ORIGINAL ARTICLE

How Appropriate are the Lengths of Syringe Needles Used for Subcutaneous Injections to the Children at School Age?

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ABSTRACT

Objectives: *To define the normal ranges of the thicknesses of the skin and subcutaneous tissues via ultrasonography, and determine whether the current syringe needle-lengths used for the subcutaneous injections were appropriate.*

Methods: *The thicknesses of the skin and subcutaneous tissues of 2244 students were measured at the left arm using ultrasonography. The patients were divided into three groups based on their age: 6–8, 9–12 and 13–17 years.*

Results: *The thicknesses of the skin, subcutaneous tissue and skin-subcutaneous tissue were found to be positively correlated with their age, body mass index (BMI) and body surface area. All these were observed to be gender related. There was the possibility to make intramuscular injections for 50%, 25% and 25% of boys within the age groups of 6–8, 9–12 and 13–17 years, respectively. For girls, the risk of intramuscular injection was 25% for all the age groups.*

Conclusion: *The study showed that the skin and skin-subcutaneous tissue thicknesses varied as a function of the patients' age, gender, BMIs and body surface areas.*

Keywords: Children, normal values, skin-subcutaneous.

INTRODUCTION

There has been a rapid increase in the development of pharmaceutical products, and the transdermal route and subcutaneous injection methods of parenteral drug application. It was reported (1, 2) that the skin thicknesses change was correlated with age and gender, while further studies showed that these thicknesses did not seem to be correlated with age, gender, body weight and ethnic groups (3, 4). Nonetheless, these studies were conducted on small sample sizes. It had been known that the subcutaneous tissue thicknesses changed considerably as a function of gender and body mass (5, 6).

There were many studies carried out on large sample sizes which investigated the skin fold thicknesses with a caliper. However, very few studies existed, which measured the skin and subcutaneous tissue thicknesses with ultrasonography (USG) and these studies were done on a small sample space (7–10). Thus, this is an area requiring further investigation. There are also no data published from our country, which had determined the reference ranges among children and adolescents. The first radiological data providing skin and subcutaneous tissue thicknesses in adults were obtained by computerized tomography (CT) and thereafter by USG (11–14). For the investigation of the skin and subcutaneous tissues in children, USG was a more suitable method in avoiding the risk of radiation (15).

Currently, there are very limited data regarding skin thickness in children. In this study, we had many objectives. Firstly, we aimed to obtain the percentile curves for the thicknesses of the skin, subcutaneous tissue and skin-subcutaneous tissues congruent with the patients' age, and gender by employing an evidence-based methodology through the measurements of the skin and subcutaneous tissue thicknesses in adolescents and children with USG. Secondly, we wanted to determine whether the current syringe needle lengths used for the subcutaneous injections were appropriate.

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MATERIALS AND METHODS

Methodology

After the research-oriented school screening was approved by the Chairman of the Clinical Research Ethics Committee of the Yüzüncü Yıl University-Medical Faculty, a second approval was also obtained from the National Education Directorate in the city of Van. Equal numbers of schools were selected to represent the various socio-economic backgrounds. Private schools were not included in this study. Written and verbal information were given to 5000 students, and consent forms were sent to their home addresses to obtain their consent of the parents. The exclusion criteria were as follows: subjects receiving daily subcutaneous injections; the subjects suffering from serious systemic disease; and those who did not allow the measurement of either their body weights or heights were excluded from the study; despite their approval for USG measurements, 2244 students representing nine different schools under the regulation of the National Education Ministry in the city of Van were included in the study. Because there are hormonal and physiological differences according to the puberty situation, patients were divided into three groups based on age: 6–8, 9–12 and 13–17 years. The study team included a radiologist, a paediatric resident and four healthcare professionals. They were trained in the techniques and the standardization of the methods used. The team used the equipment at the schools they attended to at 7:30 AM. The measurements were done between 8:00 and 12:00 mid-day. In all the participants, anthropometrics (weight, height), the thicknesses of the skin and subcutaneous tissues were measured with the USG. Throughout the study, individual procedures were performed by the same team member.

Measurements

In all the students, their dates of birth, gender and ages were recorded. The anthropometrics were done before the USG. Their weights were measured with NAN device (İstanbul) sensitive to 50 g. Their body weights were measured without shoes with only thin clothes; their arms were parallel to the body and in the neutral position. Their heights were measured using a Seca stadiometer at a 90° angle to the floor and according to the parameters established by Jelliffe and the World Health Organization (16, 17). Their thicknesses of the skin and subcutaneous tissues were measured with the USG on the left arm, when the students were on a sitting position and their elbows on flexion. Their measurement location was standardized by using skin surface or palpable landmarks in order to minimize intersubject measurement variability. In the arms, the measurements were made 5 cm below the acromion process in the children aged ≤ 13 years, while it was made below 10 cm in children aged > 14 years.

