Comparison of Anthropometric Indices of 10-16 Years Old School Girls with the NCHS International Standard

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Abstract
Introduction: One of the most important international indicators for assessing growth and physical health is measuring weight, height, BMI and other parameters of growth and development and comparing it with standard curves. Accordingly, the purpose of this study was to compare anthropometric indices of 10- 16 years old school girls with the NCHS iternational standard.
Methods: In this descriptive cross-sectional study, 267 female students aged 10 to 16 year-old in Taft city were randomly selected through cluster sampling and the mean and standard deviation of their anthropometric indices in their age ranges with related methods were measured and compared to the National Center for Health Statistics (NCHS) standard. Finally, the data were analyzed using both descriptive and inferential statistics including Kolmogrov- Smirnov and single sample t-test at a significance level of less than 0.05.
Results: The results showed that weight, triceps skinfold thickness, subscapular skinfold thickness of students in all age ranges were significantly lower than NCHS standard (p ≤0.05). But the height, body mass index, mid arm circumference, waist circumference, upper leg length and upper arm length of students in some age groups were significantly lower than the NCHS standard (P ≤0.05), and in other age groups, there was no significant difference (P≥ 0.05).
Conclusion: The results of this study showed that the anthropometric characteristics of these students are less than international standards. Significant changes made in some of these anthropometric indices can be due to the geographical, climatic, nutritional and physical activity of students, which should be given more attention.
Keywords: Anthropometric Indices, Female students, NCHS Standards

Introduction

Children are considered as the capital of each country whose health is a guarantee of the health of the succeeding generation. Physical measurements and comparison of children with well-known indicators are important in the assessment and health of the individuals and, if conducted continuously and periodically, can be a good indicator for monitoring the growth and performing executive and educational plans in the community (1). The most common method of growth monitoring in children is to measure anthropometric indices (1). Anthropometry is

derived from the two Greek words *Anthropos*, meaning human, and *metron* meaning measurement, and is known as the science of measuring body dimensions (1). Anthropometrics generally includes measuring different sizes of the body length, weight, body size, space and motor angles of each of these organs (1, 2). Anthropometry, as a method of obtaining useful information from a large number of subjects, is widely used in the research literature of physical education and sports sciences researchers (3). Currently, the World Health Organization (WHO) has recommended the National Center for Health

Statistics (NCHS) standard curves to assess the status of children's development in all countries (3). The NCHS standard is the reference for anthropometric information for adults and children of the United States collected by the National Association of American Health Statistics (3, 4). Several studies have been done to compare anthropometric characteristics with standard indicators. For example, Nemati *et al.* (2009) investigated the anthropometric factors of 7-10 years old girl students in Ardebil and compared it with the NCHS standard (5). In this research, 3996 urban and rural girls aged 7-19 years old were selected by multi-stage sampling method. The mean, standard deviation and different percentiles of 5, 10, 25, 50, 75, 90, 95, Height, weight and body mass index were calculated for all ages and compared to NCHS standard and other regions of Iran. The results showed that in 11.7% of girls, their body mass index was below the fifth-percentile of NCHS, indicating their slimming. Also, mean height and weight of urban girls were higher than their peers. The study showed that the height and weight of girls in the city of Ardebil is lower than the NCHS standard and is low in comparison with other parts of the country (5). Mahyar *et al.* (2011) investigated the weight, height, and BMI of girls aged 12-18 years old in Qazvin. The results showed that the mean height of girls aged 12-18 years was lower and the mean weight of girls aged 18, 17, 16, 15 years was lower than the optimal level. But the average BMI for girls aged 18, 16, 15, 14, and 12 years was higher than acceptable levels (6). The study of Mosavijam *et al.* (2000) on the height and weight of children aged 7-15 years in urban areas of Kurdistan province showed that the median, mean and percentiles of children's weight were lower than NCHS values (7). Banner *et al.* (2015) conducted a similar research in Qatar on girls aged 6-18. The results showed that the weight of Qatari female students is higher than the NCHS standard and their height is lower than that (8).

