Original Article

Skin and subcutaneous thickness at injecting sites in children with diabetes: ultrasound findings and recommendations for giving injection


Background: Children who inject insulin need clear guidelines as to the length of needle best for them. We studied the distance from surface to muscle in children in order to make needle choices which are evidence-based.

Methods: One hundred one children with type 1 diabetes were divided into three groups according to age: 2–6, 7–13, and 14–17 yr. The thickness of skin and subcutaneous (SC) tissue was measured by ultrasound in all injection sites.

Results: Skin thickness varied from 1.58 mm in the arm of the youngest children to 2.29 mm in the buttocks of the adolescents. Values decreased progressively based on age (2–6 < 7–13 < 14–17) and on body site (arm < thigh < abdomen < buttocks). Skin + SC thickness varied in a similar fashion. The skin surface to muscle distances were <4 mm in nearly 10% of children, especially in the 2–6 yr group. In this group, the rate of intramuscular (IM) injections using the 4-mm pen needle when a pinch-up is not used would be 20.2%. This rate of IM injections doubles when using the 5-mm needle, and when injections are given under similar conditions it triples using the 6-mm needle.

Conclusions: It seems medically appropriate for all children to use short needles where possible to minimize inadvertent IM injections which may increase glycemic variability. Currently, the safest needle for all children appears to be the 4-mm pen needle. However, when used in children aged 2–6 yr, it should be used with a pinched skin fold.

The skin is composed of two layers, the epidermis and dermis. Below these lies the subcutaneous (SC) layer. SC is the ideal site for the administration of insulin because blood flow through this fatty layer is slow and predictable in contrast to the dermis wherein the flow is slow but variable and in the muscle wherein blood flow is faster and ever-changing, depending on the state of muscle activity (1, 2). The length of needle used by patients determines the layer into which the insulin is deposited. This has a significant impact on the pharmacokinetics and pharmacodynamics of insulin (3–5). Appropriate injection technique has been shown to be a key factor in achieving optimal glucose control (6–8).

Previous studies on both healthy individuals and those with diabetes have shown that the thickness of the skin is relatively constant across age, gender, body size, and ethnic group (9–14). The same does not apply, however, to the SC layer, which varies greatly based on the gender, body mass index (BMI), and body site (15, 16). A recent study on healthy adults, assessed by ultrasound (US), showed that the average thickness of the skin is 2.02 mm (13). A similar study (14) on adults with diabetes found essentially the same results.
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Studies of skin and SC thickness in adults have been performed using computed tomography (CT) (17, 18) and US (14, 19, 20). CT scanning is not an acceptable method for studying children because of the radiation exposure. However, US has been shown to be an effective and reproducible method for studying skin and SC structures (21–23) and has no known side effects; hence, we chose it for our study on children.

The use of short pen needles (5 and 6 mm and, more recently, 4 mm) is now common among children with type 1 diabetes. Skin thickness in children has been described in previous studies (19, 22, 24–26). The variability of SC fat thickness in children has also been described in several other publications (20, 23, 26, 27), but all of these studies predate the advent of 4-mm pen needles.

The aim of our study was to evaluate, in children with type 1 diabetes and in the three main pediatric age groups, the thickness of skin and SC using US with a special focus on the 4-mm threshold. On the basis of the distance from the skin surface to muscle, we can make needle choices which are evidence-based. From our findings, we propose guidelines for needle lengths and injection techniques, to be followed in children, which can minimize the risk of intramuscular (IM) as well as intradermal (ID) injections.

Methods

Subjects

We enrolled 101 children with type 1 diabetes aged 2–17 yr, 57 males and 44 females, as they presented consecutively as ambulatory patients to the Pediatric Diabetes Center, Department of Pediatrics, University of Catania in Sicily, Italy. All subjects fulfilled the inclusion criteria: having type 1 diabetes and being on insulin for at least a year. None had any exclusion criteria: pregnancy or the presence of any pathologic condition which might affect the distribution of SC tissue. Patients were divided into three groups based on age: 2–6, 7–13, and 14–17 yr. These categories were chosen based on known preschool and school age differences as well as prepuberty vs. postpuberty hormonal and physiological differences (28).