Materials

Their body weights were assessed using a calibrated standard balance beam. Their heights were measured by a standard height bar, and their body mass index (BMI) was calculated as body weight (kg) divided by square height (m^2). Their body surface area (BSA) was calculated using the Du Bois formula: BSA = Weight (kg)$^{0.425}$ × Height (cm)$^{0.725}$ × 7184 × 104.

Ultrasonography

The Philips HD-11™ US unit with a 7.5 MHz transducer/probe (Bothell, WA, USA) was used. After ultrasonic gel was applied, the probe was placed perpendicularly to the predetermined area of the body site without a spacer. During the scanning process, the probe was moved within the marked area to obtain clear and focused images. The screen was frozen when a clear view of the skin and/or neck was obtained and the thickness of skin was at the level of triceps muscle in the posterior arm. All the measurements were done by a single technician. On screen measurements were verified by printing the copies of the images.

Statistical analyses

Statistical analyses were performed with the SPSS 13 package software (SPSS Inc, Chicago, IL, USA). The mean, median, standard deviation (SD), minimum, maximum, and 95% confidence intervals (CIs) were measured for the entire sample, for each paediatric subgroup and for the other grouping parameters such as gender, BMI, skin and subcutaneous tissues. The comparison of the subgroups was done with Chi-square and Kruskal–Wallis tests, and correlation analyses were done by using Spearman correlation analysis and the threshold for statistical significance was $\alpha = 0.05$.

RESULTS

The demographical characteristics of the students are shown in Table 1. A total of 2244 students consisting of 986 boys and 1258 girls were included in this study. They were divided into age subgroups to facilitate the analyses. The age ranges of the groups were determined according to their puberty stages. Group 1, Group 2 and Group 3 were determined as students of ages 6–8, 9–12 and 13–17 years, respectively. There were no statistical differences between these groups according to their gender ($p > 0.05$). The demographical characteristics of the study's sample are shown in Table 1.

Skin thicknesses

The skin thicknesses increased in relation to their increasing ages, BMI and BSA, and they exerted a significant correlation with each of these three parameters ($p < 0.001$, for all). The median values of the thicknesses of the cutaneous tissue, subcutaneous tissue and cutaneous–subcutaneous tissue as a function of their gender are shown in Table 2. The mean and median values and the SDs of the thicknesses of the skin, subcutaneous tissue and skin-subcutaneous tissues according to the three different age groups are displayed in Table 3. An intergroup evaluation revealed that the skin thicknesses of the children in group 3 were significantly higher than those in group 1 and group 2 ($p = 0.000$, for both comparisons). Although the comparisons with group 3 revealed significant differences both for group 1 and group 2, the difference between group 2 and group 3 was more prominent ($p < 0.003$ and $p < 0.000$, respectively).

The percentile curves of the skin thicknesses according to their ages are shown in Table 4. The average values of the skin thicknesses according to the BSA are shown in Table 5. The skin thicknesses were significantly higher in girls in comparison with boys ($p < 0.001$). An intragroup assessment revealed that the skin thicknesses showed significant differences regarding gender in all the age groups ($p < 0.033$, $p < 0.009$ and $p < 0.005$ for the 1st, 2nd and 3rd groups, respectively).

The subcutaneous tissue thicknesses

The subcutaneous tissue thicknesses increased in association with the increasing values of their ages, BMI and BSA, and exerted statistically significant correlation with each of these three parameters ($p < 0.001$, for all). An intergroup assessment revealed that the skin thicknesses of the children in group 3 were significantly higher than those of both group 2 and group 1 ($p = 0.002$, $p = 0.001$, respectively). Although there was a significant difference between group 1 and group 3, the difference between group 1 and group 2 was insignificant ($p = 0.001$ and $p = 1.00$, respectively).

The percentile curves of the subcutaneous tissue thicknesses according to their ages are shown in Table 4. The average values of the subcutaneous tissue thicknesses according to the BSA are shown in Table 5. The subcutaneous tissue thicknesses were significantly higher in girls in comparison with boys ($p < 0.001$). An intragroup assessment revealed that the subcutaneous tissue thicknesses exerted significant differences regarding the subjects' gender in all the groups ($p = 0.000$,

Table 1: The demographical characteristics of the study's sample

	Ages: 6–8	9–12	13–17
Number	556	957	731
Girls/boys	295/261	543/414	420/311
Chronological age (years)	7.65	10.7	15.1
BMI	26.9	34.3	47.7
BW (kg)	27	41.1	47.73
Height (m)	1.3	1.39	1.54

BMI = body mass index; BW = body weight.

