Effects of thickness of muscle and subcutaneous fat on efficacy of gluteal intramuscular injection sites

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ABSTRACT

Intramuscular injections given at the dorsogluteal and ventrogluteal sites are intended for the gluteus maximus and gluteus medius muscles, respectively. However, little research has confirmed the reliability of these sites for the presence and thickness of the target and other muscles, and subcutaneous fat. This study characterised and compared these at the V-method and G-method ventrogluteal sites and dorsogluteal site (n=60). Gluteus maximus, medius and minimus were identified at each site, plus tensor fascia latae at ventrogluteal sites. Gluteus maximus and subcutaneous fat were significantly thicker and gluteus minimus significantly thinner at the dorsogluteal site than both ventrogluteal sites. Gluteus medius was the thickest muscle at each injection site, and thicker at the G-method than the V-method ventrogluteal site. Therefore, the dorsogluteal site reliably targets gluteus maximus, and the G-method ventrogluteal site was more reliable than the V-method ventrogluteal site to target gluteus medius in terms of presence and thickness.

Key words: Dorsogluteal ■ Injection ■ Intramuscular ■ Muscle ■ Subcutaneous ■ Ventrogluteal

Intramuscular injections are commonly used to administer vaccines, hormones, vitamin D, antibiotics (Nicoll and Hesby, 2002), and long-term antipsychotic medications (Gillespie and Toner, 2013). Due to their large mass, the gluteal muscles are frequent targets of intramuscular injections in adults and children (Nicoll and Hesby, 2002; Elsom and Kelly, 2009; Gillespie and Toner, 2013) and can accommodate high volumes of injected medication (Cocoman and Murray, 2008).

The dorsogluteal and ventrogluteal intramuscular injection sites theoretically target the gluteus maximus and gluteus medius muscle, respectively (Nicoll and Hesby, 2002; Greenway, 2004; Cocoman and Murray, 2010; Zimmermann, 2010; Potter et al, 2013). However, little research has actually determined the presence or thickness of these target muscles or, indeed, other muscles at the injection sites, despite the clinical importance with respect to the success and efficacy of an intramuscular injection.

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Because of the posterior attachments of gluteus maximus (Sinnatamby and Last, 2011), the dorsogluteal site is most commonly identified with the patient in a prone position, using the quadrant method (*Figure 1A*). The dorsogluteal injection site is in the upper outer quadrant of the gluteal region bounded by the lateral border of the hip, iliac crest, gluteal fold and intergluteal cleft (Zelman, 1961). The bulk of gluteus medius is superolateral to gluteus maximus (Moore et al, 2010) and, consequently, the ventrogluteal site is superolateral to the dorsogluteal site (Kim and Park, 2014), accessible from posterior and lateral approaches. This can be identified using the V method (Cocoman and Murray, 2010; Kim and Parker, 2014) or the G (geometric) method (*Figure 1B*), which reduces the subjectivity of clinician hand size and placement (Meneses and Marques, 2007). The V method injection site is between the index and middle fingers when the heel of the hand is placed on the greater trochanter and the index finger is extended towards the anterior superior iliac spine. The G method injection site is at the centroid of a triangle formed between the points of the greater trochanter, anterior superior iliac spine and iliac tubercle.

However, gluteus maximus and gluteus medius will not be the only muscle at the dorsogluteal and ventrogluteal site, respectively. Indeed, gluteus minimus has been identified at the ventrogluteal site (Kaya et al, 2015), and it is suggested that tensor fascia latae may also be present here (Moore et al, 2010), while gluteus medius is likely to be present at the dorsogluteal site. The presence and thickness of the target and other muscles is significant in terms of an intramuscular injection. For example, if gluteus maximus is too thin at the dorsogluteal site, a volume of medication recommended for injection into gluteus maximus may be instead deposited into the underlying and smaller gluteus medius muscle. Any discrepancy between injection volume and muscle mass could adversely affect drug uptake and bioavailability, which is the proportion of a drug that reaches the circulation system and is available for effects at target tissues (Stedman, 2012).