Lorenzo *et al.* (2005) examined the height, weight, and BMI of Italian girls aged 12 to 6 years old. The results showed that the growth of Italian girls is very little different from the NCHS standard (9). In Iran, the ministry of health and medical education has developed a standard growth montoring that meets the conditions of our country, and is used in health centers and health homes (10). Naturally, the severity of the factors affecting the development of children in all provinces of the country is not the same. Yazd province is one of the central provinces that has a variety of factors affecting the development of children. The above-mentioned problems led the researcher to compare the anthropometric indices of 10-16-year-old girls in Taft city with the NCHS curve to address the results for various topics such as athletic scouting, sports pathology, correction of abnormalities, ergonomics, growth and health monitoring and nutritional considerations.

Methods

In this study, 267 girls aged 10- 16 years old in the city of Taft were selected randomly based on Morgan sampling formula. After obtaining a letter from the Taft Education Department and coordinating with school administrators and teachers, the researcher attended schools and tested all 267 students. The criteria for inclusion in the present study were those who were physically healthy and had neither orthopedic nor clinical problems affecting the results of the study. Anthropometric features that were evaluated in this study included height (cm) (standing position), weight (kg), upper leg length (cm), mid arm circumference (cm), waist circumference (cm) , triceps skinfold thickness (cm), subscapular skinfold thickness (cm), upper arm length (cm) and body mass index (kg / m^2). The measurement was as follows: At first, the subjects were divided into groups of 10. Their height and waist circumference were measured by tape meter, and later their weight was measured by scale. Then, by marking the hands and feet, the

measurement locations were determined and skinfold thickness in these areas was measured by caliper. All of the measurements were performed on three cyclic measurements, and the data were recorded in the special sheet of specifications and measurements. In this vein, this research carried no risk, harm and suffering in terms of intervention and measuring methods. Informed consent was received from the subjects, and all subjects were free to withdraw from the tests whenever they wished. Height of the students was measured by a tape meter connected to the wall, with the subjects' legs stuck together, while the knees, hips, shoulders, and the rear were along a vertical line, head straight and the arms placed freely on both sides. After tangling the ruler with the center of head, height was recorded with a precision of 0.5 cm. To measure the weight, subjects with a minimum dress and no shoes were measured by a 150 kg German scale of the SOEHNLE model with a precision of 0.1 kg. In order to increase the accuracy of the measurement, each subject was weighed three times and the mean of the measurements was recorded as the final weight. To measure skinfold thickness Germany-made Vagl caliper was used. First, about 2 centimeters above the region was taken using thumb and index finger and the caliper was put on it; then, after 2 seconds, the number displayed by the dial caliper was recorded. All measurements were taken from the right side of the body. Measurements were repeated 2 times, and if the difference was more than 2 mm, then the measurements were made for the third time and the average of the two numbers closest to each other was recorded. Meanwhile, the distance between each measurement was 15-20 seconds. For Triceps skinfold thickness, a layer was vertically measured by caliper in the middle of the posterior median line of elbow and in the middle part of the acromion and Olecranon process, while the hands were in an anatomical position. Subscapular skinfold thickness was diagonally measured just below the lower

scapular angle with a 45 degree angle from the horizon line to the midline of the body. In a standing position, the waist circumference was measured around the navel using a tape meter at the end of a normal inhalation without contraction in the abdominal muscles. Body mass index (BMI) was calculated by dividing weight by height squared (kg/m^2).

In addition, in this study, descriptive statistics included presentation and tabulation of tables and frequency distribution to describe the existing situation, calculating measures of central tendency and dispersion including mean and standard deviation. On the other hand, inferential statistics included Kolomogrov- Smerinov test to determine the normal distribution of samples as well as single sample t-test.

