

## The Comparison of Forearm Volumes and Some Forearm Parameters of Female and Male Children in The Adolescence Period

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**ABSTRACT: Study Aims;** Developmental differences between female and male children in the adolescence period are the subject of many researches. Making comparison according to sexes by measuring 12-year-old female and male children's forearm volumes, forearm perimeters and hand clutch force is a way of putting forward an idea about the developmental differences between children in the 12-year period which is considered as the start of male children's transition to the adolescence and as the complete transition to the adolescence of female children. **Materials and Methods;** 267 healthy and voluntary children (137 females and 130 males) whose average age is 12 attended the research. The Forearm Volumes of the Subjects were measured by volumetric measurement method (overflow water method), the Forearm Perimeters of the Subjects were measured by Aptamil tape measure and, the handgrip strength of the subjects were measured by Takei Hand Dynamometer (Handgrip). The analysis of data; first of all, Kolmogorov Smirnov (Ksz) test was applied, Man-Whitney-U test was applied in order to make comparison between Forearm Volume and Independent Sample T test was applied in the comparison of Handgrip strength and, 0,05 significance level was taken into account. **Results;** the forearm volumes and perimeters of the subjects were compared according to sexes by Man-Whitney-U test. The result of the statistic showed that there is not significance between the 'Right Forearm Volume' ( $U=8844,00$ ;  $p>0,05$ ) of female and male children and, between the 'Left Forearm Volume' ( $U=8890,50$ ;  $p>0,05$ ) of them. There was not found a statistically significant difference between the 'Right Forearm Perimeters' ( $U=8406,00$ ;  $p>0,05$ ) of female and male children and, between the 'Left Forearm Perimeters' of them ( $U=8818,50$ ;  $p>0,05$ ). Independent Sample T-test was used in the analysis of the handgrip Strength of the participants in terms of sex. According to the analysis, there was a significant difference for the benefit of males between the 'Right and Left Handgrip Strength' of the female and male participants ( $t_{Right}=2.749$ ;  $p<0.05$  ve  $t_{Left}=2.759$ ;  $p<0.05$ ). **Conclusion;** The Right and Left Forearm Volumes and Forearm Perimeters of 12-year-old female and male participants did not show a significancy according to sexes and, there occurred a significant difference between the Right and Left Handgrip Strength which is for the benefit of males. [Alparslan ÜNVEREN. **The Comparison of Forearm Volumes and Some Forearm Parameters of Female and Male Children in The Adolescence Period.** *Life Sci J* 2013; 10(10s):155-160] (ISSN: 1097-8135). <http://www.lifesciencesite.com>. 24

**Key Words:** Adolescence Period, Forearm Volume, Handgrip Strength.

### 1. Introduction

Physical structure which consists of a complicated system and sub-systems provides a basis for all functions and behaviours necessary for human life. Physical growth and development affects all the developments of individual and also, is in interaction with its all parts (Rice, 1997. Senemoğlu, 2007).

Age is an important factor in the development of people's height, weight and physical features. Also, it is known that there occur many important physical and physiological developments in children in the adolescence period (Bukatko and Daehler, 1992. Bompa, 1999. Mengütay, 2005. Sevim, 2002. Muratlı, 1997. Kalyon, 1995. Açıkada, 1990. Yavuzer, 1999).

Rapid physical and physiological changes during the growth progress cause significant differences on body structure. Hands and feet usually develop faster than the other parts of the body. This rapid and disproportionate growth can cause the disruption of coordination between body organs.

However, the adolescent, after a while, gains balance and skill which are appropriate to the new body size (Gander and Gardiner, 1998).

The adolescence is not a period that continues in the same way from the beginning until the end with monotonous changes. Instead, it is a transition period between childhood and adulthood that contains a great number of biological and social changes, and differences and uncertainties (Rice and Dolgin, 2005. Smith, Cowie and Blades, 2003. Berk, 1993).

