (n = 42) Mean (SD)	Boys (n = 229) Mean (SD)	Girls (n = 216) Mean (SD)	Boys (n = 195) Mean (SD)	Girls (n = 217) Mean (SD)	Boys (n = 82) Mean (SD)	Girls (n = 86) Mean (SD)
Height (cm)	136.00 (9.65)	137.09 (7.48)	148.42 (9.55)*	150.68 (7.41)	155.32 (10.42)*	153.07 (7.09)	164.25 (9.19)**	156.24 (6.92)
Weight(kg)	32.50 (10.19)	32.04 (7.06)	43.58 (13.33)	44.32 (10.37)	46.74 (11.62)	45.76 (9.36)	54.19 (11.17)*	49.44 (9.04)
% body fat	26.78 (4.48)	26.15 (4.38)	25.73 (4.97)**	22.23 (5.34)	26.68 (7.01)**	27.65 (5.76)	33.02 (5.97)**	27.58 (4.92)
Grip strength (kg)	11.36 (4.84)	15.58 (4.22)	21.90 (5.54)*	20.04 (4.77)	27.03 (7.27)**	22.59 (4.92)	34.93 (8.38)**	24.54 (5.28)

* Significant difference between boys and girls (p-value < 0.05)
** Highly significant difference between boys and girls (p-value < 0.001)

lated by a one-way analysis of variance (ANOVA). Pearson's correlation between variables was calculated. The prediction equation of grip strength with weight, height, age, and percentage of body fat of both gender were analyzed by multiple linear regression analysis. Coefficient of determination (R^2) was also calculated for each prediction equation.

Results

The height, weight, percentage of body fat, and grip strength of subjects of both genders and different ages are given in Table 1. The grip strength, height, and weight increased with age. The percentage of body fat of boys reduced with increasing age. The weight, height, and grip strength of both genders were

Table 2.1. The Pearson's correlation coefficients and p values between grip strength and height, weight and percentage of body fat of 11-year old boys and girls

	Boys (n = 38)		Girls (n = 42)	
	Coefficient	p-value	Coefficient	p-value
Height	0.800	0.000	0.609	0.000
Weight	0.635	0.000	0.613	0.000
Percentage of body fat	-0.126	0.449	-0.060	0.707

Table 2.2. Pearson's correlation coefficients and p values between grip strength and height, weight and percentage of body fat of 12-year old boys and girls

	Boys (n = 229)		Girls (n = 216)	
	Coefficient	p-value	Coefficient	p-value
Height	0.754	0.000	0.546	0.000
Weight	0.613	0.000	0.613	0.000
Percentage of body fat	-0.400	0.000	-0.232	0.001

Table 2.3. Pearson's correlation coefficients and p values between grip strength and height, weight and percentage of body fat of 13-year old boys and girls

	Boys (n = 195)		Girls (n = 217)	
	Coefficient	p-value	Coefficient	p-value
Height	0.725	0.000	0.575	0.000
Weight	0.599	0.000	0.554	0.000
Percentage of body fat	-0.231	0.001	-0.038	0.576

Table 2.4. Pearson's correlation coefficients and p values between grip strength and height, weight and percentage of body fat of 14-year old boys and girls

	Boys (n = 82)		Girls (n = 86)	
	Coefficient	p-value	Coefficient	p-value
Height	0.546	0.000	0.546	0.000
Weight	0.455	0.000	0.587	0.000
Percentage of body fat	-0.015	0.894	-0.211	0.005

not different in the subjects aged 11. The boys' height, weight, and grip strength significantly increased more than the girls' as the age increased.

To compare the different values of height, weight, percentage of body fat, and grip strength among different age groups, the ANOVA test was used. The results (as indicated in Table 1) showed that there is highly significant difference among age groups in both boys and girls.

The simple regression analysis was used to calculate the correlation of grip strength with height, weight, and percentage body fat in ages 11, 12, 13 and 14 as shown in Tables 2.1, 2.2, 2.3 and 2.4, respectively. In all age groups, the grip strength had a significant and high correlation with height and weight. The grip strength had a negative correlation but no significant difference with percentage body fat, except in 12 years group. However, the correlation coefficient value here was low (Table 2.2).

Due to the several variables that might influence the grip strength value, the forward multiple linear regression analysis was used to select variables in boys and girls. The study indicated that the grip strength had a significant correlation with age, height, weight, and percentage of body fat in boys but the same applies only with age, height, and weight in girls. The results of the analysis are shown in Table 3. Without the percentage of the body fat in boys, the calculated equation is seen in M2 (Table 3).

Discussion

From the results, the grip strength has increased more than double in boys and almost the same in girls (See Table 1) from ages 11-14 with significant difference. The height and weight also increased significantly with age. Compared with the reference value of Thai boys and girls in previous studies[13], the present results indicate less hand grip strength in age group 11 but more value in age groups 12, 13,14. The means of the height is not different from the previous studies but that of the weight in the present study has higher value in all ages. The presented percentage of body fat between boys and girls is not different at age 11. However, the girls of 13-14 have higher value than the boys and have a tendency to increase[24,25]. Interestingly, the boys' percentage of body fat is prone to decrease with age. Nonetheless, the findings are somewhat similar to those of other studies. The difference of the hand grip and weight from the previous studies[13,25] might derive because the last study is almost ten years old. Further, the country's socioeconomic status and the children's lifestyle and food have considerably changed in this period. This brings about children's being more obese[16].