For a successful intramuscular injection, the needle tip should penetrate the target muscle at least 5 mm, with another 5 mm of muscle beyond this point (Zaybak et al, 2007). A standard 32 mm

(1.25 inches) needle has a penetration depth of 30 mm, therefore overlying subcutaneous fat needs to be less than 25 mm to avoid an inadvertent subcutaneous injection (Greenway, 2004; Chan et al, 2006), and total tissue thickness (subcutaneous fat and muscle) needs to be at least 35 mm to avoid the deeper fascia or bone. Although many articles espouse that the dorsogluteal site has thicker subcutaneous fat than the ventrogluteal site (Greenway, 2004; Cocoman and Murray, 2010), the only two studies that compared this had contradictory findings: that subcutaneous fat was thicker at the dorsogluteal site (Nisbet, 2006) and did not differ between sites (Dayananda et al, 2014). Total tissue thickness has been reported only for the ventrogluteal site (Kaya et al, 2015). While it is regularly reported that females have significantly thicker subcutaneous fat and greater risk of subcutaneous injection than males (Chan et al, 2006; Nisbet, 2006; Zayback et al, 2007; Dayananda et al, 2014), limited research has assessed the influence of gender on muscle thicknesses (Kaya et al, 2015), or the influence of body mass index (BMI) on tissue thicknesses (Chan et al, 2006; Kaya et al, 2015).

The reliability of an intramuscular injection site in terms of successful intramuscular injection depends on the presence and adequate thickness of the target muscle, as well as sufficiently thin subcutaneous fat at this site. To date, no research has characterised and compared all three gluteal injection sites. This study aims to provide comprehensive data relevant to gluteal intramuscular injections by identifying and quantifying the thickness of all the muscles and subcutaneous fat at the three gluteal intramuscular injection sites, including comparisons between sites and genders and correlations with BMI. Ultrasonography was used to determine: i) which muscle(s) were present, and the thickness of each muscle and subcutaneous fat, at the V-method and G-method ventrogluteal sites and the dorsogluteal site; ii) whether the muscle or subcutaneous fat thicknesses differed between the three gluteal intramuscular injection sites or genders, or correlated with BMI.

Materials and methods

Participants were recruited after ethics approval was granted (HE15/223; University of Wollongong Human Research Ethics Committee); inclusion criteria were that participants were at least 18 years old and physically able to move between standing and lying positions. Height and weight were measured, then the gluteal intramuscular injection sites were identified bilaterally by a registered nurse. The dorsogluteal site was identified using the quadrant method, and the ventrogluteal site was identified using both the V method and the G methods.

The thickness of the subcutaneous fat and each muscle layer was measured bilaterally at the three injection sites via ultrasound (Sonoscape S6 Portable Digital Color Doppler Ultrasound System) using a linear (L7–42; 5–12 MHz) or convex array transducer (C3–44; 2–5 MHz), the latter for better resolution at increased depth when subcutaneous fat or muscle was thick. The probe was placed in contact with the skin in a longitudinal plane at the ventrogluteal sites, and in a transverse plane at the dorsogluteal site for optimal distinction between the muscle layers, based on their fibre directions at each site. Subcutaneous fat thickness was measured from the skin to the superficial muscle fascia, and the thickness of each muscle was measured from its superficial fascia to the fascia of the muscle deeper to it or to the bone (*Figure 2*). Intra-rater reliability of ultrasound measurements was more than 90%.