The physical development in this period provides a basis for social, emotional and mental maturity. To sum up, adolescence starts with biological change and continues with physical, mental and psychological developments (Yavuzer, 1999). This period in which there is rapid development is between 10-12 ages in females and between 12-14 ages in males. Also, it is known that all the phases of adolescence occur in the same line (Ceyhan, 2002. Senemoğlu, 2007). The growth

explosion of male children usually occur later than female children and it is usually seen at the age of 14. The increase in muscle and bone mass in puberty development of male children is more clear than of female children (Gönç, 2009).

This period is a process in which physical and sexual maturity is gained as the results of rapid and sudden biological changes. Skeletal system, body size and rate develop and change significantly (Berk, 2000. Sigelman and Rider, 2009. Santrock, 2001). However, it is stated that it is not possible to draw the complete lines of this period and that the timing of it has significant difference between sexes and individuals (Rice and Dolgin, 2005. Smith, Cowie and Blades, 2003. Berk, 1993).

Males are usually taller and heavier than females in the childhood. However, from the age of 10 to 15, the height and weight of females pass the height and weight of males of the same age. Females are taller than males at the beginning of high school period. Nevertheless, males make up this difference within a few years and in fact, they pass (Bukatko and Daehler, 1992. Craig and Baucum, 2002).

Different changes occur on the bodies of male and female children according to sexual differences. The lung and heart of males are bigger than of females and, the oxygen-carrying capacity of blood is also higher. For this reason, males display higher activity in terms of force, speed and physical endurance in the adolescence period (Senemoğlu, 2007). Muscles develop quite rapidly for both sexes. However, muscle mass in males develops more significantly. Consequently, adipose tissue is more on a mature female body whereas muscle tissue is more on a male body. Total body weight increases significantly for both females and males. Yet the distribution of fat is different on the body. Shoulders of males widen and thus, more muscular and stronger appearance is formed. Females have more round appearance than males because they tend to collect adipose tissue more (Bukatko and Daehler, 1992. Sigelman and Rider, 2009. Yazgan, Bilgin, and Kılıç Atıcı, 2004).

The most significant organ of humans that gains functionality to upper extremities is the hand. Handgrip strength is known to be an important feature in both daily life and sportive acts (Nicolay and Walker, 2005). For this reason, handgrip strength is accepted as a criterion in the evaluation of general performance (Gabriel and Andy, 2001).

It is stated in some researches that handgrip strength is an indicator in terms of hand power and general power, and that it is a significant measurement in order to determine the performance level of sportsmen in addition to its being associated with features such as body structure, age and height.

Also, handgrip strength is considered as a significant indicator in following the recovery level of physiotherapy and rehabilitation patients and the development level of children (Sinaki, 1989. Charles, Burchfiel, Fekedulegn et al 2006).

Also, it is found that it is directly associated with physical and physiological development level, forearm volume and forearm anthropometric features. Forearm parameters and handgrip strength measurements are accepted as practical way in evaluating the physical differences of children in parallel with adolescence period and in directing the children (female-male) into branches in addition to determination of children's development level (Günther, Bürger, Rickert and Schulz, 2008).

The most significant reason for the differences in the physical and physiological developments of 10-12 aged male and female children is adolescence. The 12 age group is accepted as the period in which male children enters adolescence and as the complete transition of female children to adolescence. The developmental differences of 12-year-old children have been continually discussed.

In this research done in this regard, sexual comparison was made by measuring some forearm parameters in order to get some information about the developmental differences of 12-year-old female and male children.

## 2. Materials and Methods

267 children (137 females and 130 males) whose average age is 12 (year) from different primary schools attended the study. The study was explained to the subjects and their age and sexes were recorded. Then, whether the subjects had had any disruption of upper extremities was determined. Finally, healthy children were tested.

The forearm volumes of the subjects were determined by volumetric measurement method (overflow water method). The end point of the elbow and the hem of the arm in the inner side were marked when the forearm was 90 degrees flexed. The forearm of the subject was put into the water until the marked point in the volume measurement device that was full of water and, the overflow water was determined by millimetric volumetric meter (beaker).