Table 2: The median values of the thicknesses of the cutaneous tissue, subcutaneous tissue and cutaneous–subcutaneous tissue as a function of gender

	C. tissue thickness	SC.tissue thickness	C.-SC. tissue thickness
Gender	**Med. (R)**	**Med. (R)**	**Med. (R)**
Boys	1 (14.8)*	2.9 (18.4)*	4.0 (18.7)
Girls	1 (6.9)	3.3 (9.6)	4.4 (10.6)

Med. (R) = median (range), *: $p < 0.001$. C. = cutaneous; SC. = subcutaneous; C.-SC. = cutaneous-subcutaneous.

Table 3: Mean and median values of the thicknesses of the cutaneous tissue, subcutaneous tissue and cutaneous–subcutaneous tissues as a function of the age groups

	C. tissue thickness	SC.tissue thickness	C.-SC. Tissue thickness
	μ ± σ ± SD mm Med	μ ± σ ± SD mm Med	μ ± σ ± SD mm Med
Age	**B/G**	**B/G**	**B/G**
6 to 8	0.97 ± 0.21–1.00/1.01 ± 0.24–1.00	3.14 ± 1.03–2.9/3.49 ± 1.19–3.3	3.96 ± 1.32 – 3.90/ 4.31 ± 1.56 – 4.46
9 to 12	1.04 ± 0.47–1.00/1.06 ± 0.37 – 1.00	3.23 ± 1.30–2.9/3.45 ± 1.3–3.2	4.12 ± 1.6 – 4.00/ 4.29 ± 1.72 – 4.20
13 to 17	1.2 ± 0.90–1.20/1.20 ± 0.40–1.30	3.25 ±1.70–2.9/4.03 ± 1.46–3.8	3.6 ± 2.56–4.10/ 3.39 ± 2.88–5.20

B = boy, G = girl; mean ± SD = mean ± standard deviation; med. = median; C.-SC. = cutaneous–subcutaneous.
μ: mean.
σ: standard deviation.

Table 4: The percentiles of the thicknesses of the cutaneous tissue, subcutaneous tissue and cutaneous-subcutaneous tissue as a function of the age groups

Boy								Girl						
Tissue thickness 5 p.	**10 p.**	**25 p.**	**50 p.**	**75 p.**	**90 p.**	**95 p.**	**Age groups**	**5 p.**	**10 p.**	**25 p.**	**50 p.**	**75 p.**	**90 p.**	**95 p.**
0.70	0.71	0.80	1.00	1.10	1.30	1.30	**6–8**	0.70	0.80	0.90	1.00	1.20	1.30	1.50
0.70	0.80	0.90	1.00	1.20	1.30	1.50	**8–12**	0.80	0.80	0.90	1.00	1.20	1.40	1.50
0.70	0.80	0.90	1.20	1.40	1.60	1.90	**12–19**	0.80	0.90	1.00	1.30	1.40	1.60	1.70
SC. **Tissue thickness**														
1.70	2.02	2.50	2.90	3.60	4.68	5.14	**6–8**	1.70	2.10	2.70	3.30	4.10	5.00	5.70
1.70	2.00	2.42	2.90	3.70	4.60	5.79	**8–12**	1.80	2.20	2.60	3.20	4.00	5.03	6.01
1.70	1.90	2.30	2.90	3.60	4.90	6.40	**12–19**	2.10	2.40	2.90	3.80	4.75	6.00	6.73
C.+SC. Thickness														
2.70	2.92	3.40	3.90	4.60	5.70	6.04	**6–8**	2.51	3.00	3.70	4.40	5.22	4.10	6.88
2.60	3.00	3.40	4.00	4.77	5.80	6.99	**8–12**	2.78	3.20	3.60	4.20	5.10	6.40	7.53
2.70	3.00	3.50	4.10	4.90	6.40	8.40	**12–19**	3.10	3.40	4.00	5.20	6.10	7.50	8.60

C.-SC. = cutaneous–subcutaneous.