This study was approved by the Ethics Committee of the University of Catania Hospital, complied with the Declaration of Helsinki and current Good Clinical Practice Guidelines and was conducted from 2 January to 1 October 2011 in the Pediatric Diabetes Center. Patients and their parents/guardians were informed that the study would gather data on children in a non-invasive, painless manner to determine skin and fat tissue characteristics, and all gave informed consent.

Measurements

From each patient, the following demographic parameters were obtained: date of birth, sex, age, height, weight, date of diagnosis of diabetes, number of injections per day, use or not use of a lifted skin fold (‘pinch-up’) for injecting, needle length, needle gauge, perpendicular or angled approach to injection, and most frequently used injecting site. From height and weight values, the BMI was determined. Glucose control was assessed by averaging glycated hemoglobin (HbA1c as measured by direct enzymatic assay on a venous blood sample) values obtained every 3 months during the last year of therapy (four values in total on each patient).

The thickness of skin and SC tissue was then measured by using US bilaterally in all injection sites: arm, thigh, abdomen, and buttocks (eight measurements per child). Measurements were made in all sites, regardless of whether the child injected in the site or not. The measurement location was standardized using skin surface or palpable landmarks in order to reduce intersubject measurement variability. For the arms, we measured 5 cm directly inferior to the acromium process in children 13 yr old and younger and 10 cm in children 14 yr and older. For the thighs, we measured 5 cm directly inferior to the greater trochanter in children 13 yr old and younger and 10 cm in children 14 yr and older. In the abdomen, we measured 5 cm directly lateral to the umbilicus in children 13 yr old and younger and 10 cm in children 14 yr and older. For the buttocks, we used the upper outer quadrant 5 cm below the iliac crest in children 13 yr old and younger and 10 cm in children 14 yr and older. No US measurements were made over sites of lipohypertrophy.

Materials

The MyLabTouch™ portable US unit with a 33-mm, 13.6-MHz transducer/probe (ESAOTE Biomedica Deutschland GmbH, Köln, Germany) 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 images were recorded using a cine loop setting containing a series of 500 images captured during a single measurement. The screen was frozen when a clear view of the skin and/or SC was obtained and the thickness of structures measured by placing two cursors at the interface extremities. All measurements were made by a single technician. On screen measurements were verified by printing copies of the image, which were later measured by a second technician using hand-held calipers. All
measurements were made in millimeters, and the screen-based values, which were highly correlated with print-based ones, were used for the study.

Data analysis

A sample size of 20 or more in each pediatric subgroup allows description of site dimensions with 95% confidence margins of ±0.09 mm for skin and ±0.72 mm for SC measurements. Mean, median, SD, minimum, maximum, and 95% confidence intervals (CIs) were measured for the entire population, for each pediatric subgroup, and for other grouping parameters such as gender, BMI, and needle length. Comparisons of subgroups were performed using chi-square, ANOVA, and log linear models, and the threshold for statistical significance was α = 0.05. Multivariate analyses were carried out to assess the impact of the parameters of age, BMI, gender, needle length, preferred body site, angle of injection, HbA1c, and number of injections/day on skin and SC dimensions.

Results

Subjects’ demographics

Table 1 gives the population descriptors for our study group. A larger number of subjects were intentionally recruited into the 7–13 yr age group as it covers a 7-yr interval (including the peak years for type 1 diabetes diagnosis in children) while group 2–6 yr covers an interval of 5 yr, and group 14–17 of 4 yr. A total of 57 males were included in the study, compared with 44 females. The mean BMI values among the three groups increased with age (p = 0.003), but there were no differences in the mean HbA1c values. All patients used insulin pens. Most of the patients in the youngest group were using the 4-mm pen needle, most in the oldest group were using 6-mm needles, and the split amongst 4, 5, and 6 mm lengths was almost equal in the middle-aged group. All raised a skin fold (‘pinch-up’), into which they injected perpendicularly, which is the standard practice in our center. The preferred injection site overall was the abdomen, but the arm was used as frequently as the abdomen in preschool children (n = 10 each). Most of the patients in each age group were given four injections per day.