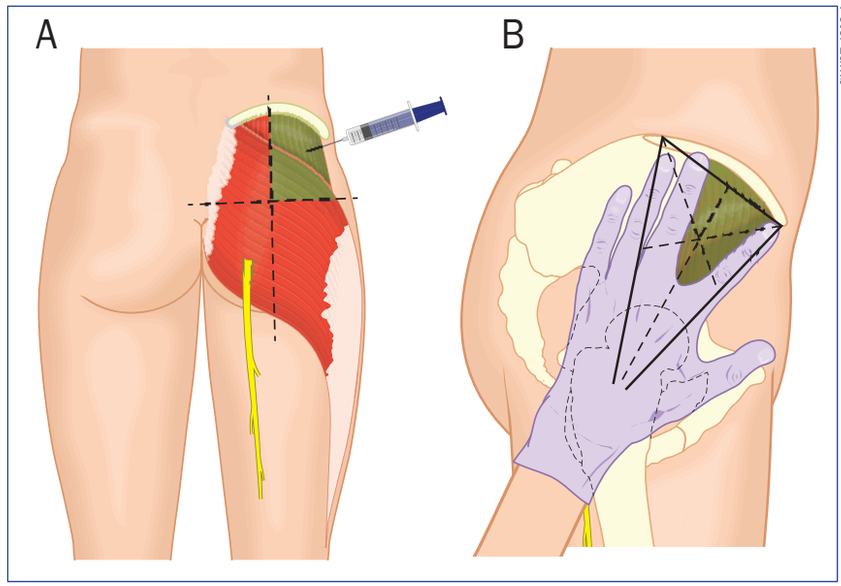

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Figure 1. A: Quadrant method for dorsogluteal site identification. B: V and G methods for ventrogluteal site identification: V method site between the index and middle fingers when the heel of the hand is on the greater trochanter; G method site at the centroid of the triangle formed between the greater trochanter, anterior superior iliac spine and iliac tubercle (adapted from Barry et al, 2014)

Results are reported as means and standard deviations. All statistical analyses were conducted using IBM SPSS statistics 20th edition. Effects of site (V-method and G-method ventrogluteal sites and dorsogluteal site) and gluteal muscle (maximus, medius and minimus) were analysed using a two-way repeated measures analysis of variance (ANOVA) with between groups comparison for gender. Because there was a significant interaction between site and muscle, univariate ANOVA with repeated measures was then conducted to determine the effect of site on the thickness of each of gluteus maximus, gluteus medius and gluteus minimus muscles individually. Subcutaneous fat was compared across sites using a univariate repeated measures ANOVA. Bonferroni post-hoc comparisons were included for all ANOVAs. Bivariate correlations (Pearson's coefficient) were performed to determine associations between BMI and thickness of muscle and subcutaneous fat at each site.

Results

A total of 60 participants (28 males; 32 females), with a mean age of 35.2±13.6 years (range: 18–71 years) participated in the study. The mean weight and BMI of all participants was 73.1±12.7 kg and 25.1±3.8 kg/m^2, respectively. When classified according to BMI, 37 participants were normal BMI (17 males; 20 females), 12 participants were overweight (7 males; 5 females) and 11 participants were obese (4 males; 7 females).

All three gluteal muscles (gluteus maximus, gluteus medius, and gluteus minimus) were identified at each injection site, in addition to tensor fascia latae muscle at both ventrogluteal sites (*Table 1*). At the dorsogluteal site, the gluteus maximus and gluteus

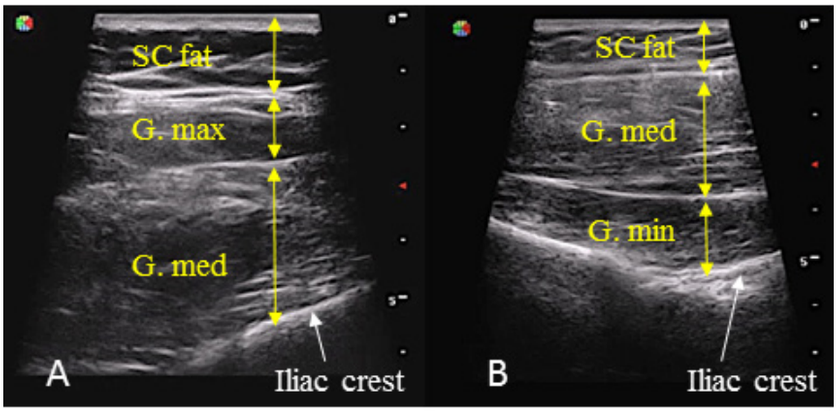

Figure 2. Ultrasound images for gluteal intramuscular injection sites using Sonoscape S6 Portable Digital Colour Doppler Ultrasound System, linear probe (L7–42), frequency 12.0–5.0 MHz. A: Dorsogluteal site; B: Ventrogluteal site, with subcutaneous fat (SC. fat), gluteus maximus (G. Max.), gluteus medius (G. Med.), gluteus minimus (G. Min.) and iliac crest labelled

medius muscles were found bilaterally in all participants. All three gluteus muscles were present more frequently at the G-method than the V-method ventrogluteal site.

