ORIGINAL ARTICLE

Journal of the ASEAN Federation of Endocrine Societies

Ultrasound-Guided Skin and Subcutaneous Fat Thickness Profiling for Insulin Delivery in Overweight and Obese Adults with Type 2 Diabetes: A Cross-Sectional Malaysian Study

Chiawoon Tai, Yusuhaimi Remli, Madihah Nasuha Yunus

Pharmacy Unit, Mahmoodiah Health Clinic Johor Bahru, Ministry of Health Malaysia

Abstract

Background. Safe insulin administration requires delivery into the subcutaneous tissue to avoid intradermal or intramuscular injection. Although international guidelines recommend the universal use of 4 mm needles, local anatomical data supporting this recommendation among overweight and obese adults with type 2 diabetes mellitus (T2DM) in Malaysia are limited.

Objective. To assess skin thickness (ST) and subcutaneous adipose tissue (SAT) using ultrasound to evaluate the safety of 4 mm insulin needles in overweight and obese adults.

Methodology. This cross-sectional study involved 98 adults with T2DM on insulin therapy (body mass index [BMI] ≥23 kg/m²) attending a primary care clinic in Johor Bahru, Malaysia. ST and SAT at 10 abdominal injection sites and 8 upper arm injection sites were measured using ultrasonography. Data were analyzed using descriptive statistics, correlation tests, and multiple linear regression to identify associations with BMI, age, gender, and other variables.

Results. The median abdominal ST was 2.46 mm (interquartile range [IQR]: 2.20–2.80), and upper arm ST was 1.92 mm (IQR: 1.73–2.11). Only 6.1% of participants had any site with ST greater than 4 mm. Median abdominal SAT was 16.75 mm (IQR: 14.83–19.28), and upper arm SAT was 15.38 mm (IQR: 12.10-17.73). Multiple linear regression showed that abdominal ST was significantly predicted by BMI (β = 0.244, p = 0.015) and inversely by age (β = –0.202, p = 0.040). Gender was the strongest predictor of upper arm ST (β = –0.418, p <0.001), with females having thinner skin. Abdominal SAT was positively associated with BMI (β = 0.469, p <0.001) and male gender (β = –0.205, p = 0.026), suggesting that BMI may serve as a useful clinical indicator of abdominal injection depth. No significant predictors were found for upper arm SAT.

Conclusion. Most overweight and obese Malaysian adults with T2DM have adequate ST and SAT for safe insulin delivery using 4 mm pen needles. Ultrasonographic data support individualized injection technique education in primary care, considering BMI, gender, and age.

Key words: type 2 diabetes mellitus, obesity, primary health care

INTRODUCTION

Malaysia records one of the highest diabetes prevalence rates in Asia.[1] According to the 2023 National Health and Morbidity Survey (NHMS), approximately 15.6% of Malaysian adults (2.2 million individuals) are affected.[2] For individuals with advanced type 2 diabetes mellitus (T2DM), insulin therapy remains a cornerstone for achieving optimal glycemic control. Over the past two decades, its use has expanded significantly within Malaysia's public healthcare system. The DiabCare Malaysia study reported a progressive increase in insulin use: 28% in 2003, 54% in 2008, and 65% in 2013.[3] In parallel, the National Diabetes Registry (NDR) noted a rise in insulin therapy among T2DM patients in primary healthcare clinics (PHCs) from 23.1% in 2013 to 30.3% in 2019.[4]

The effectiveness of insulin therapy depends not only on the insulin formulation but also on accurate delivery into the SAT. While international guidelines, such as the Forum for Injection Technique and Therapy Expert Recommendations (FITTER), emphasize that proper subcutaneous (SC) deposition ensures predictable absorption, these recommendations are largely based on global averages.[5] Inadvertent intramuscular (IM) injections may result in accelerated and unpredictable absorption, leading to glycemic instability, whereas intradermal injections often cause pain and leakage.[5-7]

eISSN 2308-118x (Online)
Printed in the Philippines

Received: February 28, 2026. Accepted: April 6, 2026.
Published online first: August 28, 2026.
https://doi.org/10.15605/jafes.041.02.6339

Corresponding author: Ms. Chiawoon Tai, RPh
Registered Pharmacist,
Mahmoodiah Health Clinic Johor Bahru, Ministry of Health Malaysia,
Jalan Mahmoodiah, 80100, Johor Bahru, Malaysia
Tel. No.: (+60) 072246166
E-mail: taichiawoon@yahoo.com.sg
ORCiD: https://orcid.org/0000-0003-0158-6413

Current international guidelines advocate for universal use of shorter insulin needles (4 mm), based on the findings that ST remains relatively constant across populations.[5,6] However, while ST may vary minimally, SAT differs considerably depending on body mass index (BMI), gender, and injection site.[8] Additionally, ethnic differences in body composition indicate that Asians tend to have higher body fat percentages and different fat distribution patterns than Caucasians at the same BMI.[9] These variations raise concerns regarding the applicability of general recommendations for Malaysia's multi-ethnic, overweight, and obese population, which may exhibit distinct ST and SAT characteristics at common injection sites such as the abdomen and upper arm.