Skin and SC thickness

Mean values of the thickness of skin in the pediatric subgroups are shown in Table 2. For comparative purposes, values from adults from a recent similar study are shown in the last column of Table 2. In children the thickness of the skin increases significantly with age (with preschoolers having the thinnest skin and adolescents the thickest) and by body site [from arms (with the lowest values) to thighs to abdomen to buttocks (with the highest values)]. All differences between pediatric age groups (columns 2, 3, and 4) and between body sites of pediatric age groups (rows) are significant at a p = 0.02, except for thigh and abdomen measurements for the youngest group.

Mean values of the thickness of skin + SC in pediatric subgroups are shown in Table 3. The same general trends as seen with skin apply to the values of skin + SC except that there is a greater variability overall. We found a decrease in the thickness of skin + SC in the abdomen and buttocks in 7–13 and 14–17 yr age groups, with the middle-aged group having higher values than the older age group. However, all values in these two groups were significantly higher than those in preschool children when compared site for site (p = 0.02).

Figure 1 shows the raw values of the skin + SC thickness in the 2–6 yr old group as a function of BMI, with a threshold line drawn at 4 mm, corresponding to the shortest needle currently available. Figure 2 shows the corresponding values in the 7–13 yr old group, and Fig. 3 in the 14–17 yr old group. A number of children had <4 mm of surface-to-muscle distances. This was found across the range of BMI values and at all four injection sites. The frequency of this finding was greatest in the youngest age group and least in the oldest.

Table 4 shows the estimated incidence of SC and IM injections in the three groups of pediatric populations based on US measurements of skin + SC thickness, and on assuming a non-pinch and 90° injection approach. In the 2–6 yr group, the rate of IM injections after using the 4-mm pen needle when a pinch-up is not used is 20.2%. It is more than two times higher with the use of 5-mm needle when injections are given under similar conditions and more than three times higher with the use of 6-mm needle. In the 7–13 yr group, the rate of IM injections with the use of 4-mm pen needle when a pinch-up is not used falls to 4.6%, and in the 14–17 yr group it is only 2.4%, or 4 injections out of 164. The frequencies of IM injections with the other needle lengths are quite similar between the 7–13 and 14–17 yr old groups: 5 mm (18.4 and 16.1%), 6 mm (38.0 and 34.5%), 8 mm (65.3 and 66.1%), and 12.7 mm (93.9 and 96.4%). Table 4 probably underestimates the incidence of IM injections when injections are given perpendicularly.

There was no significant difference in the mean skin thickness values based on gender, either overall or viewed by age group (Table 5). There was a gender difference in mean skin + SC thickness values, with females having higher values overall and in the youngest and middle age groups (p = 0.01); however, there was no difference in the older age group (Table 6).
Table 1. Demographic features of the study population

<table>
<thead>
<tr>
<th>Age 2–6 yr</th>
<th>Age 7–13 yr</th>
<th>Age 14–17 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>31</td>
<td>49</td>
</tr>
<tr>
<td>Males/females</td>
<td>18/13</td>
<td>29/20</td>
</tr>
<tr>
<td>Mean age (±SD)</td>
<td>5.44 ± 1.54</td>
<td>10.6 ± 1.83</td>
</tr>
<tr>
<td>Mean body mass index (±SD)</td>
<td>16.9 ± 2.03</td>
<td>19.9 ± 3.02</td>
</tr>
<tr>
<td>Mean HbA1c (±SD)</td>
<td>7.58 ± 0.83</td>
<td>7.48 ± 0.77</td>
</tr>
<tr>
<td>Number using 4/5/6 mm pen needles, respectively</td>
<td>18/8/4</td>
<td>15/15/19</td>
</tr>
<tr>
<td>Percent injecting using pinch-up</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Primary injecting site

| Abdomen | 10 | 30 | 11 |
| Arm | 10 | 7 | 4 |
| Thigh | 5 | 4 | 3 |
| Buttocks | 6 | 8 | 3 |