The thickness of each muscle and subcutaneous fat at the three injection sites is presented in *Table 2*. When not present, muscle thickness was recorded as 0 mm. There was a significant main effect of site ($F(2,57)=63.6$, $p<0.001$) and muscle ($F 2,57)=292.5$, $p<0.001$) on muscle thickness, with no influence of gender ($p=0.952$). Muscle thickness was significantly different between each of the three sites: thickest at the dorsogluteal site and thinnest at the V-method ventrogluteal site ($p<0.001$ for all). Gluteus medius was significantly thicker than gluteus maximus and gluteus minimus ($p<0.001$ for both). There was an interaction between site and muscle on muscle thickness ($F(4,55)=149.1$, $p<0.001$), and subsequent univariate ANOVAs revealed a significant effect of injection site on the thickness of each gluteal muscle (gluteus maximus: $F(2,58)=244.4$, $p<0.001$; gluteus medius: $F(2,58)=20.4$, $p<0.001$; gluteus minimus $F(2,58)=114.2$, $p<0.001$). Gluteus maximus and gluteus medius were significantly thicker and gluteus minimus significantly thinner at the dorsogluteal site than both ventrogluteal sites ($p<0.001$ for all). Gluteus medius was significantly thicker at the G-method ventrogluteal site than the V-method ventrogluteal site ($p=0.045$).

Subcutaneous fat differed significantly between injection sites ($F(2,57)=53.9$, $p<0.001$), being thicker at the dorsogluteal site than both ventrogluteal sites ($p<0.001$). Females had significantly thicker subcutaneous fat than males ($p=0.019$). There was significant correlation between BMI and subcutaneous fat thickness at each site (*Table 2*). At the dorsogluteal site, 15% of participants ($n=9$) had total thickness of subcutaneous fat and gluteus maximus less than 30 mm, meaning a needle of 32 mm length would instead penetrate the gluteus medius muscle. The majority ($n=7$) of these were male, with a BMI range of 21–26 kg/m^2; the BMI of the two females did not exceed 21 kg/m^2. There was significant correlation between BMI and gluteus maximus thickness at each site, and with gluteus medius thickness at the G-method ventrogluteal site and the dorsogluteal site (*Table 2*).

Distribution of participants' subcutaneous fat versus total tissue thickness varied across the three injection sites (*Figure 3*). Several participants had subcutaneous fat thicker than 25 mm (upper limit for successful intramuscular injection with a standard 32 mm (1.25 inches) needle): 15% at the G-method ventrogluteal site, 13% at the V-method ventrogluteal site and 27% at the dorsogluteal site. Of note is that participants who met this criteria for the dorsogluteal site had a significantly smaller BMI (27.9±4.2 kg/m^2) than those who met this criteria for both ventrogluteal sites (G-method: BMI=31.4±3.4 kg/m^2, V-method: BMI=32.2 ± 2.7 kg/m^2; $p=0.048$ and $p=0.018$, respectively). Total tissue (muscle+subcutaneous fat) thinner than 35 mm (lower limit for successful intramuscular injection with a standard 32 mm (1.25 inches) needle) was encountered in 5% and 17% of participants at the G-method and V-method ventrogluteal site, respectively, and not at the dorsogluteal site.

Table 1. Presence of the muscles identified bilaterally and unilaterally at each injection site per cohort (n=60), males (n=28) and females (n=32)

Injection site	Muscle	Bilaterally (n)			Unilaterally (n)		
		Cohort	Males	Females	Cohort	Males	Females
Ventrogluteal (G method)	Gluteus maximus	12 (20%)	3 (11%)	9 (28%)	11 (18%)	6 (21%)	5 (16%)
	Gluteus medius	60 (100%)	28 (100%)	32 (100%)	-	-	-
	Gluteus minimus	48 (80%)	22 (79%)	26 (81%)	9 (15%)	4 (14%)	5 (16%)
	Tensor fascia latae	1 (2%)	0	1 (3%)	4 (7%)	0	4 (13%)
Ventrogluteal (V method)	Gluteus maximus	9 (15%)	1 (4%)	8 (25%)	10 (17%)	6 (21%)	4 (13%)
	Gluteus medius	57 (95%)	25 (89%)	32 (100%)	2 (3%)	1 (4%)	1 (3%)
	Gluteus minimus	46 (77%)	21 (75%)	25 (78%)	8 (13%)	4 (14%)	4 (13%)
	Tensor fascia latae	2 (3%)	1 (4%)	1 (3%)	12 (20%)	3 (11%)	9 (28%)
Dorsogluteal	Gluteus maximus	60 (100%)	28 (100%)	32 (100%)	-	-	-
	Gluteus medius	60 (100%)	28 (100%)	32 (100%)	-	-	-
	Gluteus minimus	6 (10%)	4 (14%)	2 (6%)	4 (7%)	4 (14%)	0