Recent studies have demonstrated the value of ultrasonography, including elastography, in assessing subcutaneous tissue in adults with T2DM, particularly in obese individuals. These imaging techniques enable precise identification of injection site complications and support individualized insulin injection strategies.[5,10-13] Unlike clinical palpation, which often fails to detect subclinical LH or accurately assess tissue depth, ultrasonography provides real-time, accurate visualization of anatomical structures at injection sites.[14] Despite these advantages, there is a lack of local data utilizing ultrasonography to evaluate ST and SAT profiles in Malaysian adults with T2DM, especially within overweight and obese populations.

This study aims to address this gap by profiling ST and SAT thickness at standard insulin injection sites using ultrasonography in overweight and obese Malaysian adults. By characterizing these anatomical profiles, we aim to provide evidence-based insights into injection site suitability and needle length appropriateness for the local primary care setting.

METHODOLOGY

Study design and setting

This prospective cross-sectional study was conducted at the Mahmoodiah Health Clinic, Johor Bahru, Malaysia, in January 2019.

Patient recruitment and eligibility

Patients attending the diabetes clinic at Mahmoodiah Health Clinic, Johor Bahru in January 2019 were screened for participation in this study. Eligible patients were recruited using consecutive sampling, whereby all patients meeting the inclusion criteria during the study period were approached for participation. Inclusion criteria were: (1) Age ≥18 years; (2) T2DM diagnosis; (3) Insulin therapy for ≥12 months; and (4) Classification as overweight or obese, defined as a BMI of ≥23 kg/m^2, according to Asian population standards.[15] Exclusion criteria included pregnancy or skin pathologies (e.g., scars, lipohypertrophy) at injection sites. Patients who fulfilled the criteria were approached and informed about the study objectives and procedures. Those who agreed to participate provided written informed consent in Malay or English. Demographic data and relevant clinical history were recorded using a structured data collection form. The data collection form was developed with reference to clinical guidelines and relevant literature, and refined through pilot testing to ensure clarity and content validity.[5,12]

Sample size

The sample size was calculated for the primary descriptive objective of estimating ST at common insulin injection sites (abdomen and upper arm) among overweight and obese Malaysian adults with T2DM, in order to evaluate the appropriateness of using a 4 mm insulin needle. Based on pilot data collected during the preliminary phase of the study, the standard deviation of abdominal ST was estimated to be 0.60 mm. Using a 95% confidence level and a desired precision (margin of error) of ± 0.12 mm, the minimum sample size required to estimate the population mean was 96 participants. A total of 98 eligible consenting participants were recruited during the study period. This sample size was adequate for the primary descriptive objective, but it was not powered for subgroup comparisons; therefore, secondary association and subgroup analyses should be interpreted as exploratory.

Study procedure and tools

After obtaining informed consent, demographic data (including age, gender, BMI and ethnicity), clinical history of T2DM, and insulin injection practices were documented using a structured data collection form. ST and SAT thickness at insulin injection sites (abdomen and upper arm) were assessed using a portable ultrasound machine. The SonoSite M-Turbo portable ultrasound unit with a 13-6 MHz, 38 mm broadband linear array transducer probe (Sonosite Ltd.) was utilized for the study. Each participant underwent ultrasound measurements at 10 standardized abdominal sites and 8 standardized upper arm sites, following a grid-based method adapted from Sim KH et al., with permission (Figure 1).[12] The anatomical grid used to identify these sites was based on a previously validated protocol to ensure measurement consistency and reproducibility. ST was defined as the combined thickness of the epidermis and dermis, measured from the skin surface to the interface with the underlying subcutaneous fat, in accordance with the reference methodology. Ultrasound gel was applied to the skin, and care was taken to avoid probe-induced compression during measurement. All ultrasound measurements and grid mapping were performed by a single trained pharmacist to minimize inter-operator variability. The operator had completed formal Sonosite M-Turbo Ultrasound System training prior to study implementation. For measurements with ST >4 mm, the measurement was repeated twice at the same site during the initial assessment to confirm the finding before the final value was recorded. Measurements were initially

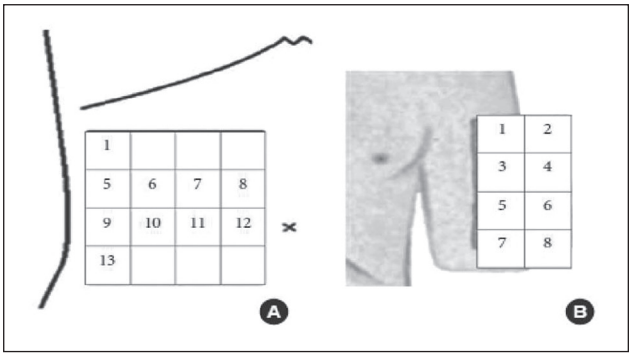

Figure 1. Measurement sites for ST and SAT on the **(A)** abdomen and **(B)** upper arm.