There is no difference of grip strength between boys and girls at age 11. However, the girls have a higher value of grip strength and are taller than boys. The girl's stronger grip and taller figure might be the effect of growth hormone and thyroid hormone after entering puberty[16,17]. In general, the girls enter the pubertal period earlier than boys[16,17,25,27,28]. Moreover, Rogol[18] has also demonstrated that pubertal girls are stronger than pre-pubertal boys at the same chronological age.

Although the boys enter pubertal stage later than girls[16,17], the Growth hormone and testosterone have more effects on physical body and performance than girls[16,17]. The present results also reflect that the grip strength, height, and weight increase with age and boys have more significant difference than girls at age 12-14. After entering puberty, the growth rate of boys is higher than girls and continues on to the age of 18, resulting in the boys becoming taller[29]. Greater body height means greater bone length, which is an important determinant of muscle mass and force[30,31]. Additional factor is the higher testosterone level in boys,

Table 3. Grip strength prediction equation in ages 11-14 year old (boys and girls)

BOYS
M1 Grip strength (kg) = -40.315 + 0.996 age (yr) +0.332 height (cm) +0.163 weight (kg) -0.221 percentage body fat
Adjust R^2 = 0.682
M2 Grip strength (kg) = -59.797 + 2.493 age (yr) +0.308 height (cm) +0.147 weight (kg)
Adjust R^2 = 0.656
GIRLS
Grip strength (kg) = -32.887 + 0.926 age (yr) +0.236 height (cm) +0.155 weight (kg)
Adjust R^2 = 0.480

R^2 = Coefficient of determination

resulting in a strong muscle anabolic effect[32] and maximal isometric force during puberty[33]. Another factor seems to be the boys' playing vigorous sports, giving them better performances[17].

The grip strength has a high-value positive correlation with height and weight in all ages. However, the percentage body fat has a negative correlation with grip strength but the relationship is not significant. Due to the physiologic decrease of percentage body fat in boys and increase in girls during puberty[16], the percentage body fat alone should not be used to calculate the performance. Using percentage of body fat to predict grip strength in the pubertal period might cause estimation error.

Age is important to predict the variables for body density[25] and to calculate the grip strength. By using the forward linear regression to predict the grip strength and calculate the correlation coefficient, the authors derived the following equations for prediction grip strength in boys and girls:

Grip strength (kg) (boy) = -40.315 + 0.996 Age (yr) +0.332 Height (cm) +0.163 Weight (kg) -0.221 percentage of body fat

Grip strength (kg) (girl) = -32.887 + 0.926 Age (yr) +0.236 Height (cm) +0.155 Weight (kg)

Although the percentage of body fat can be included in the boys' equation to predict the grip strength, using height and weight only seem to be easier and simpler, as in the next equation:

Grip strength (kg) = -59.797 + 2.493 Age (yr) +0.308 Height (cm) +0.147 Weight (kg)

From the present research, some limitations can be found. To begin with, the presented subjects comprise students from Central Thailand. However, to gain a more precise estimation, subjects from all the regions should be included. Second, the present study displays merely the correlation of physical properties and grip strength. The genuine factor that directly impacts the grip strength may be the levels and effects of the growth and sex hormones. Further studies, therefore, should consider such factors.

In summary, grip strength in puberty has a high correlation with age, height, and weight. Therefore, to predict the grip strength value in puberty, chronological age, height, and weight should be included.

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การหาค่าประมาณของแรงบีบมือของเด็กในช่วงอายุ 11-14 ปี

สัญญาณ เนียมปุก, ยงยุทธ ศิริปการ, ธงชัย สุนทราภา

การศึกษานี้เป็นการศึกษาหาความสัมพันธ์ระหว่างแรงบีบมือ กับช่วงอายุ ความสูง น้ำหนักและเปอร์เซ็นต์ของไขมันในร่างกาย ในช่วงวัยรุ่น โดยทำการศึกษาจาก อาสาสมัครนักเรียนอายุ 11-14 ปี จำนวน 1,105 คน จากโรงเรียนในกรุงเทพมหานครและเขตภาคกลางของประเทศไทย โดยทำการวัดส่วนสูง ชั่งน้ำหนัก วัดค่าเปอร์เซ็นต์ไขมันในร่างกายโดยใช้เครื่องวัดชนิด อินฟราเรด และวัดแรงบีบมือด้วยเครื่องวัดดิจิตอล นำค่าที่วัดได้มาทำการวิเคราะห์ทางสถิติ พบว่าค่าแรงบีบมือมีความสัมพันธ์กับอายุ ความสูง และน้ำหนักอย่างมีนัยสำคัญ แต่ไม่มีความสัมพันธ์กับเปอร์เซ็นต์ไขมันในร่างกาย และคำนวณได้สมการสำหรับประมาณค่าแรงบีบมือในช่วงอายุ 11-14 ปีได้ดังนี้

เพศชาย แรงบีบมือ (Grip strength) (กิโลกรัม) = -59.797 + 2.493 x อายุ (ปี) +0.308 x ความสูง (เซนติเมตร) +0.147 x น้ำหนัก (กิโลกรัม) และเพศหญิง แรงบีบมือ (Grip strength) (กิโลกรัม) = -32.887 + 0.926 x อายุ (ปี) +0.236 x ความสูง (เซนติเมตร) +0.155 x น้ำหนัก (กิโลกรัม) จากสมการนี้ทำให้สามารถประมาณค่าแรงบีบมือของเด็กช่วงอายุ 11-14 ปีได้แม่นยำมากกว่าการใช้อายุเพียงอย่างเดียว