Table 5: Mean values of the thicknesses of the cutaneous tissue, subcutaneous tissue and cutaneous + subcutaneous tissue as a function of the body surface area

BSA (m^2)	**C. tissue thickness**		**SC. tissue thickness**		**Mean C. + SC tissue thickness**	
	G	**B**	**G**	**B**	**G**	**B**
	μ ± σ (mm)	**μ ± σ (mm)**	**μ ± σ (mm)**	**μ ± σ (mm)**	**μ ± σ (mm)**	**μ ± σ (mm)**
0.7	0.91 ± 0.33	1.00 ± 0.31	2.90 ± 0.12	3.45 ± 0.14	3.81 ± 0.14	4.46 ± 0.15
0.8	0.96 ± 0.17	0.96 ± 0.17	2.92 ± 0.07	3.23 ± 0.84	3.88 ± 0.71	4.20 ± 0.90
0.9	0.96 ± 0.15	0.95 ± 0.15	3.00 ± 0.07	3.38 ± 0.75	3.97 ± 0.74	4.33 ± 0.81
1	1.04 ± 0.54	1.03 ± 0.44	3.15 ± 0.09	3.17 ± 0.96	4.20 ± 0.10	4.20 ± 0.11
1.1	0.97 ± 0.17	1.07 ± 0.20	3.16 ± 1.11	3.26 ± 0.10	4.14 ± 0.11	4.33 ± 0.11
1.2	1.02 ± 0.28	1.05 ± 0.22	3.40 ± 1.13	3.29 ± 0.11	4.42 ± 0.14	4.34 ± 0.11
1.3	1.05 ± 0.28	1.22 ± 0.21	3.18 ± 0.13	3.64 ± 0.12	4.24 ± 0.14	4.87 ± 0.13
1.4	1.16 ± 0.30	1.34 ± 0.41	3.66 ± 0.26	4.26 ± 0.15	4.83 ± 0.26	5.60 ± 0.16
1.5	1.34 ± 0.37	1.33 ± 0.24	3.38 ± 0.20	4.50 ± 0.17	4.72 ± 0.21	5.84 ± 0.18
1.6	1.74 ± 0.29	1.51 ± 0.11	3.75 ± 0.45	5.11 ± 0.23	5.49 ± 0.51	6.62 ± 0.28
1.7	1.76 ± 0.22	1.38 ± 0.67	3.88 ± 0.38	5.79 ± 0.36	5.64 ± 0.47	7.17 ± 0.38
1.8	1.43 ± 0.81	1.45 ± 0.15	4.47 ± 0.75	6.55 ± 0.95	5.16 ± 0.51	8.00 ± 1.10

BSA (m^2) = body surface area in square meters; B = boys; G = girls; μ ± σ = mean ± standard deviation; C.-SC. = cutaneous–subcutaneous.

$p = 0.002$ and $p = 0.000$ for the 1st, 2nd and 3rd groups, respectively).

The skin-subcutaneous tissue thicknesses

The skin-subcutaneous tissue thicknesses increased in association with the increasing values of their age, BMI and BSA, and showed significant correlation with each of these three parameters ($p < 0.001$, for all). The skin-subcutaneous tissue thicknesses of the children in group 3 were significantly higher than those in both group 2 and group 1 ($p < 0.000$ for both). Although there was a significant difference between group 1 and group 3 regarding the skin-subcutaneous tissue thickness, the difference between group 1 and group 2 was insignificant ($p > 0.000$ and $p > 0.95$, respectively). The average and median values and the standard deviations of the skin-subcutaneous thicknesses in relation with age are shown in Table 3, and their relevant percentile curves are shown in Table 4.

The average values of the skin-subcutaneous tissue thicknesses according to the BSA are shown in Table 5. The skin-subcutaneous tissue thicknesses were significantly higher in girls in comparison with boys ($p < 0.001$). The average skin-subcutaneous tissue thickness was 3.3 mm in girls and 2.9 mm in boys. The median and range values of the skin-subcutaneous tissues are shown in Table 2. An intragroup assessment revealed that the skin-subcutaneous tissue thicknesses showed differences based on their gender in group 1 and 2, but not in group 3 ($p = 0.000$, $p = 0.012$ and $p = 0.55$, respectively). The skin-subcutaneous tissue thickness was below 4 mm among 50% of the boys and 25% of the girls in group 1 (age group 6–8 years). The skin-subcutaneous tissue thickness was below 4 mm among 25% of both the boys and girls in groups 1 and 2 (age group 9–12 and 13–17 years).

The mean values of the thicknesses of the cutaneous tissue, the subcutaneous tissue and the cutaneous + subcutaneous tissue as a function of BSA are shown in Table 5.