Number of injections/day

| 3 | 4 | 2 | 1 |
| 4 | 27 | 42 | 20 |
| 5 | 0 | 3 | 0 |
| 6 | 0 | 2 | 0 |

Table 2. Values of skin thickness in pediatric subgroups and adults from another similar study (14)

<table>
<thead>
<tr>
<th>Skin thickness (mm ± SD)</th>
<th>2–6 yr</th>
<th>7–13 yr</th>
<th>14–17 yr</th>
<th>Adults*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm</td>
<td>1.58 ± 0.23</td>
<td>1.71 ± 0.29</td>
<td>1.92 ± 0.42</td>
<td>2.23 ± 0.44</td>
</tr>
<tr>
<td>Thigh</td>
<td>1.71 ± 0.25</td>
<td>1.89 ± 0.30</td>
<td>2.14 ± 0.35</td>
<td>1.87 ± 0.39</td>
</tr>
<tr>
<td>Abdomen</td>
<td>1.71 ± 0.27</td>
<td>2.07 ± 0.31</td>
<td>2.18 ± 0.50</td>
<td>2.15 ± 0.42</td>
</tr>
<tr>
<td>Buttocks</td>
<td>1.97 ± 0.27</td>
<td>2.11 ± 0.35</td>
<td>2.29 ± 0.41</td>
<td>2.41 ± 0.48</td>
</tr>
</tbody>
</table>

*Values from another study (14).

Table 3. Skin + SC thickness in pediatric subgroups

<table>
<thead>
<tr>
<th>Skin + SC thickness (mm ± SD)</th>
<th>2–6 yr</th>
<th>7–13 yr</th>
<th>14–17 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm</td>
<td>4.89 ± 1.47</td>
<td>6.02 ± 1.86</td>
<td>6.31 ± 1.94</td>
</tr>
<tr>
<td>Thigh</td>
<td>6.05 ± 2.44</td>
<td>7.36 ± 2.31</td>
<td>7.49 ± 2.10</td>
</tr>
<tr>
<td>Abdomen</td>
<td>6.12 ± 3.47</td>
<td>7.98 ± 3.40</td>
<td>7.75 ± 2.91</td>
</tr>
<tr>
<td>Buttocks</td>
<td>6.53 ± 2.26</td>
<td>8.73 ± 3.18</td>
<td>8.12 ± 2.81</td>
</tr>
</tbody>
</table>

SC, subcutaneous.

Skin thickness of pediatric groups compared to the adult group

In a large study of adults with diabetes, using the same injection sites and a similar US technique (14), the skin thickness ranged from 1.87 mm (95% CI = 1.83–1.91 mm) in the thigh to 2.41 mm (2.35–2.47 mm) in the buttocks. The last column in Table 2 lists these values observed in adults, which may be compared to our pediatric values.

Other parameters

HbA1c values were not significantly related to skin thickness (p = 0.87) or to skin + SC thickness (p = 0.35). There was also no relationship between HbA1c values and BMI (p = 0.80). When values from the right side of the body (at the same site in the same patient) were compared to values from the left side by using regression analysis, the correlation was very high (data not shown).

Discussion

When one considers age distributions, HbA1c values, number of injections per day, and values of skin and SC thickness, our population study of pediatric patients with type 1 diabetes appears to be a representative of other published studies (20, 23–25, 29, 30). The low variability between US values (right to left side of the body, across body sites, and from subject to subject within the same age group) supports the reliability and applicability of our findings.