Takei Hand Dynamometer (Handgrip), whose validity and reliability was found high in many researches, was used in order to determine the handgrip strength and then, the highest value was recorded after 3 measurements were made. (Josaria, Marcelly and Jose, 2012, Tamer, 2000).

The forearm perimeter was recorded in cm by measuring the maximal zone perimeter by Aptamil

tape measure, which is not flexible, when the forearm was 90 degrees flexed.

In the analysis of the data; SPSS (Statistical Package for the Social Sciences) 16.0 for Windows program was used. One sample Kolmogorov Smirnov (Ksz) test was applied in order to decide what statistical technique would be used to determine whether there was difference between the sexes of the participants. The Ksz test analysis showed that the Right Forearm Perimeter, Left Forearm Perimeter, Right Forearm Volume and Left Forearm Volume variables did not show a normal distribution ( $p < 0,05$ ); and that the Right Forearm

Handgrip Strength and Left Forearm Handgrip Strength variables showed a normal distribution ( $p > 0,05$ ). For this reason, it was decided to use Mann-Whitney-U Test for the Right Forearm Perimeters, Left Forearm Perimeters, Right Forearm Volumes and Left Forearm Volumes and to use Independent Sample T-test for the Right Handgrip Strength and Left Handgrip Strength variables. The calculations were analysed by using 0,05 significance level.

### 3. Results

**Table 1. The Comparison of the Right Forearm Volumes of the Participants in Terms of Their Sex**

Sex	n (267)	Mean Rank	Sum of Ranks	U	Z	p
Female (Girls)	137	134.45	17359.00	8844.0	-0.097	0.923
Male (Boys)	130	133.53	18419.00			

There was not found a statistically significant difference at the 0,05 significance level between the "Right Forearm Volumes" of female and male children as the result of Man-Whitney-U analysis ( $U=8844,00$ ;  $p > 0,05$ ). As seen on the Table

1, the sex variable does not form a significant difference on "Right Forearm Volumes" and, female and male children have similar values in terms of Right Forearm Volumes.

**Table 2. The Comparison of the Left Forearm Volumes of the Participants in Terms of Their Sex**

Sex	n (267)	Mean Rank	Sum of Ranks	U	Z	p
Female (Girls)	137	134.11	18372.50	8890.5	-0.023	0.982
Male (Boys)	130	133.89	17405.50			

There was not found a statistically significant difference at the 0,05 significance level between the "Left Forearm Volumes" of female and male children as the result of Man-Whitney-U analysis ( $U=8890,50$ ;  $p > 0,05$ ). As seen on the Table

2, the sex variable does not form a significant difference on "Left Forearm Volumes" and, female and male children have similar values in terms of Left Forearm Volumes.

**Table 3. The Comparison of the Right Forearm Perimeters of the Participants in Terms of Their Sex**

Sex	n (267)	Mean Rank	Sum of Ranks	U	Z	p
Female (Girls)	137	130.36	17859.00	8406.0	-0.794	0.427
Male (Boys)	130	137.84	17919.00			

There was not found a statistically significant difference at the 0,05 significance level between the "Right Forearm Perimeters" of female and male children as the result of Man-Whitney-U analysis ( $U=8406,00$ ;  $p > 0,05$ ). As seen on the Table

3, the sex variable does not form a significant difference on "Right Forearm Perimeter" and, female and male children have similar values in terms of Right Forearm Perimeters.

**Table 4. The Comparison of the Left Forearm Perimeters of the Participants in Terms of Their Sex**

Sex	n (267)	Mean Rank	Sum of Ranks	U	Z	p
Female (Girls)	137	134.67	18271.50	8818.5	-0.138	0.890
Male (Boys)	130	133.37	17506.50			

There was not found a statistically significant difference at the 0,05 significance level between the "Left Forearm Perimeters" of female and

male children as the result of Man-Whitney-U analysis ( $U=8818,50$ ;  $p > 0,05$ ). As seen on the Table 4, the sex variable does not form a significant

difference on "Left Forearm Perimeter" and, female and male children have similar values in terms of Left

Forearm Perimeters.

