



Original research

Ultrasound-guided measurement of skin and subcutaneous tissue thickness in children with diabetes and recommendations for giving insulin injections



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A B S T R A C T

Aim: To measure skin thickness (ST) and skin + subcutaneous layer thickness (SCT) by ultrasound and estimate the risk of intramuscular injection (IM) with different needle lengths across injection sites according to age group.

Method: Children recruited between 1 and 18 years with type 1 and 2 diabetes on insulin injections and divided into three age groups: 1–6 years, 7–12 years and 13–18 years. A portable ultrasound was used to measure ST and SCT at four injection sites on the abdomen, arm, thigh and buttock.

Results: Total 153 children enrolled for the study. The mean (SD) measurement of ST & SCT at four sites on abdomen, arm, thigh & buttocks were as follows; 4.33 mm (± 2.22), 5.55 mm (± 2.26), 5.83 mm (± 3.12), 6.48 mm (± 3.47) in 1–6 years old; 7.11 mm (± 3.68), 7.79 mm (± 4.54), 7.17 mm (± 3.62), 8.51 mm (± 3.65) in 7–12 years old; 8.94 mm (± 4.50), 8.42 mm (± 5.00), 8.61 mm (± 4.76), 9.76 mm (± 4.38) in 13–18 years old. Young children, 1–6 years have the highest risk of IM injection with all needle lengths, i.e. 4, 5, 6, 8 & 12.7 mm, while older children 7–12 & 13–18 years have a lower risk with shorter needles (4, 5 and 6 mm) as compared to longer needles (8 and 12.7 mm).

Conclusions: Children with diabetes on insulin therapy should be advised on the appropriate needle length accordingly to their age and BMI.

Introduction

Multiple-dose insulin injections are the mainstay of diabetes management in children and are given subcutaneously at four recommended sites with the prescribed technique. In recent years, the effectiveness of insulin therapy has improved tremendously with the availability of different needle lengths. Since injections are to be administered three to four times daily, the three most important points of the correct site, needle length and technique [1] are emphasised from the start to ensure delivery of insulin into the subcutaneous (SC) tissue and optimise insulin absorption. SC is the correct site for insulin administration as blood flow through this fat layer is slow and predictable in contrast to muscle wherein it is fast and ever-changing. If the injection becomes intramuscular, the absorption of insulin is rapid and can cause hypoglycaemia. Therefore, to avoid fluctuations in blood glucose, it is essential that injections are given consistently in the SC tissue.

Repeated injections at the same site over time can also lead to skin injuries such as hypertrophy, lipoatrophy and subcutaneous nodularity, thereby altering skin thickness [1]. Therefore, patients are advised to rotate and rest the sites as needed on a day-to-day basis. The technique to be used for insulin injections are part of standard diabetes education, and needle length depends on patient's age [2]. But the most objective recommendation should be based on total skin and subcutaneous layer thickness (SCT) measurement across age groups [3–6]. Even among the different age groups ST and SCT will vary according to body mass index (BMI) which differs across ethnicity and gender. In children studies comparing this variability is lacking. However the adult study has shown that factors which influence ST at the abdomen and upper arms were gender and BMI whereas SCT at abdomen was gender and BMI, and SCT at upper arms was gender, BMI and age [5]. The studies done using ultrasonography to measure ST and SCT in children with type 1 diabetes showed that there is a progressive increase in thickness with age and also it varies at different sites (arm, thigh, abdomen and

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Table 1
Baseline characteristics of patients.¹