Results

Table 1 shows the number of participants and their age range. As shown, the participants in the study were 10 to 16 years old, and total of 267 people. The results of comparison of the mean weight of girls aged 10-16 years with the NCHS standard showed that there is a significant difference between the weight of 10-16 year old students with NCHS standard (10 age, p=0.033; 11 age, p=0.009; 12 age, p=0.008; 13 age, p=0.005; 14 age, p=0.005; 15 age, p=0.041; 16 age, p=0.006) also the weight of students in all age ranges is less than the NCHS standard (Fig. 1). The results of comparison of mean height of girls aged 16-10 years with NCHS standard with independent t-test shown that the height of students aged 10, 11, 13 and 14 years old in Taft population was significantly lower than the NCHS standard, but there was no significant difference in the age groups of 12, 15 and 16 years (10 age, p=0.007; 11 age, p=0.008; 12 age, p=0.061; 13 age, p=0.043; 14 age, p=0.031; 15 age, p=0.072; 16 age, p=0.074) (Fig. 2). The results of comparison of the mean body mass index (BMI) of 10-16 year old girls with NCHS standard with independent t-test showed that there was a significant difference between the

BMI of 10-16 year old students in Taft city with NCHS in the age groups of 12, 13, 14, 15 and 16 years, but there was no significant difference in the age groups of 10 and 11 years (10 age, p=0.059; 11 age, p=0.066; 12 age, p=0.004; 13 age, p=0.006; 14 age, p=0.006; 15 age, p=0.001; 16 age, p=0.003) (Fig. 3). The results of comparison of the mean triceps skinfold thickness of the 10 to 16-year-old female students with the NCHS standard with independent t-test showed that there is a significant difference between triceps skinfold thickness of 10 to 16-year-old students in Taft city with the NCHS standard, and in all age groups it is lower than NCHS standard (10 age, p=0.009; 11 age, p=0.004; 12 age, p=0.008; 13 age, p=0.001; 14 age, p=0.006; 15 age, p=0.038; 16 age, p=0.008) (Fig. 4). The results of comparison of subscapular skinfold thickness in 10-16 year old female students with NCHS standard with independent t-test showed that there is a significant difference between subscapular skinfold thickness in 10- to 16-year-old students in Taft city with the NCHS standard, and subscapular skinfold thickness in all age groups is lower than the NCHS standard (10 age, p=0.000; 11 age, p=0.002; 12 age, p=0.006; 13 age, p=0.005; 14 age, p=0.004; 15 age, p=0.000; 16 age, p=0.007) (Figure 5). The results of comparison of mean mid arm circumference of female students aged 16-10 years with NCHS standard with independent t-test showed that there was a significant difference between mid arm circumference of the students aged 10-16 years old in Taft city with NCHS standard in the age groups of 11, 15 and 16 years, but in the age groups 10, 12, 13 and 14 there was no significant difference (10 age, p=0.58; 11 age, p=0.032; 12 age, p=0.71; 13 age, p=0.059; 14 age, p=0.85; 15 age, p=0.028; 16 age, p=0.019) (Fig. 6). The results of comparison of mean waist circumference of girls aged 10-16 years with the NCHS standard with independent t-test showed that there was a significant difference between the waist

circumference of students aged 10-16 years old in Taft city with NCHS standard in the age groups of 11, 12 and 13 years but in the age groups of 10, 14, 15 and 16 years there was no significant difference (10 age, p=0.077; 11 age, p=0.007; 12 age, p=0.006; 13 age, p=0.006; 14 age, p=0.085; 15 age, p=0.076; 16 age, p=0.058) (Fig. 7). The results of comparison of the mean upper leg length of girls aged 10-16 years with the NCHS standard with independent t-test showed that there was a significant difference between the upper leg length of 10, 11, 12, 13, and 14-year old students of Taft city with a NCHS standard, but in the age group of 15 and 16 years there was no significant difference (10 age, p=0.011; 11 age, p=0.016; 12 age, p=0.026; 13 age, p=0.028; 14 age, p=0.031; 15 age, p=0.88; 16 age, p=0.082) (Fig. 8). The results of comparison of the mean upper arm length of the girls aged 16-10 years with the NCHS standard with independent t-test showed that there was a significant difference between the upper arm length of 10-16 year old students in Taft city with NCHS standard in the age group of 11, 15 and 16 years old, but in the age groups of 10, 12, 13 and 14 years there was no significant difference (10 age, p=0.84; 11 age, p=0.013; 12 age, p=0.69; 13 age, p=0.51; 14 age, p=0.42; 15 age, p=0.042; 16 age, p=0.044) (Fig. 9).