The thickness of the skin within each pediatric age group in our study increases progressively based on age (2–6 < 7–13 < 14–17) and on body site (arm < thigh < abdomen < buttocks). Seidenari et al. (19) found, as we did, that skin thickness in children progressively increases with advancing age and that skin is thinner in the limbs than in the truncal areas. Nevertheless, this modest rise of skin thickness should have no impact
Skin and SC thickness in children with diabetes

Fig. 1. Skin + subcutaneous thickness in the 2–6 yr old group as a function of body mass index, with a threshold line drawn at 4 mm.

Fig. 2. Skin + subcutaneous thickness in the 7–13 yr old group as a function of body mass index.

on the choice of current needle lengths. All marketed needles’ lengths will easily clear the skin barrier and reach the SC space without the risk of ID injections.

Children in our study had, on average, less than 9 mm distance from the skin surface to the muscle fascia. The younger the child the lower this distance, with the limbs having a shorter skin-to-muscle distance than the more truncal regions in all age groups (Table 3). This raises concerns about the risk of IM injections when insulin is given using longer needles. Table 4 quantifies this risk by age group and clearly shows that the youngest group is at highest risk. Other studies have shown a higher than expected incidence of IM injections based on thickness alone (29, 26, 27). This probably reflects pressure on the skin with a vertical injection, and a skin depression of 1–2 mm is probably not uncommon. Our data as well as those from these studies furthermore suggest that shorter needles are safer for all groups, and that the safest needle currently available is the one with 4 mm.
Fig. 3. Skin + subcutaneous thickness in the 14–17 yr old group as a function of body mass index.

Table 4. The estimated incidence of SC and IM injections by age groups

<table>
<thead>
<tr>
<th>Expected injection destinations through 90° insertion</th>
<th>Needle lengths (mm)</th>
<th>SC</th>
<th>IM</th>
<th>Percentage of IM injections (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age 2–6 yr (total n = 248)</td>
<td>4</td>
<td>198</td>
<td>50</td>
<td>20.2</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>134</td>
<td>114</td>
<td>46.0</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>83</td>
<td>165</td>
<td>66.5</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>40</td>
<td>208</td>
<td>83.9</td>
</tr>
<tr>
<td></td>
<td>12.7</td>
<td>7</td>
<td>241</td>
<td>97.2</td>
</tr>
<tr>
<td>Age 7–13 yr (total n = 392)</td>
<td>4</td>
<td>374</td>
<td>18</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>320</td>
<td>72</td>
<td>18.4</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>243</td>
<td>149</td>
<td>38.0</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>136</td>
<td>256</td>
<td>65.3</td>
</tr>
<tr>
<td></td>
<td>12.7</td>
<td>24</td>
<td>368</td>
<td>93.9</td>
</tr>
<tr>
<td>Age 14–17 yr (total n = 168)</td>
<td>4</td>
<td>164</td>
<td>4</td>
<td>2.4</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>141</td>
<td>27</td>
<td>16.1</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>110</td>
<td>58</td>
<td>34.5</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>57</td>
<td>111</td>
<td>66.1</td>
</tr>
<tr>
<td></td>
<td>12.7</td>
<td>6</td>
<td>162</td>
<td>96.4</td>
</tr>
</tbody>
</table>

SC, subcutaneous; IM, intramuscular.

Birkebaek et al. (16), in a similar study, found that 44% of girls and 95% of boys had less than 8 mm of skin + SC thickness at the thigh, and 16% of girls and 50% of boys had skin + SC thickness of less than 6 mm on the thigh and buttocks. SC thickness was reduced by up to 35% with skin compression (buttocks and abdomen 27–35%, thigh 10–33%). The authors were the first to propose that 4-mm needles be used in children.