Adapted from Sim et al.,[12] with permission.

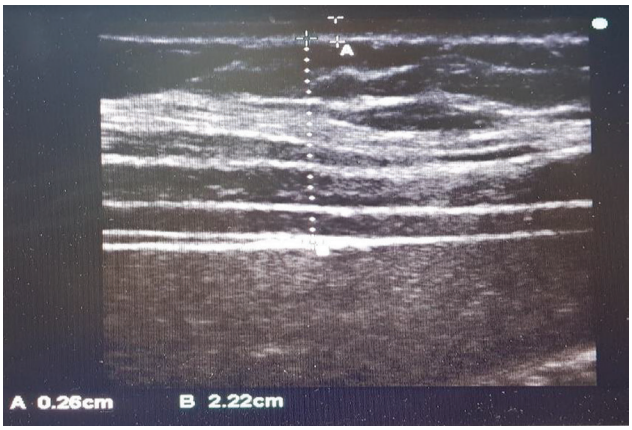

Figure 2. Representative ultrasound image illustrating vertical skin thickness (ST) measurement from the skin surface to the dermis–subcutaneous interface (labelled "A": 0.26 cm = 2.6 mm).

recorded in centimeters and converted to millimeters for analysis. The procedure required approximately 30 minutes per participant. An illustrative archived ultrasound image used for ST assessment is shown in Figure 2.

Study outcomes

The primary outcome of this study was ST at standard insulin injection sites, specifically the abdomen and upper arm. Secondary outcomes included the proportion of participants with ST >4 mm, descriptive SAT thickness profiles, and exploratory assessment of associations between tissue thickness and selected demographic or clinical variables.

Statistical analysis

Data was coded and analyzed using SPSS software version 24.0 (IBM Corp., Armonk, New York, United States). All 98 recruited participants had complete ultrasound measurements and covariate data required for the reported analyses; therefore, no imputation was performed. Implausible values were checked against the original data collection forms and ultrasound records before analysis. Normality of continuous variables was tested using the Shapiro–Wilk and Kolmogorov–Smirnov tests, along with visual inspection of histograms and Q–Q plots. Given the non-normal distribution of most tissue measurement, ST and SAT values were summarized using medians with interquartile ranges (IQRs), and full range (min–max). For each participant, average ST and SAT across all abdominal and upper arm sites was computed as a composite variable to assess overall ST and SAT for each region. Descriptive analyses were used to present ST and SAT distribution by site and region. Bivariate associations were assessed using Spearman's correlation and Mann-Whitney U tests. Multiple linear regression was performed to identify predictors of tissue thickness. Prior to interpreting the multiple linear regression models, assumptions were assessed. Linearity and homoscedasticity were evaluated using partial regression plots and scatterplots of standardized residuals versus standardized predicted values. Normality of residuals was assessed using histograms and normal P–P plots of standardized residuals. Multicollinearity was assessed using tolerance and variance inflation factor (VIF), while influential observations were assessed using studentized residuals, Cook's distance, and Mahalanobis distance. Durbin–Watson statistics were examined to assess independence of errors. A p-value <0.05 was considered statistically significant.

Use of reporting guidelines

This manuscript was prepared in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for cross-sectional studies. The STROBE checklist was completed during manuscript revision to ensure transparent and comprehensive reporting of the study's design, methodology, results, and limitations.

Patient and public involvement

Patients and members of the public were not involved in the design, conduct, reporting, or dissemination plans of this research. All participants were involved only as study subjects after providing written informed consent in accordance with the Malaysian National Medical Research Register (NMRR) and Ministry of Health research ethics requirements.

RESULTS

Demographic and clinical characteristics

The study included 98 participants (56.1% female, 43.9% male) with a mean age of 58.90 ± 8.49 years (Table 1). The study population was ethnically diverse, consisting of 59.2% Malay, 25.5% Indian, and 15.3% Chinese participants. The mean BMI at recruitment was 29.8 6 ± 4.97 kg/m^2. When classified according to Asian population standards, 40.8% of participants were pre-obese (overweight), while the remaining majority fell into Obese classes I (35.7%), II (15.3%), or III (8.2%).

Skin thickness profiles

Ultrasound profiling of the 10 standardized abdominal sites revealed a non-normal distribution of ST (Table 2). The overall abdominal ST had a median of 2.46 mm (IQR: 2.20-2.80 mm). Individual site values ranged from 1.30 mm to a maximum of 5.70 mm, with Site 7 recording the highest value of 5.70 mm, followed by Site 11 (5.60 mm) and Site 12 (5.30 mm). In the upper arm region, the median ST across 8 sites was 1.92 mm (IQR: 1.73–2.11 mm). The upper arm values ranged from 1.10 mm to 4.50 mm, with upper arm Site 2 exhibiting the greatest thickness.