Table 1. Subjects participating in the study

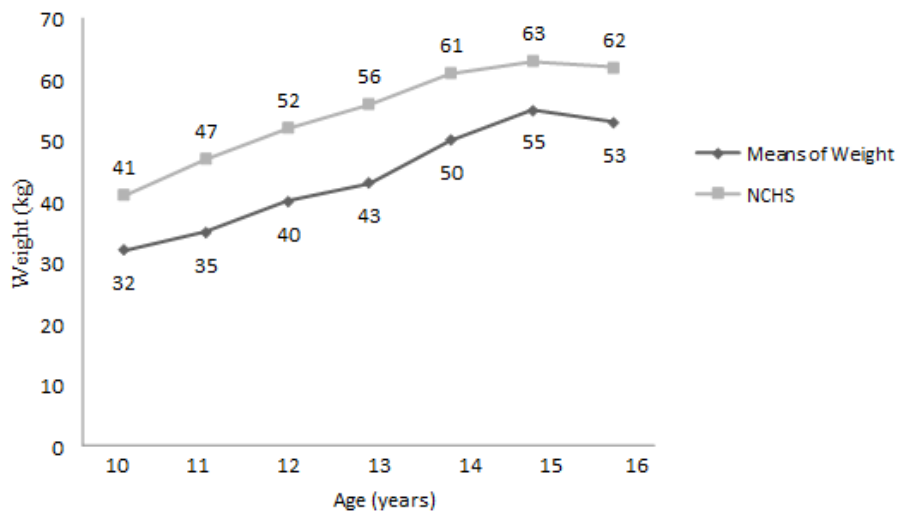| Age Group (Year)	Number	Percent
10	17	6.4
11	48	18
12	53	19.9
13	26	9.7
14	43	16.1
15	38	14.2
16	42	15.7
total	267	100

Figure1. Comparison of the mean weight of girls
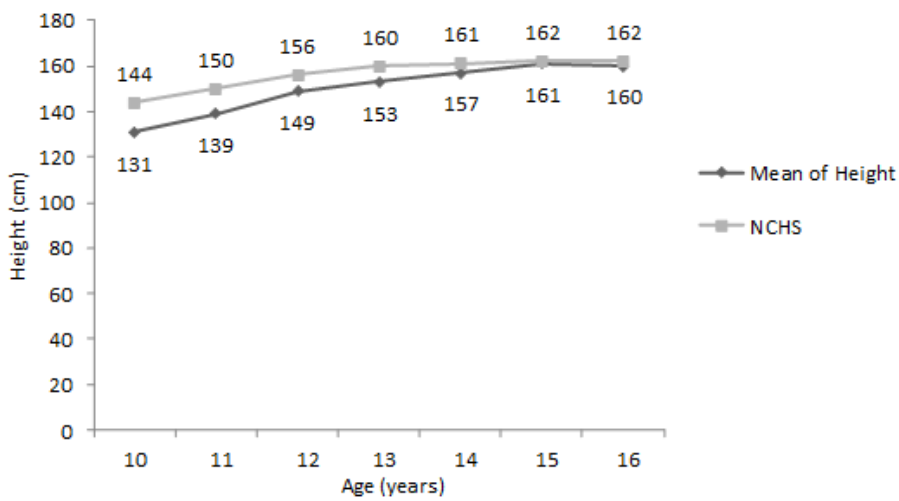