**Table 5. The Comparison of the Right Handgrip Strength of the Participants in Terms of Their Sex**

Variable	Sex	n (267)	X	SS	t	p
Sex	Female (Girls)	137	20.233	4,639	2,749	0.006
	Male (Boys)	130	21.79	4,607		

A statistically significant difference at the 0,05 significance level between the "Right Handgrip Strength" of female and male children was found as the result of the Independent Sample T-test ( $t=2.749$ ;  $p< 0.05$ ). When looked at the average powers of the groups in order to understand who has the benefit of this difference, it is seen that the Right Handgrip

Strength of male participants ( $X_m = 21.049$ ) are higher than the Right Handgrip Strength of female participants ( $X_f = 20.233$ ). As a result, this case can be interpreted as that the Right Handgrip Strength of male participants are stronger than the Right Handgrip Strength of female participants.

**Table 6. The Comparison of the Left Handgrip Strength of the Participants in Terms of Their Sex**

Variable	Sex	n (267)	X	SS	t	p
Sex	Female (Girls)	137	19.433	4,877	2,759	0.006
	Male (Boys)	130	21.049	4,681		

A statistically significant difference at the 0,05 significance level between the "Left Handgrip Strength" of female and male children was found as the result of the Independent Sample T-test ( $t=2.759$ ;  $p< 0.05$ ). When looked at the average powers of the groups in order to understand who has the benefit of this difference, it is seen that the Left Handgrip Strength of male participants ( $X_m = 21.049$ ) are higher than the Right Handgrip Strength of female participants ( $X_f = 19.433$ ). As a result, this case can be interpreted as that the Left Handgrip Strength of male participants are stronger than the Left Handgrip Strength of female participants.

though there is difference in ages, all the phases are similar in the adolescence period (Ceyhan, 2002. Senemoğlu, 2007). Gönc, 2009)

The growth explosion of male children usually occur later than female children and the increase in muscle and bone mass is more than in females. With the adolescence, the development of children is associated with nutritional status, activity level and environmental factors. Fat rate is high on female children whereas male children have more intense muscular development. Children whose body fat content is low and who make intensive activity enter adolescence much later and, children who are obese enter adolescence at younger ages. This is very important in terms of the emotional health of children.

#### 4. Discussion and Conclusion

Physical development is the basis of maturity in the adolescence period and it differs in female and male children. In addition to biological, mental, social and emotional changes in this period, the physical and physiological developments of children have also been the subject of many researches, yet they have still being discussed.

Physical development which provides a basis for all functions and behaviours necessary for human life affects all the developments of the individual (Rice, 1997. Senemoğlu, 2007). Age is an important factor in the development of height, weight and physical features especially at young age. Also, it is known that many multilateral and significant changes occur in the adolescence period (Bukatko and Daehler, 1992. Bompa, 1999. Mengütay, 2005. Sevim, 2002. Murath, 1997. Kalyon, 1995. Açıkada, 1990. Yavuzer, 1999).

This period of children ends with changes in appearance, development in genital organs, increase in length, increase in bone-muscle mass and gaining reproductive capacity. The maturation and development of children shows an explosion in the adolescence period and its schedule changes depending on the sex (female and male). It has been told by many researchers that the average age for the beginning of adolescence for males is 12, that 95% of them enter adolescence between the 9-14 ages, that this period is between 10-12 ages for females and between 12-14 ages for males, and finally that even

It is observed in studies that in addition to the fact that activity levels and regular exercises of children in this period affect their development, even several-week-exercises can also contribute to the development significantly. (Jürimae, Hurbo, Jürimae J., 2009. Watts, Joubert, Lish, Mast and Wilkins,

2003. Watts and Joubert, 2007. Sanchis-Moysi, Idoate, Serrano-Sanchez, Dorado and Calbet, 2012)

It was significant to include 12-year-old children to the study in analysing the physical developments on females and males, and lighting the field in terms of adolescence period.