Table 1. Demographic and clinical characteristics (n = 98)

Characteristic	n (%)	Mean ± SD
Age (years)		58.90 ± 8.49
<60 years	48 (49.0%)	
≥60 years	50 (51.0%)	
Gender		
Male	43 (43.9%)	
Female	55 (56.1%)	
Ethnicity		
Malay	58 (59.2%)	
Chinese	15 (15.3%)	
Indian	25 (25.5%)	
BMI (kg/m²)		29.86 ± 4.97
Pre-obese (23.0–27.4 kg/m²)	40 (40.8%)	
Obese Class I (27.5–32.4 kg/m²)	35 (35.7%)	
Obese Class II (32.5–37.4 kg/m²)	15 (15.3%)	
Obese Class III (≥37.5 kg/m²)	8 (8.2%)	
Duration of T2DM (years)		13.05 ± 6.85
<5 years	7 (7.1%)	
5-9 years	22 (22.4%)	
10-19 years	53 (54.1%)	
≥ 20 years	16 (16.3%)	
Duration of insulin therapy (years)		5.61 ± 4.43
<5 years	7 (7.1%)	
≥ 5 years	91 (92.9%)	
Insulin regimen		
Basal only	21 (21.4%)	
Premixed	62 (63.3%)	
Basal-Bolus	15 (15.3%)	

Legend: Summary of participants' age, gender, ethnicity, BMI categories (based on Asian cutoffs), duration of type 2 diabetes mellitus (T2DM) and insulin therapy, and insulin regimen types.

Subcutaneous adipose tissue profiles

SAT thickness demonstrated high variability, particularly in the abdomen (Table 3). The overall abdominal SAT thickness had a median of 16.75 mm (IQR: 14.83-19.28 mm). Individual measurements varied widely, ranging from a minimum of 2.70 mm to a maximum of 37.80 mm. In contrast, upper arm SAT was generally thinner and less variable, with a median thickness of 15.38 mm (IQR: 12.10-17.73 mm) and a range of 4.60 mm to 28.70 mm.

Risk of intradermal injection

Regarding the safety of 4 mm needles, the proportion of participants with ST exceeding 4 mm indicating a potential risk for intradermal injection, was 6.1% (n = 6) overall. Specifically, 5 participants (5.1%) had at least one abdominal site exceeding 4 mm, whereas only 1 participant (1.0%) had an upper arm site exceeding this threshold.

Predictors of ST and SAT: Multiple linear regression analysis

Multiple linear regression analyses were performed to determine the independent effects of BMI, age, and gender on tissue thickness (Table 4). Regression diagnostics showed no evidence of problematic multicollinearity or highly influential observations. Residual diagnostics were

Table 2. Skin thickness profiles of abdomen and upper arm

Site	Mean ± SD (mm)	Median (mm)	IQR (mm)	Median (IQR) (mm)	Min–Max (mm)
Abdomen					
1	2.40 ± 0.45	2.30	0.7	2.30 (2.00–2.70)	1.70–4.00
5	2.41 ± 0.47	2.35	0.7	2.35 (2.00–2.70)	1.60–3.50
6	2.59 ± 0.58	2.40	0.8	2.40 (2.10–2.90)	1.60–4.50
7	2.69 ± 0.69	2.55	1.0	2.55 (2.10–3.10)	1.80-5.70
8	2.68 ± 0.64	2.60	0.7	2.60 (2.20–2.90)	1.60–4.70
9	2.37 ± 0.49	2.30	0.7	2.30 (2.00–2.70)	1.60–3.80
10	2.56 ± 0.53	2.50	0.7	2.50 (2.20–2.90)	1.70–4.30
11	2.75 ± 0.72	2.60	0.8	2.60 (2.30–3.10)	1.70–5.60
12	2.66 ± 0.65	2.50	0.8	2.50 (2.20–3.00)	1.30–5.30
13	2.35 ± 0.46	2.20	0.6	2.20 (2.00–2.60)	1.60–3.70
Overall	2.55 ± 0.48	2.46	0.7	2.46 (2.20–2.80)	1.90-4.20
Upper Arm					
1	1.93 ± 0.42	1.85	0.5	1.85 (1.60–2.10)	1.10–3.60
2	2.31 ± 0.49	2.20	0.5	2.20 (2.00–2.50)	1.50–4.50
3	1.89 ± 0.34	1.90	0.5	1.90 (1.60–2.10)	1.10–3.00
4	2.14 ± 0.43	2.10	0.6	2.10 (1.80–2.40)	1.30–3.60
5	1.90 ± 0.31	1.80	0.4	1.80 (1.70–2.10)	1.30–2.90
6	1.99 ± 0.35	1.90	0.4	1.90 (1.80–2.20)	1.20–3.80
7	1.79 ± 0.28	1.80	0.3	1.80 (1.60–1.90)	1.10–2.70
8	1.80 ± 0.29	1.80	0.4	1.80 (1.60–2.00)	1.20–2.90
Overall	1.97 ± 0.30	1.92	0.4	1.92 (1.73–2.11)	1.40–3.20

Legend: Ultrasound-based skin thickness measurements (in mm) across 10 abdominal and 8 upper arm sites. Values are presented as mean ± standard deviation (SD), median, interquartile range (IQR), and range. Composite median ST for each region is also provided.