Table 2. Thickness of the muscles and subcutaneous fat at each of the gluteal intramuscular injection sites: ventrogluteal site (G method), ventrogluteal site (V method) and dorsogluteal site. The values represent the mean ± standard deviation of the cohort (n=60), males (n=28), females (n=32)

Site	Tissue	Cohort (mm) (range)	Males (mm)	Females (mm)	Correlation with BMI
Ventrogluteal (G method)	Gluteus maximus	3.5±6.2 (0.0–26.6)	2.7±6.6	4.2±5.8	R=0.341 p=0.008
	Gluteus medius	23.3±5.4 (11.4–37.0)	24.7±6.1	22.2±4.4	R=0.310 p=0.016
	Gluteus minimus	13.0±5.7 (0.0–25.6)	13.2±6.6	12.8±5	R=0.073 p=0.578
	Tensor fascia latae	0.2±0.8 (0.0–3.9)	0.0±0.0	0.4±1.0	–
	Subcutaneous fat	13.3±9.9 (2.5–50.5)	9.9±5.3	16.2±12.0	R=0.775 p<0.0001
Ventrogluteal (V method)	Gluteus maximus	2.6±5.1 (0.0–26.6)	1.9±5.4	3.2±4.9	R=0.392 p=0.002
	Gluteus medius	21.3±6.9 (0.0–37.0)	21.1±7.9	21.4±5.9	R=0.215 p=0.099
	Gluteus minimus	12.2±6.4 (0.0–27.6)	12.4±7.4	12±5.6	R=0.036 p=0.784
	Tensor fascia latae	0.6±1.2 (0.0–3.9)	0.4±1.0	0.8±1.3	R=0.036 p=0.784
	Subcutaneous fat	12.9±10.2 (2.5–54.4)	9.8±6.6	15.6±12.0	R=0.792 p<0.0001
Dorsogluteal	Gluteus maximus	24.3±8.2 (10.3–47.6)	22.4±7.6	26.0±8.5	R=0.612 p<0.0001
	Gluteus medius	29.1±8.1 (11.4–53.1)	30±6.5	28.3±9.3	R=0.595 p<0.0001
	Gluteus minimus	1.1±3 (0.0–16.0)	2.0±3.8	0.4±1.7	R=-0.107 p=0.415
	Subcutaneous fat	21.3±9.3 (6.6–55.5)	18.8±8.3	23.5±9.6	R=0.622 p<0.0001

Discussion

The dorsogluteal site and the G-method and V-method ventrogluteal sites were each characterised by multiple muscle layers, with all three gluteal muscles (gluteus maximus, medius and minimus) present at each site in at least 10% of participants. Gluteus maximus and gluteus medius were identified in all participants at the dorsogluteal site, providing empirical evidence that this injection site does reliably target gluteus maximus; this has not been reported previously. The gluteus medius muscle was the most prevalent and thickest muscle at the ventrogluteal sites, which confirms this as the target muscle of injections given at this site, as previously reported in a single other paper (Kaya et al, 2015).

The G-method ventrogluteal site was more reliable than the V-method ventrogluteal site in terms of the presence and thickness of the target muscle, gluteus medius. Gluteus medius was present in 100% of cases and significantly thicker at the G-method than the V-method ventrogluteal site. Gluteus minimus was also identified at the ventrogluteal site in the majority of participants, which supports the results of Kaya et al (2015). Gluteus maximus was also present bilaterally and the tensor fascia latae muscle unilaterally at the ventrogluteal site in up to 20% of the cohort. This has not been previously reported, but is expected due to their anatomical attachments. Therefore, tensor fascia latae can be targeted at the ventrogluteal site (Moore et al, 2010); however, its presence was inconsistent, more often unilateral than bilateral and at the V-method than at the G-method ventrogluteal site. There were also more participants at risk of total tissue being too thin at the V-method ventrogluteal site for a successful intramuscular injection. Taken together, this highlights the greater variability and lower reliability of the V-method ventrogluteal site.