Hofman et al. (26) examined 122 children and adolescents aged 4–18 yr using US to identify the location for sterile air injections (corresponding to 20 IU of insulin) with 32G 5-mm needles at 90° or 45°, in the abdomen and thigh and with or without a pinched skin fold. This study found that 5.5% of injections were IM and 0.5% were ID. The prime predictor of IM risk was SC thickness, which varied in direct proportion to BMI. There were gender differences, with boys being at higher risk of IM injections in both children and adolescent groups because of reduced SC thickness.

Several strategies had been used, before the advent of shorter needles, for mitigating the IM risk in children. One was to teach the children to lift a skin fold and inject into it (15, 31). This is still the current practice in our center. However, the pinch-up only expands the SC space by a modest degree in children (15) and IM injections are still a risk, especially if the needle is >6 mm. Polak et al. (15) found that the use of 8-mm needles in 50 thin to normal-weight children, all of whom used a pinch-up, significantly reduced the risk, but by no means eliminated the risk of IM injections. Hofman et al. (24) showed that, in thin children, lifting a skin fold in the thigh actually increased the risk of IM injection. They used 6-mm needle with an angled approach and achieved more consistent deposition in SC tissue.

Such findings have led some authorities to recommend to use an angled approach to avoid IM injections (24), but not every patient can mentally...
visualize a 45° angle and execute it consistently when injecting. Furthermore, with the shortest needles, injecting at an angle risks foreshortening the injection depth to an extent that it may end in ID injections risk.

Birkebaek et al. (30) studied the performance of a 4-vs. 6-mm needle in children and lean adults after giving injections straight in without a pinch-up. They found that more patients injected SC using the 4-mm needle than using the 6-mm needle in the abdomen (p = 0.032) as well as in the thigh (p ≤ 0.001). They concluded that most patients could inject at 90° in the thigh by using a 4-mm needle without a pinch-up. When using a 6-mm needle in such patients, the authors propose injecting into a skin-fold with a 45° angle.

Hirsch et al. (32) studied the use of 4-mm needle in adults with diabetes with a mean BMI of 31 kg/m². Injections were given straight in without a pinch-up. The authors showed that the 4 mm × 32G pen needle provided equivalent glucose control compared with 31G, 5- and 8-mm needles, with reduced pain, no differences in insulin leakage, and was preferred by patients. The authors concluded that the vast majority of patients could use the 4-mm needle without a pinch-up.

In 2010, Gibney et al. (14) studied a large diverse group of adult patients with diabetes (n = 388) to determine skin and SC thickness at the usual injecting sites, using US. Skin thickness averaged 2.2 mm in the arm, 1.9 mm in thigh, 2.2 mm in the abdomen, and 2.4 mm in the buttocks. Statistically significant relationships were found in multivariate analyses between skin thickness and gender, race, and BMI (but not age), but the estimated effects on skin thickness were clinically trivial. A 10 kg/m² difference in BMI was estimated to account for only a 0.2 mm difference in skin thickness. In this study, by combining the published dimensions for skin and SC thickness (14), we estimate that the average skin surface to muscle distance in adults at the four injection sites is to be 12.2 mm in the thigh, 12.9 mm in the arm, 16.1 mm in the abdomen, and 17.9 mm in the buttocks. These values are, site for site, at least a double of those which we found in children and even in our adolescent group (Table 3). The increased adiposity in the adults studied by Gibney (mean BMI = 29.9, SD = 7.1) compared with that in the children in our study (mean BMI = 16.9, SD = 2.0 in the youngest group, mean BMI = 19.9, SD = 3.0 in the middle group, and mean BMI = 21.4, SD = 3.8 in the adolescents) almost certainly explains these differences. Gibney et al. (14) estimated that >98% of 90° insertions with a 5-mm needle in adults would be in the SC, with the remainder being IM, and concluded that the 4-mm needle would deliver insulin into the SC space >99.5% of the time even without a pinch-up.