Table 3. Subcutaneous adipose tissue profile of abdomen and upper arm

Site	Mean ± SD (mm)	Median (mm)	IQR (mm)	Median (IQR) (mm)	Min–Max (mm)
Abdomen					
1	15.86 ± 5.51	14.75	7.00	14.75 (12.38-19.38)	2.70-37.10
5	16.32 ± 5.06	16.15	5.30	16.15 (13.53-18.88)	6.10-37.10
6	16.74 ± 4.51	16.45	4.60	16.45 (14.08-18.68)	7.00-37.10
7	17.63 ± 4.62	17.10	5.50	17.10 (14.90-20.40)	6.80-37.60
8	18.28 ± 4.49	17.95	4.40	17.95 (15.88-20.33)	5.60-37.60
9	16.83 ± 5.57	15.90	6.30	15.90 (12.75-19.08)	6.90-37.10
10	16.82 ± 4.80	16.65	4.80	16.65 (14.10-18.93)	6.20-37.80
11	18.01 ± 4.84	17.60	5.00	17.60 (15.70-20.72)	7.00-37.80
12	19.07 ± 4.70	18.35	5.60	18.35 (16.20-21.80)	9.30-37.80
13	16.71 ± 5.68	16.60	7.80	16.60 (12.50-20.28)	6.40-37.10
Overall	17.23 ± 4.25	16.75	4.50	16.75 (14.83-19.28)	7.10-37.10
Upper Arm					
1	14.63 ± 4.90	14.10	7.30	14.10 (10.88–18.23)	6.30–26.00
2	15.28 ± 4.15	15.25	6.20	15.25 (12.08–18.23)	6.40–24.70
3	15.65 ± 4.29	15.60	6.20	15.60 (12.70–18.90)	6.80–26.50
4	14.79 ± 4.13	14.85	6.20	14.85 (11.68–17.90)	6.10–23.20
5	15.74 ± 4.28	16.25	6.90	16.25 (12.05–19.00)	7.10–26.00
6	14.69 ± 4.66	14.50	7.20	14.50 (10.95–18.20)	5.60–28.70
7	15.58 ± 5.00	16.00	8.50	16.00 (11.08–19.60)	7.00–25.40
8	13.57 ± 4.74	13.45	7.60	13.45 (9.30–16.90)	4.60–23.80
Overall	15.00 ± 3.78	15.38	5.60	15.38 (12.10–17.73)	7.90–21.80

Legend: Ultrasound-based SAT measurements (in mm) across the same abdominal and upper arm sites. Data are summarized using mean ± SD, median, IQR, and minimum–maximum values. Regional composite SAT values are included.

Table 4. Multiple linear regression predicting ST and SAT thickness

Outcome variable	Predictor	B (Unstandardized)	SE B	*p*-value	Model adjusted R^2
ST abdomen	BMI	0.002	0.001	0.015*	0.069
	Age	-0.001	0.001	0.040*	
	Gender	-0.005	0.009	0.610	
ST upper arm	BMI	0.001	0.001	0.053	0.156
	Age	0.000	0.000	0.808	
	Gender	-0.025	0.006	<0.001*	
SAT abdomen	BMI	0.039	0.008	<0.001*	0.206
	Age	0.001	0.005	0.774	
	Gender	-0.173	0.077	0.026*	
SAT upper arm	BMI	0.012	0.008	0.123	-0.002
	Age	0.002	0.005	0.705	
	Gender	0.019	0.077	0.811	

*Indicates statistical significance (p <0.05)
Legend: Regression models showing the relationship between ST/SAT (dependent variables) and BMI, age, and gender (independent variables). Unstandardized coefficients (B), standard errors (SE), and p-values are reported. Significant predictors (p <0.05) are indicated with an asterisk (*).

generally acceptable for the abdominal ST, upper-arm ST, and abdominal SAT models, while the upper-arm SAT model was interpreted cautiously.

Abdominal ST: The model was statistically significant [F(3,96) = 3.45, p = 0.020], explaining 6.9% of the variance. BMI (β=0.244, p=0.015) and age (β = -0.202, p = 0.040) were significant predictors, indicating that higher BMI is associated with thicker abdominal ST, while increasing age is associated with thinner ST.