DISCUSSION

The thicknesses of the skin, the subcutaneous tissue and the skin-subcutaneous tissue increased in correlation with the subjects' age, BMI and BSA, and the skin and subcutaneous tissue thicknesses were higher in girls in comparison with boys. In a study (18), conducted on 101 children with type 1 diabetes, it was revealed that the skin thickness was correlated with their age but not associated with their gender. In a recent study on 384 infants and children with ages 4–66 months, it was found that the skin thickness measured on the deltoid area changes in association with their age, gender and BMI, although variations existed dependent on other body areas (19).

An intergroup evaluation in our study demonstrated that the difference of skin thickness was more prominent between group 2 (9–12 years) and group 3 (13–17 years) in comparison with the difference between group 1 (6–8 years) and group 2 (9–12 years). In regard to the thicknesses of the subcutaneous tissue and the skin-subcutaneous tissue, no significant change was seen between group 1 and group 2, yet a significant increase was observed between group 2 and group 3. These findings demonstrated that the subjects' stage of puberty might have modified the thicknesses of their skin and their skin-subcutaneous tissue.

The thicknesses of the skin and subcutaneous tissues correlated with gender for each three years of age groups, yet only the thicknesses of the skin-subcutaneous tissue did not correlate with gender in group 3 (age group 13–17 years, $p = 0.55$). The two studies mentioned above (18, 19) were conducted on different ethnic groups. Thus, when our study and these two previous studies are compared, it leads to the conclusion that the factors influencing the thicknesses of the skin, subcutaneous tissue and skin-subcutaneous tissues exert variable patterns in relation to the subjects' ethnicity and age groups.

In our study, important correlations existed between the subjects' BMI, BSA and the thicknesses of their skin, subcutaneous tissue and the skin-subcutaneous tissue ($p < 0.001$). To the best of our knowledge, no previous study existed, which evaluated the correlations between subjects' BMI, BSA and the thicknesses of the skin and skin-subcutaneous tissues determined *via* USG. In some of the previous studies, it was demonstrated that the risk of intramuscular injection was less during the employment of syringe needles with a length of 8 mm in comparison with needles with a length of 12.7 mm (9, 20). This risk was found also to be lower during the employment of needles with a length of 8 mm in comparison with the needles with a length of 6 mm (7). In a study, it was demonstrated that the usage of syringes with needle lengths of 4 mm reduced the risk of intramuscular insulin injections without causing a back-flow (21). A further study conducted on 168 adults with diabetes also supported the usage of syringes with a needle length of 4 mm (22). In a study conducted on 101 Italian children with type 1 diabetes, the intramuscular injection rates were calculated conjecturally based on the measurements of the skin-subcutaneous tissues with USG. In this study, it was reported that there was a possibility of intramuscular injection for 20.2%, 4.6% and 2.4% of the children for the age groups of 2–6, 7–13 and 14–17 years, respectively. In our study, the thickness of the skin-subcutaneous tissue was found below 4 mm in 50%, 25% and 25% of the boys at the ages of 6–8, 9–12 and 11–17 years, respectively. Among the girls, thicknesses below 4 mm were found with a percentage of 25% for all the age groups.

We also estimated the risks of intramuscular injections based on the knowledge that the shortest syringe needles commercially available today have a length of 4 mm. In this regard, even when using the needles with the shortest length for the subcutaneous injections, there is a possibility to make intramuscular injections for the 50%, 25% and 25% of the boys with age groups of 6–8, 9–12 and 13–17 years, respectively. For the girls, the risk of intramuscular injection was 25% for all the age groups. In our study group, the risk of intramuscular injection was found higher than in the previously published studies. This fact indicates that the skin-subcutaneous tissue thickness should be determined separately for the different samples.

When it is also regarded that the nutritional status of children exerts variations, our study also revealed the necessity to consider the normalized values according to the subjects' BMI and BSA besides their age and gender when establishing the percentiles for their skin-subcutaneous tissue thicknesses. Also, excess body fat was associated with the risk factors such as diabetes, hypertension, and elevated triglyceride and cholesterol levels in children and adolescents (23–26). The studies progressively increased, which determined the body fat percentage thresholds calculated by using the skin-fold thicknesses for employment in obesity diagnosis and also in studies to investigate the linkage between the body fat percentage and obesity complications (27). The determinations of the skin-subcutaneous tissue thicknesses may also help in obesity diagnosis and in the prediction of the treatment risk factors, besides guiding in selecting the proper needle lengths.

As currently seen, there is a global lack of studies, which provide normal ranges of these values based on the USG measurements.

CONCLUSION

We believe that a substantial lack of necessary data are provided with our current study, since it constitutes the first study in Turkey conducted on childhood and with USG measurements, which revealed the percentile curves and median values of the thicknesses of the skin, subcutaneous tissue and skin-subcutaneous tissue in regard to the subjects' age and gender.

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