Figure2. Comparison of mean height of girls
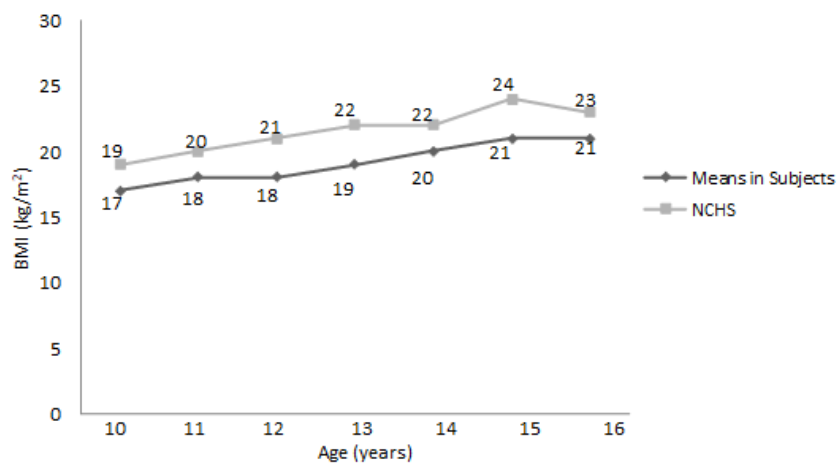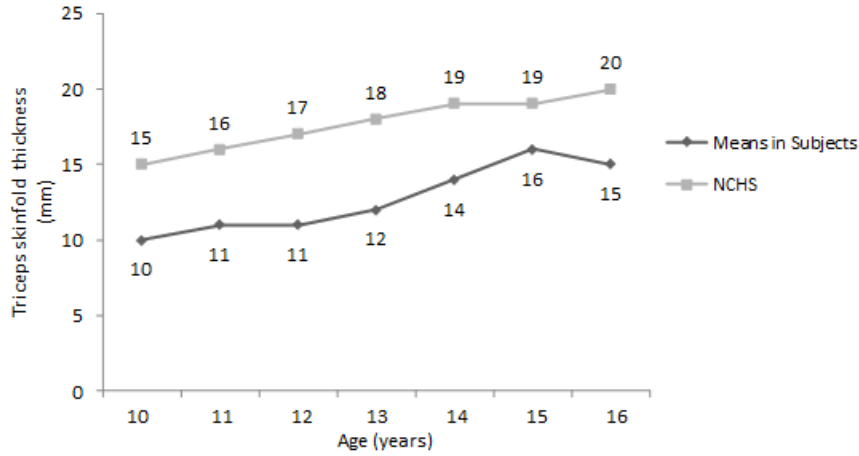

Figure3. Comparison of the BMI

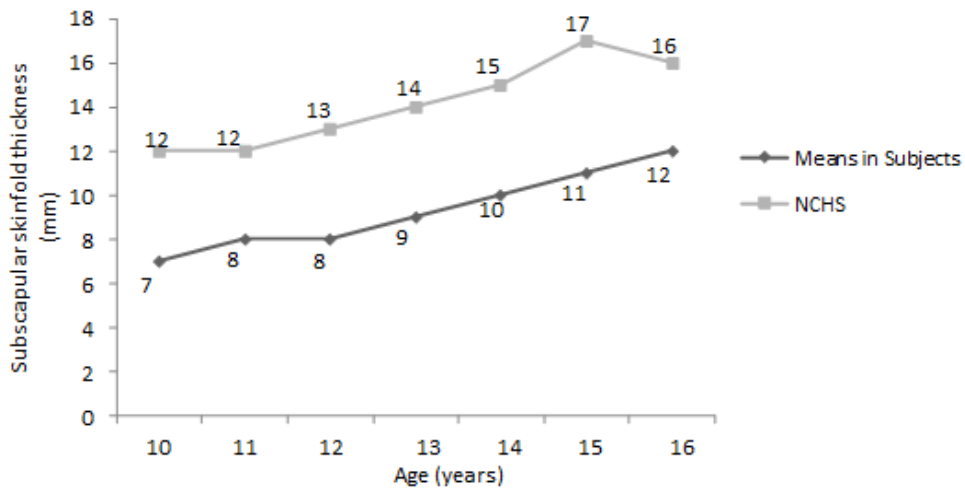**Figure 4.** Comparison of the mean triceps skinfold thickness