Upper arm ST: This model was highly significant [F(3,96) = 7.12, p<0.001], accounting for 15.6% of the variance. Gender was the strongest predictor (β = -0.418, p <0.001), confirming that females have significantly thinner skin on the upper arm compared to males. BMI was not a statistically significant predictor of upper arm ST (p = 0.053).

Abdominal SAT: The model for abdominal SAT was significant [F(3,96) = 9.58, p <0.001] and explained 20.6% of the variance. BMI was a strong positive predictor (β = 0.469, p <0.001). Additionally, gender emerged as a significant predictor (β = -0.205, p = 0.026), suggesting that males tend to have higher abdominal SAT thickness than females when controlling for BMI.

Upper arm SAT: The regression model for upper arm SAT was not statistically significant (p=0.424), indicating that BMI, age, and gender were poor predictors of SAT thickness in this region for the study cohort.

Comparison between injection sites

Comparatively, abdominal sites consistently displayed higher median ST (2.46 mm vs. 1.92 mm) and higher median SAT (16.75 mm vs. 15.38 mm) than upper arm sites.

While ST showed relatively low variability across both regions, SAT demonstrated marked variability, particularly in the abdomen where the interquartile ranges (IQR) for individual sites were wider (ranging from 4.40 to 7.80 mm) compared to the narrower IQRs observed in the upper arm (6.20 to 8.50 mm). These findings suggest that while ST is relatively predictable, abdominal subcutaneous fat depth is highly variable and significantly influenced by BMI.

DISCUSSION

With diabetes prevalence in Malaysia estimated at 15.6% and insulin use rising in primary care, correct injection technique (IT) is increasingly important.[2] This study represents the first targeted profiling ST and SAT using ultrasonography at standard insulin injection sites (abdomen and upper arm) among overweight and obese Malaysian adults with T2DM. The findings provide local validation for international needle length recommendations and highlight anatomical variations by body composition and gender, supporting the need for personalized insulin injection strategies.

The primary finding that the median ST was 2.46 mm at the abdomen and 1.92 mm at the upper arm supports the use of 4 mm pen needles as the standard of care for overweight and obese Malaysian adults. These values are consistent with other Asian cohorts, such as Korean adults (2.29 mm at abdomen and 2.00 mm at upper arm) and Filipino adults (2.25 mm at abdomen and 2.12 mm at upper arm).[12,16] Our results also validate the updated FITTER Forward Expert Recommendations (2025), which reaffirm that 4 mm needles are the safest option for adults of all BMIs to minimize IM risk.[17] This study adds important local evidence that Malaysian adults, despite obesity rate, generally have ST values well within the safe range for 4 mm needle use.

Among the 98 participants, only 6.1% (n = 6) had ST greater than 4 mm at any site, indicating a low risk of intradermal injection with a 4 mm needle. Specifically, 5.1% (n = 5) had at least one abdominal site above 4 mm, and only 1.0% (n = 1) had an upper arm site exceeding this value. These findings strongly support local and international guidance that a 4 mm needle can be safely used without creating a skin fold for most overweight and obese insulin-treated patients.[5,6] This low risk is clinically relevant as it facilitates simpler insulin IT, enhances adherence, and reduces pain, leakage, and glycaemic variability associated with intradermal delivery.[5-7]

It is notable that our observed prevalence of thicker abdominal ST (5.1%) is slightly lower than the 9.5% reported by Torii-Goto et al., in Japan,[7] This divergence may be attributed to measurement posture; our study used a supine position, while Torii-Goto et al. measured patients sitting, which resulted in higher ST values (mean 3.3 mm) compared to supine measurements. This suggests that ST may increase when sitting due to tissue compression, and our supine measurements might slightly underestimate functional ST during self-injection. However, the median ST in our cohort (2.46 mm) is sufficiently low that even with a hypothetical postural increase (e.g., +1 mm), the ST would likely remain well below the 4 mm threshold. Future studies should consider standardizing or comparing measurement postures to better reflect real-world injection conditions.

Given the substantial SAT layers in our participants, with a median abdominal SAT of 16.75 mm and upper arm SAT of 15.38 mm, the risk of IM injection with a 4 mm needle is negligible. This SAT depth is comparable to Filipino adults (19.1 mm) but higher than leaner Korean cohorts (10.15 mm), reflecting the specific obesity demographic of our study.[12,16] Importantly, de la Peña et al. demonstrated that in obese subjects, the depth of subcutaneous deposition does not affect the pharmacokinetics or glucodynamics of insulin, confirming that 4 mm needles are both safe and clinically effective even when insulin is deposited superficially within deep fat layers.[18]

Multiple linear regression analysis identified BMI and gender as significant predictors of tissue profiles. Gender was the strongest predictor for upper arm ST, with females having significantly thinner ST compared to males. This finding is consistent with previous studies who reported similar gender disparities.[8,12] While 4 mm needles are safe for both genders, females with lower BMI may benefit from careful assessment or the use of a skin fold to avoid IM injection, and future studies should define a threshold BMI or ST value for when a skin fold is advisable.