A number of studies have been performed in both children (27, 29, 30, 33) and adults (32–36), comparing shorter- with longer-length needles in a crossover fashion. These have consistently shown that the shorter needles give equivalent glucose control, do not lead to more insulin leakage, and are generally preferred by patients. Some studies found that the shorter needles were less painful in children (33) and in adults (32, 35), but it must be kept in mind that shorter needles are usually thinner and the reduced diameter may have an impact on pain.

Some children may not insert the needle to its whole length if they find it painful, thereby increasing the risk of ID injections with a 4-mm needle. All children should receive instructions on proper injection technique, including insertion of the needle to its full length while avoiding skin compression which may force the needle into the IM space.

Almost 10% of subjects in our pediatric study exhibit values of skin + SC thickness which are at or below the threshold of 4 mm (Figs 1–3, Table 4). Multivariate analysis shows that the risk is greatest in the 2–6 yr age group, at the lower range of the BMI spectrum and in the arm compared to other sites. However, occasional cases can be found in all age groups, across the BMI range, and in all the other injection sites. These findings raise concerns that some injections, especially in very young patients, may go into the IM space when they are given perpendicularly without a pinch-up, even with the
4-mm needle. This concern does not appear to apply to adults giving 90° injections with this needle (14). Therefore, there may be a role in younger pediatric populations for continuing the ‘pinch-up’ technique even with shorter needles.

To avoid giving complex and confusing information to parents, our own practice is to educate families in the pinch-up technique regardless of the injection site. However, the latter is our own opinion and should be left to the discretion of the pediatric diabetes specialist or nurse.

Limitations of our study

A somewhat higher proportion of males than females were included in the study, but there is no reason to believe that this introduced a bias. There were also more subjects in the 7–13 yr age group than in the other age groups. This was intentional, as this group covered the largest time interval (7 yr) of any group. This discrepancy also did not affect the results.

The female adolescents in our study did not show increased values for skin + SC tissue thickness, characteristic of adult females (14) and generally attributable to the hormonal changes occurring at puberty. This is contrary to other studies showing increased fat deposition in pubertal females and reducing SC fat mass in pubertal males (14, 24, 26, 28). However, many girls in this group were only 14 yr old and all but one had BMI values in the low- to mid-normal range for their age. Their average BMI values did not differ from those of the boys in this group.

There may be differences in other centers and populations where obesity is significantly more prevalent than in Sicily, i.e. USA, Canada, Australia, and some parts of Europe. Further studies should be carried out to confirm that expected results can be generalized to the overweight and obese populations. However, our skin thickness measurements of 1.6–2.3 mm would not likely be so different even in obese children, so the risk of ID injections should not arise with any of the current needle lengths.

Conclusions

On the basis of the mean values of skin + SC thickness in different pediatric age groups, it seems medically appropriate for all children to use short needles to minimize inadvertent IM injections which may increase glycemic variability. Currently, the shortest is the 4-mm pen needle. Our study found that the rate of IM injections could double with the use of 5-mm needle, and when injections are given under similar conditions it could triple with the use of 6-mm needle.

Considering the lower limits of the range of skin + SC thickness, we continue to recommend the pinch-up technique in the youngest group of pediatric children (2–6 yr old) at all injecting sites, even when using the 4-mm pen needle. This, however, warrants further prospective studies. Patients over the age of 6 yr can generally inject without a pinch-up. Finally, injections when given straight in without a pinch-up are clearly safest when given with the 4-mm needle.

Acknowledgements

The authors wish to thank Dr Laurence Hirsch and Dr Paul Hofman for a careful review and editing of this paper. Becton Dickinson & Company (BD) provided the use of an ultrasound for this study.

Conflict of interest

K. S. employed by BD. No honorarium, grant, or other form of payment was given to anyone to produce the manuscript.

Author contributions

Dr D. L. P. wrote the first draft of the manuscript.

References

Skin and SC thickness in children with diabetes