Figure 5. Comparison of subscapular skinfold thickness
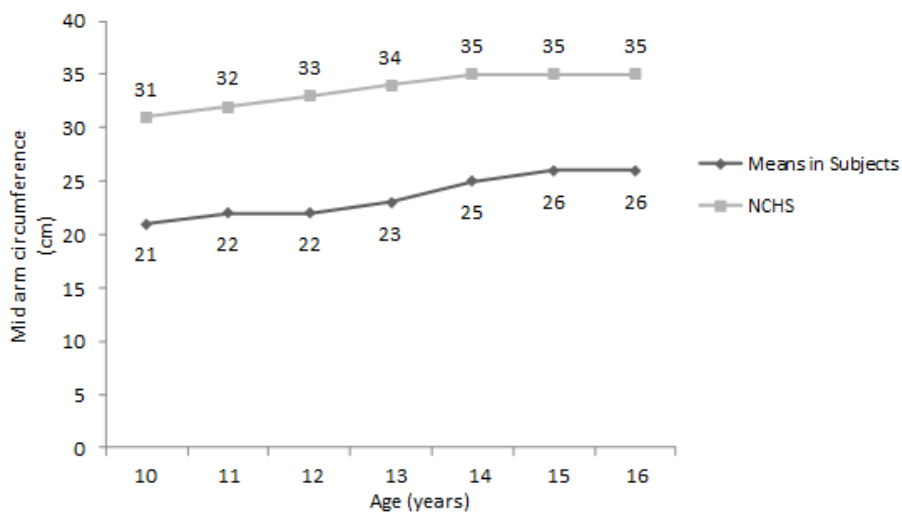

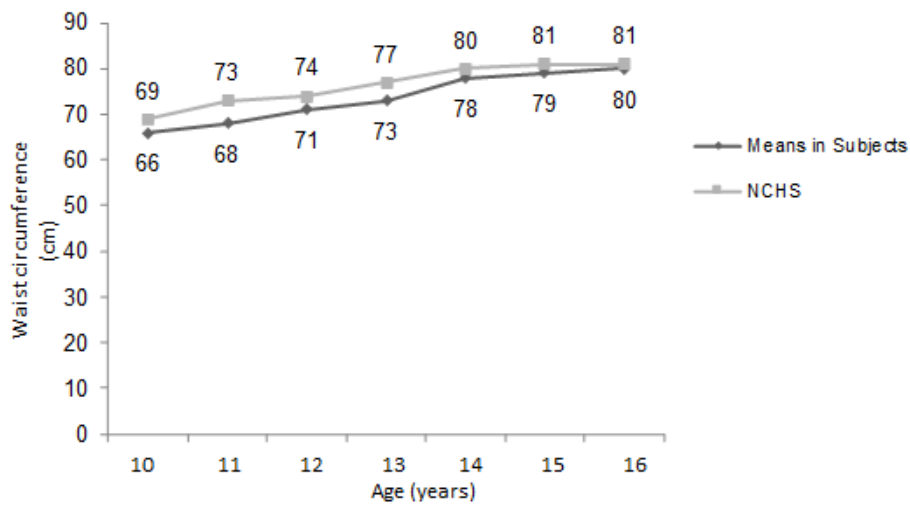**Figure6.** Comparison of mean mid arm circumference

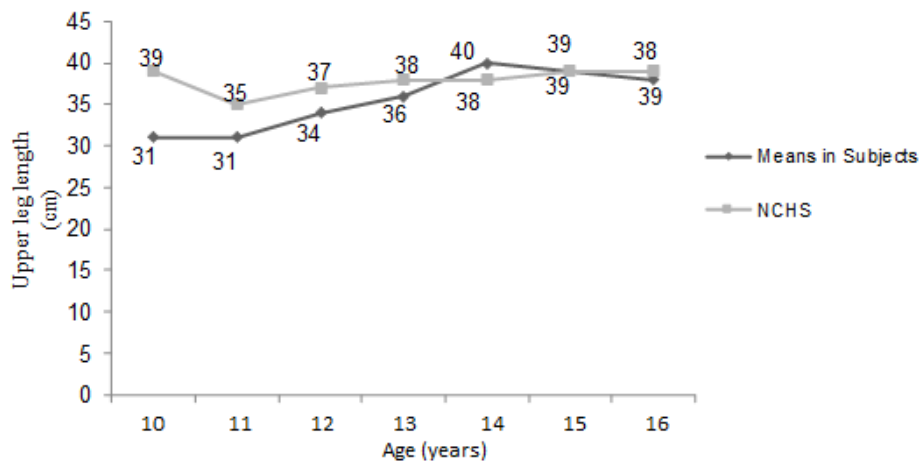**Figure 7.** Comparison of mean waist circumference