The data taken as a result of the forearm volume and forearm perimeter measurements of the children (137 females and 130 males) were compared by Man-Whitney-U test. The statistical analysis showed that there is not a statistically significant difference between the 'Right Forearm Volumes' of the female and male participants ( $U=8844,00$ ;  $p>0,05$ ). Also, there was not found a statistically significant difference at the the 0,05 significance level between the 'Left Forearm Volumes' of the participants ( $U=8890,50$ ;  $p>0,05$ ). Thus, according to the sex variable; there was not found a significant difference between the 'Right and Left Forearm Volumes' of the female and male participants and the fact that they have similar levels in terms of 'Right and Left Forearm Volumes' is obvious. (Table 1, 2)

There was not found a statistically significant difference between the 'Right Forearm Perimeters' of the subjects ( $U=8406,00$ ;  $p>0,05$ ). Also, there was not found a statistically significant difference at the 0,05 significance level between the 'Left Forearm Perimeters' ( $U=8818,50$ ;  $p>0,05$ ). Thus, according to the sex variable; there was not found a significant difference between the 'Right and Left Forearm Perimeters' of the female and male participants and, the fact that both Forearm Perimeters had similar features is obvious. (Table 3,4)

Independent Sample T-test was applied in the analysis of the sex-based handgrip strength of the participants. There was found a statistically significant difference between the 'Right Handgrip Strength' of the female and male participants ( $t=2.749$ ;  $p< 0.05$ ). When looked at the average values of the groups in order to understand who has the benefit of this difference, it is seen that the 'Right Handgrip Strength' of males ( $X_m = 21.790$  kg) are higher than the 'Right Handgrip Strength' of females ( $X_f = 20.233$  kg). (Table 5,6)

Also, there was found a statistically significant difference between the 'Left Handgrip Strength' of the subjects ( $t=2.759$ ;  $p< 0.05$ ). When looked at the values in order to decide on which sex this difference is dominant, it was obviously observed that the Left Hand Grasp average strength of males ( $X_m = 21.049$  kg) was higher than the Left Hand Grasp average strength of females ( $X_f = 19.433$  kg).

Consequently; there was not seen a significant difference between the Right and Left Forearm Volumes and the Forearm Perimeters of the

participants (137 females and 130 males) when compared according to sexes. On the other hand, there was seen a significant difference between the Right and Left Handgrip Strength of the participants. Finally, both the Right Hand and Left Handgrip Strength of the male children were higher than of the female children. Thus, it is seen that 12-year-old female and male children are similar in terms of upper extremity volumes and some antropometric measurements, and that male children are much stronger than female children. This case can be explained with the fact that the muscular development of male children are more quality than of female children and that female children have lower quality muscle structure and more adipose tissue.

### References

1. **Açıkada, C., Ergen, E.** Bilim ve Spor, Bürotek Ofset Matbaacılık, Ankara;1990.
2. **Berk, L. E.** Child development (Fifth Edition). Needham Heights, MA: Allyn and Bacon;2000.
3. **Berk, L. E.** İnfant, children and adolescents development. Needham Heights, MA: Allyn and Bacon;1993.
4. **Bompa, T.O.** Total Training For Young Champions, Human Kinetics, USA;1999.
5. **Bukatko, D. and Daehler, M. W.** Child development. Boston, MA: Houghton Mifflin Company;1992.
6. **Ceyhan, A.** Fiziksel gelişim. G. Can (Editör). Gelişim ve öğrenme (ss.43–68). Eskişehir: Anadolu Üniversitesi Yayınları, Eskişehir;2002.
7. **Charles LE, Burchfiel CM, Fekedulegn D et al.** Occupational and other risk factors for handgrip strength: the Honolulu-Asia Aging Study. *Occup Environ Med.*2006;63:820-827.
8. **Craig, G. J. and Baucum, D.** Human development (Ninth Edition). New Jersey: Prentice Hall.;2002.
9. **Gabriel YF N, Andy CCF.** Does elbow position affect strength and reproducibility of power grip measurements, *Physiotherapy*; 2001;87: 68-72.
10. **Gander, M. J. and Gardiner, H. W.** Çocuk ve ergen gelişimi. (Çev. A. Dönmez, N. Çelen ve B. Onur). İmge Kitapevi, Ankara: 1998.
11. **Gönç, E.N.** Normal Puberte Gelişimi ve Puberte Prekoks, *Hacettepe Tıp Dergisi*; 40:164-168.
12. **Günther CM, Bürger A, Rickert M, Schulz CU.** Key pinch in healthy adults: Normative values. *J Hand Surg Eur Vol*; 2009;33:144-148.
13. **Josaria F. A., Marcelly M., Jose M.N.** Comparison of three hand dynamometers in relation to the accuracy and precision of the measurements, *Brazilian Journal of Physical Therapy*, 2012;v. 16, n. 3, p. 216-24.