Regarding BMI, higher values were associated with thicker abdominal ST. While this positive correlation aligns with Sim et al., the literature is complex; Torii-Goto et al., observed that patients with BMI ≥25 kg/m^2 actually had thinner skin, while Catambing et al., found no variation.[7,12,16] These discrepancies suggest the relationship between adiposity and ST is complex and may vary by population or measurement technique. The influence of BMI on SAT is expected, as BMI is a surrogate marker for adiposity. However, the finding that BMI and age were poor predictors of upper arm SAT thickness suggests that other factors, such as fat distribution patterns specific to the Asian phenotype, may play a more dominant role in the upper arm, warranting further investigation. In exploratory subgroup analysis, Indian participants had significantly thicker abdominal ST than Chinese participants. While data on ethnic variation in ST is limited, this observation warrants further investigation. Catambing et al. noted that ST varied "marginally" in their population but cited limited comparative data, and Lim et al. have highlighted the general lack of Asian-specific tissue profiling.[16,19] Given the limited sample size and imbalance across ethnic groups, these findings should be interpreted as preliminary. Larger studies are needed to confirm whether ethnicity is a definitive factor for IT customization in Malaysia's multi-ethnic population.

Our study confirms that the abdomen offers a deeper and more variable depot for insulin compared to the upper arm. The strong positive correlation between BMI and abdominal SAT suggests BMI is a reliable clinical indicator for estimating abdominal injection depth. However, the lack of correlation between BMI and upper arm SAT indicates that arm fat storage is less predictable. This supports the preference for the abdomen as the primary injection site for consistent absorption in obese patients, as echoed by previous tissue profiling studies.[12]

Limitation

A limitation of this study is that data collection occurred in 2019; however, the anatomical parameters profiled are physiologically stable, and the persistent high prevalence of obesity (NHMS 2023) ensures continued applicability. The sample size was sufficient for the primary objective of estimating skin thickness, but it was not powered for subgroup comparisons, or ethnicity-stratified analyses. Generalizability is also limited by the single-center design and the imbalance in ethnic representation. Although the operator underwent formal ultrasound training and selected technically challenging cases received informal expert input, the study did not include systematic independent review of each ultrasound image by a radiologist or second assessor. The original exported ultrasound image files were not available at the time of manuscript preparation; therefore, the retained archived image was used for illustrative purposes only. Additionally, measurements were restricted to the supine position and did not assess functional outcomes such as glycaemic variability. Future multi-center research should prioritize larger, ethnically balanced cohorts to evaluate the clinical impact of these anatomical profiles across different injection postures.

CONCLUSION

Ultrasonographic profiling confirms that overweight and obese Malaysian adults generally present with ST values well within the range for safe short-needle use, accompanied by deep SAT. These anatomical profiles support the safety of 4 mm needles while emphasizing the need for healthcare professionals to consider individual factors such as gender and BMI when providing IT education.

Acknowledgments
The authors would like to thank the Director General of Health Malaysia for permission to publish this paper. We also extend our sincere appreciation to the pharmacy staff at Mahmoodiah Health Clinic Johor Bahru for their invaluable assistance and cooperation throughout this study. We acknowledge Becton, Dickinson and Company and Ms Angela Tan for their technical support and for providing the ultrasound equipment used in this research.

Statement of Authorship
All authors certified fulfillment of ICMJE authorship criteria.

CRediT Author Statement
CT: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data curation, Writing – original draft preparation, Writing – review and editing, Visualization, Supervision, Project administration; **YR:** Conceptualization, Methodology, Validation, Investigation, Resources, Writing – original draft preparation, Visualization; **MNY:** Conceptualization, Methodology, Validation, Investigation, Resources, Writing – original draft preparation, Visualization.

Data Availability Statement
Datasets are not publicly available because participants in the study did not give written consent for their data to be shared.

Author Disclosure
The authors declare no conflicts of interest. Becton, Dickinson and Company provided the ultrasound equipment but had no role in the study design, data collection, analysis, decision to publish, or preparation of the manuscript.

Funding Source
None. The ultrasound equipment was provided as in-kind support by Becton, Dickinson and Company.