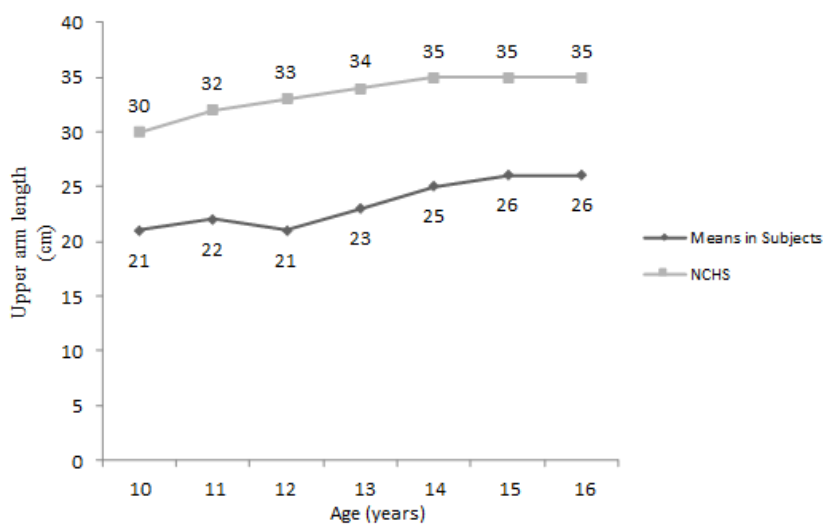**Figure 8.** Comparison of the mean upper leg length

Figure 9. Comparison of the mean upper arm length

Discussion

The results showed that the weight of students aged 10-16 years in Taft city was significantly different from NCHS standard, so that the weight of students in all age range was lower than NCHS standard. The results of this part of the research are consistent with the research by Montazerifar *et al.* (2006) (10), Nemati *et al.* (2009) (5), Ahmadi *et al.* (1999) (11) and MosaviJam *et al.* (2000) (7). However, they do not match with the results of Banner *et al.* (2015) (8), Jalalvand *et al.* (2006) (12) and Namakian *et al.* (2016) (13). The results of Banner *et al.* (2015) study showed that the weight of Qatari students was higher than the reference standard and their height was lower than the standard, and suggested increasing their daily physical activity to prevent an increase in the number of obese students (8). Research conducted in Qatar, America, Italy, France and Punjab showed that the weight of child and adolescent girls is increasing and they tend to obesity.Various factors such as inactivity, high fat intake and snacks consumption can play an important role in weight gain (16-20). Overall, the results of the research showed that students of Taft city are not well-off and are likely to face nutritional problems. Accordingly, careful follow up of the growth process, regular physical activity and proper nutrition in girls to achieve a global reference standard and health needs is essential. Therefore, in order to achieve better and more effective results, long-term researches are needed at the level of counties and provinces, so that by providing national norms related to indices, we can accurately control the process of development of children and adolescents at all stages of the age. The results of the height of the subjects showed that the height of 10-16 year old students in Taft city was lower than the NCHS standard in the age groups of 10, 11, 13 and 14 years old, which is consistent with Montazerifar *et al.* (2006) (10), Nemati *et al.* (2009) (5), MosaviJam *et al.* (2000) (7), but there was no significant difference between the age groups