14. **Jürimae, T., Hurbo, T., Jürimae, J.** Relationship of handgrip strength with anthropometric and body composition variables in prepubertal children. *Homo*. 2009;60(3):225-38.
15. **Kalyon, T.A.** Spor Hekimliği Sporcu Sakatlığı ve Sporcu Sakatlıkları, GATA Basımevi, Ankara;1995.
16. **Mengütay, S.** Çocuklarda Hareket Gelişimi ve Spor, Morpa Kültür Yayıncılık, Ankara;2005
17. **Murath, S.** Çocuk ve Spor, Kültür Matbaası, Ankara;2997
18. **Nicolay CW, Walker AL.** Grip strength and endurance: Influences of anthropometric variation, hand dominance, and gender. *Int J Ind Ergon*,2005; 35:605-618.
19. **Rice, F. P. and Dolgin, K. G.** The adolescent: development, relationships, cultures (Eleventh Edition). Boston: Allyn and Bacon;2005.
20. **Rice, F. P.** Child and adolescent development. New Jersey: Prentice-Hall Inc.1997.
21. **Sanchis-Moysi, J. Idoate, F., Serrano-Sanchez, J.A., Dorado, C., Calbet, J.A.** Muscle hypertrophy in prepubescent tennis players: a segmentation MRI study. *Plos One*. 2012;7(3):e33622.
22. **Santrock, J. W.** Child development (Ninth Edition). New York: McGraw-Hill Companies, Inc.;2001
23. **Senemoğlu, N.** Gelişim Öğrenme ve Öğretim, Kuramdan Uygulamaya, Düzenlenmiş Yeni Basım, Gönül Yayıncılık, Ankara;2007.
24. **Sevim, Y.** Antrenman Bilgisi, Nobel Yayınevi, Ankara;2002
25. **Sigelman, C. K.** Rider, E. A. Life-span human development (Sixth Edition). Belmont, CA: Wadsworth Cengage Learning;2009.
26. **Sinaki M.** Relationship of muscle strength of back and upper extremity with level of physical activity in healthy women. *Am J Phys. Am J Phys. Med. Rehabil.*1989; 68:134-138.
27. **Smith, P. K.** Cowie, H. and Blades, M. Understanding children's development (Fourth Edition), Oxford: Blackwell Publishing.2003.
28. **Tamer, K.** Sporda Fiziksel ve Fizyolojik Performansın Ölçülmesi ve Değerlendirilmesi, Bağırğan Yayınevi, Ankara;2000.
29. **Visnapuu, M., Jürimae, T.** Handgrip strength and hand dimensions in young handball and basketball players. *J Strength Cond Res*. 2007 Aug;21(3):923-9.
30. **Watts, P.B., Joubert L.M., Lish, A.K., Mast, J.D., Wilkins, B.** Anthropometry of young competitive sport rock climbers. *Br J Sports Med*. 2003;37(5):420-4.2003;37(5):420-4.
31. **Willmore, J.H., Costill, D.L.** Physiology of Sport and Exercise, Human Kinetics, America;1994
32. **Yavuzer, H.** Çocuk Psikolojisi. (17. Basım), Remzi Kitabevi. İstanbul;1999.
33. **Yazgan İnanç, B., Bilgin, M. ve Kılıç Atıcı, M.** Gelişim psikolojisi: Çocuk ve Ergen Gelişimi, Nobel Yayınevi, Adana;2004.

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