References
1. International Diabetes Federation. IDF Diabetes Atlas, 10th ed. International Diabetes Federation; 2021.
2. Institute for Public Health (IKU). National Health and Morbidity Survey (NHMS) 2023: Non-Communicable Diseases and Healthcare Demand: Technical Report. Ministry of Health Malaysia; 2024.
3. Hussein Z, Taher SW, Gilcharan Singh HK, Chee Siew Swee W. Diabetes care in Malaysia: problems, new models, and solutions. Ann Glob Health. 2015;81(6):851-62. PMID: 27108152 DOI: 10.1016/j.aogh.2015.12.016
4. Chandran A, Abdullah MN, Abdul F. National Diabetes Registry Report 2013-2019. Ministry of Health Malaysia; 2019:1-34.
5. Frid AH, Kreugel G, Grassi G, et al. New insulin delivery recommendations. Mayo Clin Proc. 2016;91(9):1231-55. PMID: 27594187 DOI: 10.1016/j.mayocp.2016.06.010
6. Forum for Injection Technique Malaysia. FIT-MY: Recommendations for Best Practice in Injection Technique. Petaling Jaya, Malaysia: Malaysian Diabetes Educators Society; 2017.
7. Torii-Goto A, Hirai K, Inukai Y, et al. Investigation of appropriate needle length considering skin thickness with the real injection posture for insulin injections in diabetic patients. J Pharm Health Care Sci. 2023;9(1):19. MID: 37259150 PMCID: PMC10233969 DOI: 10.1186/s40780-023-00288-9
8. Derraik JG, Rademaker M, Cutfield WS, et al. Effects of age, gender, BMI, and anatomical site on skin thickness in children and adults with diabetes. PLoS One. 2014;9(1):e86637. PMID: 24466182 PMCID: PMC3897752 DOI: 10.1371/journal.pone.0086637
9. Deurenberg-Yap M, Schmidt G, van Staveren WA, Deurenberg P. The paradox of low body mass index and high body fat percentage among Chinese, Malays and Indians in Singapore. Int J Obes Relat Metab Disord. 2000;24(8):1011-7. PMID: 10951540 DOI: 10.1038/sj.ijo.0801353
10. Akkus O, Oguz A, Uzunlulu M, Kizilgul M. Evaluation of skin and subcutaneous adipose tissue thickness for optimal insulin injection. J Diabetes Metab. 2012;3(8), 2. DOI:10.4172/2155-6156.1000216
11. Wang W, Huang R, Chen Y, Tu M. Values of ultrasound for diagnosis and management of insulin-induced lipohypertrophy: A prospective cohort study in China. Medicine (Baltimore). 2021;100(29):e26743. PMID: 34398053 PMCID: PMC8294902 DOI: 10.1097/MD.0000000000026743
12. Sim KH, Hwang MS, Kim SY, Lee HM, Chang JY, Lee MK. The appropriateness of the length of insulin needles based on determination of skin and subcutaneous fat thickness in the abdomen and upper arm in patients with type 2 diabetes. Diabetes Metab J. 2014;38(2):120-33. PMID: 24851206 PMCID: PMC4021299 DOI: 10.4093/dmj.2014.38.2.120
13. Arora S, Agrawal NK, Shanthaiah DM, et al. Early detection of cutaneous complications of insulin therapy in type 1 and type 2 diabetes mellitus. Prim Care Diabetes. 2021;15(5):859-64. PMID: 34154931 DOI: 10.1016/j.pcd.2021.06.004
14. Yu J, Wang H, Zhu M, et al. Detection sensitivity of ultrasound scanning vs. clinical examination for insulin injection-related lipohypertrophy. Chin Med J (Engl). 2021;135(3):353-5. PMID: 34561336 PMCID: PMC8812698 DOI: 10.1097/CM9.0000000000001742

15. Ministry of Health Malaysia. Clinical Practice Guidelines: Management of Obesity, 2nd ed. Ministry of Health Malaysia; 2023. Accessed December 10, 2025. https://www.moh.gov.my/moh/resources/Penerbitan/CPG/Endocrine/CPG_Management_of_Obesity_(Second_Edition)_2023.pdf
16. Catambing I, Villa M. Ultrasonographic measurement of skin and subcutaneous thickness at insulin injection sites among adult Filipinos with diabetes. J ASEAN Fed Endocr Soc. 2014;29(1):24–32.
17. Klonoff DC, Berard L, Franco DR, et al. Advance insulin injection technique and education with FITTER forward expert recommendations. Mayo Clin Proc. 2025;100(4):682-99 PMID: 40180487 DOI: 10.1016/j.mayocp.2025.01.004
18. de la Peña A, Yeo KP, Linnebjerg H, et al.. Subcutaneous injection depth does not affect the pharmacokinetics or glucodynamics of insulin lispro in normal weight or healthy obese subjects. J Diabetes Sci Technol. 2015;9(4):824-30. PMID: 25697717 PMCID: PMC4525656 DOI: 10.1177/1932296815573865
19. Lim STJ, Hui YCA, Lim PK, Lim CCE, Yen Chia Y, Vasanwala RF. Ultrasound-guided measurement of skin and subcutaneous tissue thickness in children with diabetes and recommendations for giving insulin injections. J Clin Transl Endocrinol. 2018;12:26-35. PMID: 29892564 PMCID: PMC5992686 DOI: 10.1016/j.jcte.2018.04.004