of 12, 15 and 16 years. Growth in height is influenced by many factors such as race, geographical area, nutrition, general culture and family economic status, which ultimately causes changes in the health and the natural pattern of the growth of children in different parts of the world. The range of height changes in children's age groups is wide and, of course, by measuring the height in children and comparing them to the standard, one can judge the process of changes in the above index. Of the factors affecting growth in height, gender is usually a significant variable from birth. The prevalence of stunting in girls in the aforementioned age groups is indicative of chronic malnutrition in children (21-25). In the present study, the results showed that body mass index of students aged 10-16 years old in Taft city was significantly different from NCHS standard in groups of 12, 13, 14, 15 and 16 years, which match the results of Nemati *et al.* (2009) (5) and Montazierfar *et al.* (2006) (10), but did not match the results of mahyar *et al.* (2011) (6). On the other hand, there was no significant difference between the 10 and 11 years age group. According to scientific findings, BMI is rising in girls during childhood and modest changes occur at age 5-6, and then again the ascension progresses until the ages of 13 to 15 years, and is reduced when they reach the age of adulthood (17 years old). It should be noted that the BMI increases with age, so one should not expect a crucial index of body composition in children. The main weakness of the BMI is to ignore the fact that muscle tissue in comparison to fatty tissue may contribute more to overweight. Investigating triceps skinfold thickness showed that in all age groups of 10- to 16-year-old students in Taft city it was lower than the NCHS standard. The results of this part of the research are in line with the research by Joshi *et al.* (2005) (15). Various reasons can be noted for the low level of triceps skinfold thickness of these students compared with the reference standard. Among the most important factors race, nutritional problems,

environmental conditions and high activity can be mentioned, which may be due to insufficient attention of parents and relevant organizations to the nutrition in the period of growth and maturity as well as the weakness of the household's economic situation. The results of a study conducted in Nepal by Joshi *et al.* showed that anthropometric indices have a direct relationship with factors such as education level and family status. Also, subscapular skinfold thickness in 10-16 year old students in Taft city is lower in all age groups than the NCHS standard. The results of this part of the study are consistent with Joshi *et al.* (2005) (15). The results of the present study also indicated that the mean mid arm circumference of the students in Taft city aged 11-, 15-, and 16-years was lower than the NCHS standard. The results of this part of the study were consistent with Joshi *et al.* (2005) (15), but there was no significant difference in the age groups of 10, 12, 13 and 14 years. It was shown that the waist circumference of the students aged 16 to 10 years in Taft city was lower than the NCHS standard at the age groups of 11, 12 and 13 years . The results of this part were in line with the results of Joshi *et al.* (2005) (15), but there was no significant difference in age groups of 10, 14, 15 and 16 years. Also, the results showed that the upper leg length of the students aged 10, 11, 12, 13 and 14 years old in Taft city was significantly different from the NCHS standard, and the results of this part of the study were in line with the results of Joshi *et al.* (2005) (15), but there was no significant difference in the age groups of 15 and 16. It was further shown that the upper arm length of the students aged 10-16 years in Taft city is lower in the age group of 11, 15 and 16 years than the standard NCHS. The results of this section of the study were in line with the results of Joshi *et al.* (2005) (15), but there was no significant difference in the age groups of 10, 12, 13 and 14 years. The findings of this study, while describing the existing situation and providing information about the anthropometric characteristics and physical composition of girls aged 16-10 years old in Taft during the above-mentioned period, can attribute to sports scouting, growth monitoring, nutritional considerations, and design of public structures. Factors affecting the results of this study compared with others studises can be due to race characteristics, weather, nutritional status, physical activity and other factors. The present study contained some limitations that could affect the outcome of the research, such as the gender of the subjects, the impossibility of selecting the same number of girls and boys, and the research community. It is suggested that other studies be conducted with more people and in both sexes in different age groups in different provinces.

Conclusion

Based on the results of this study that the female students had lower weight and skinfold thickness than the reference standard, the difference in economic status and dietary habits may be due to this difference. Considering the results of this study, it is necessary to improve the body composition of the future generation, especially girls, who are mothers of the coming days. By increasing the awareness and education of families in illumination and explication of the growth curve and with a comprehensive educational and executive planning, we can prepare the background to promote the growth and development of children. The results of this study provide a background for further research to investigate the growth of children in all regions of the country and to determine the appropriate standards for the development of Iranian children. In this way, it is possible to study the body composition of children with a more precise criterion and, with proper planning, proceed to take a more effective step in the health and well-being of children.

Ethical issues

The present study was approved by the Islamic Azad University of Taft Branch.

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