	Boys + Girls			p ²	Boys only			p ²	Girls only			p ²
	1–6 years (n = 12) n (%)	7–12 years (n = 55) n (%)	13–17 years (n = 86) n (%)		1–6 years (n = 11) n (%)	7–12 years (n = 24) n (%)	13–17 years (n = 34) n (%)		1–6 years (n = 1) n (%)	7–12 years (n = 31) n (%)	13–17 years (n = 52) n (%)	
Gender (n, %)				0.003 [*]				–				–
Boys	11 (91.7)	24 (43.6)	34 (39.5)		–	–	–	–	–	–	–	–
Girls	1 (8.3)	31 (56.4)	52 (60.5)		–	–	–	–	–	–	–	–
Ethnicity (n,%)				0.68				0.82				0.53
Chinese	9 (75.0)	34 (61.8)	54 (62.8)		8 (72.7)	18 (75.0)	23 (67.6)		1 (100)	16 (51.6)	31 (59.6)	
Malay/ Indian/ Others	3 (25.0)	21 (38.2)	32 (37.2)		3 (27.3)	6 (25.0)	11 (32.4)		0 (0)	15 (48.4)	21 (40.4)	
BMI-for-age percentile (n, %)				0.40				0.030 [*]				0.26
3rd–25th	0 (0)	10 (18.2)	14 (16.3)		0 (0)	2 (8.3)	9 (26.5)		0 (0)	8 (25.8)	5 (9.6)	
25th–75th	9 (75.0)	32 (58.2)	45 (52.3)		8 (72.7)	17 (70.8)	21 (61.8)		1 (100)	15 (48.4)	24 (46.2)	
75th–90th	3 (25.0)	7 (12.7)	14 (16.3)		3 (27.3)	1 (4.2)	3 (8.8)		0 (0)	6 (19.4)	11 (21.2)	
90th–97th	0 (0)	6 (10.9)	13 (15.1)		0 (0)	4 (16.7)	1 (2.9)		0 (0)	2 (6.5)	12 (23.1)	
Type of diabetes (n, %)				0.027 [*]				0.51				0.072
Type 1	12 (100)	53 (96.4)	72 (83.7)		11 (100)	23 (95.8)	31 (91.2)		1 (100)	30 (96.8)	41 (78.8)	
Type 2	0 (0)	2 (3.6)	14 (16.3)		0 (0)	1 (4.2)	3 (8.8)		0 (0)	1 (3.2)	11 (21.2)	
HbA1c level (n, %)				0.78				0.61				0.23
≤7.5%	2 (16.7)	14 (25.5)	18 (20.9)		1 (9.1)	6 (25.0)	8 (23.5)		1 (0)	8 (25.8)	10 (19.2)	
7.6–9.0%	6 (50.0)	19 (34.5)	29 (33.7)		6 (54.5)	7 (29.2)	14 (41.2)		0 (0)	12 (38.7)	15 (28.8)	
≥9.1%	4 (33.3)	22 (40.0)	39 (45.3)		4 (36.4)	11 (45.8)	12 (35.3)		0 (0)	11 (35.5)	27 (51.9)	

¹ Values are expressed as n (%).

² Chi-square test conducted to compare different age groups; p < 0.05 taken to be statistically significant.

* p < 0.05.

buttocks) [1]. Additionally, the rate of intramuscular injection with the shortest needle (4mm) was found to be five times more in the 1–6 years old age group (20.2%) compared to 7–13 years (4.6%) and 14–17 years (2.4%) with a non-pinch skin-fold [6]. Lean children with a thin layer of subcutaneous tissue may also need to pinch a skin fold when using 4 or 5 mm needles for injection over arms or thighs [1,5]. In adults, a pinch-up skin fold is not required for 4 or 5 mm needle but may be necessary when using 6, 8, or 12.7 mm needle to ensure adequate delivery of insulin in the SC [7]. These findings highlight the importance of both appropriate injection technique and consideration on needle length across different age groups. Recommendations for insulin injection must include measurements of the ST and SCT to make an evidence-based recommendation for needle length.

The data for Asian children are lacking and it remains uncertain whether previous findings could be generalised to our local population with diabetes since ST and SCT thickness could differ by race and ethnicity. Therefore, this study aims to establish recommendation of appropriate needle length for insulin injection among children with diabetes across different age groups in Singapore.

Materials and methods

Patient recruitment

Children between 1 and 18 years with diabetes on insulin injections recruited between 1st August 2013 and 30th June 2014 at KK Children's & Women's Hospital. They were divided into three groups according to their age: 1–6 years, 7–12 years and 13–18 years. Children excluded include those with secondary diabetes, duration of diabetes less than one year and hypertrophy/lipoatrophy/nodularity at insulin injection sites. Singhealth Centralized Institutional Review Board (CIRB)

approved the study.

Data collection

Questionnaires were administered to patients more than age 13 years old and to the parents of patients less than age 13 years old to obtain participants' demographics and medical history. The weight (kg) was measured using the digital weighing machine (Avalanche Mechatronic, Singapore) and height (cm) using (Wall mounted Stadiometer) and BMI (kg/m²) calculated from these measurements. A capillary one millimetre's blood sample was collected and tested for glycated haemoglobin (HbA1c) using clinical chemistry analyser (Bio-Rad Abbott Architect c8000, Unites States). Two trained Diabetes Nurse Educators did a measurement of ST and SCT in millimetres using portable M-Turbo® ultrasound system (Sonosite, United States) with 5–15 MHz transducer probe on four injection sites – arm, thigh, abdomen and buttocks on right or left side of the body. Standard procedures were adopted which include a selection of good sites, non-pinch (non-compressed) skin fold and transducer probe positioned perpendicularly to the marked area to obtain a clear and focused image to measure ST & SCT. The site of measurement was standardized using landmarks in order to reduce intersubject variability. The measurement site was mid-length directly inferior to the acromion process for the arms, greater trochanter for the thigh, 2 cm away from the umbilicus at the lateral abdomen and upper outer quadrant for the buttocks. No measurements were made over sites of lipohypertrophy. All measurements were calculated from an average of two readings obtained by each operator. Training for measurements was validated on two operators with inter-rater variability below 5%. The percentage of IM injection with different needle lengths (4 mm, 5 mm, 6 mm, 8 mm and 12.7 mm) across three age groups at four different injection sites was

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