At the dorsogluteal site, both gluteus maximus and gluteus medius were present bilaterally in 100% of participants, which

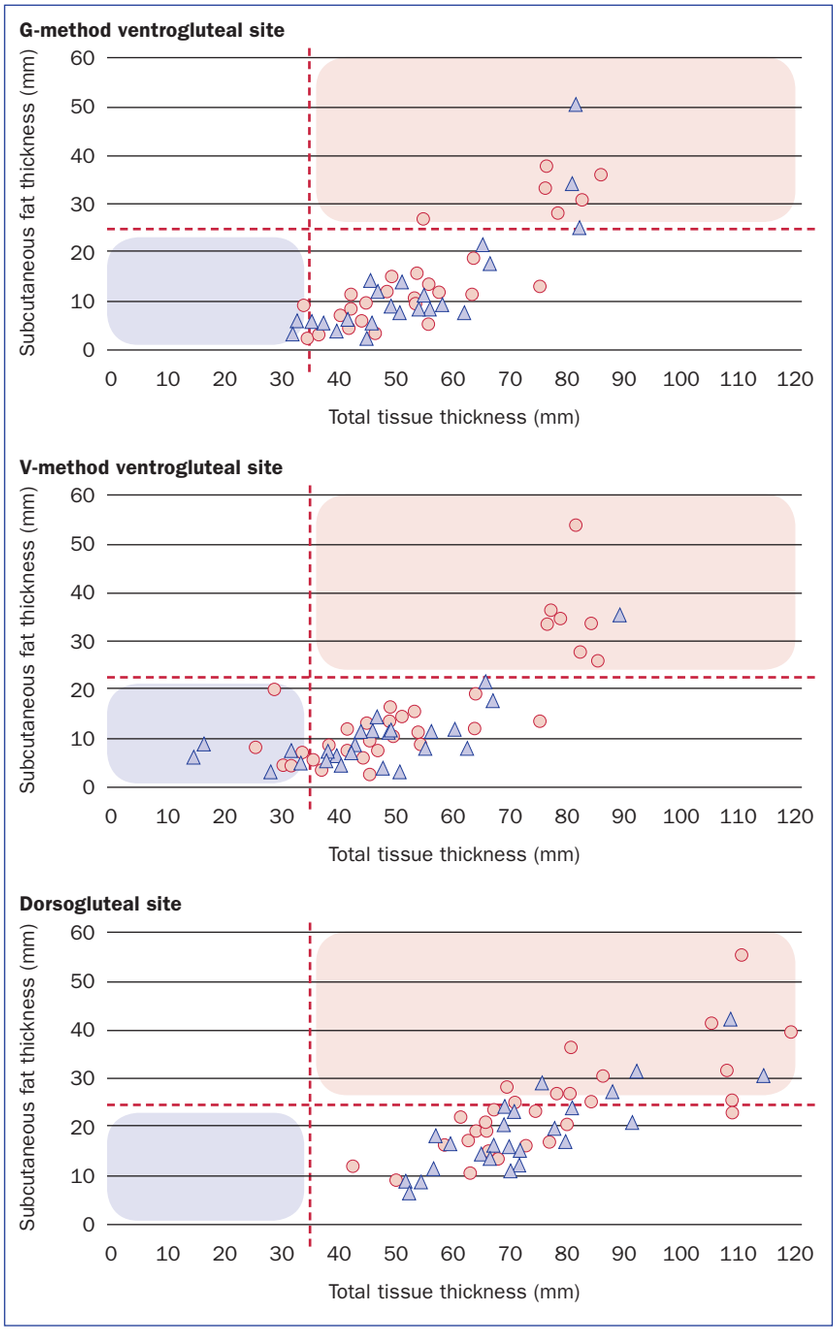

Figure 3. Subcutaneous fat thickness versus total tissue thickness for G-method ventrogluteal site, V-method ventrogluteal site and dorsogluteal site. Males: n=28, females: n=32. Data points above the broken horizontal line indicate participants who would receive a subcutaneous injection (tan-shaded area). Data points to the left of the broken vertical line indicate participants at risk of the needle reaching the bone (mauve shaded area)

reflects their anatomical attachments (Ellis and Mahadevan, 2010; Moore et al, 2010; Sinnatamby and Last, 2011). Gluteus minimus was also present bilaterally in 10% of participants at the dorsogluteal site; this has not been previously reported. Of clinical importance is that for 15% of participants, total subcutaneous fat plus gluteus maximus thickness at this site was thinner than the penetration depth of the standard needle. Consequently, medication would be injected into gluteus medius instead of gluteus maximus. If an injected volume exceeds the capacity of the lesser size and vasculature of gluteus medius, medication uptake and bioavailability may be reduced. Further investigation, including more detailed characterisation of patients at risk, is warranted.

Subcutaneous fat thickness was influenced by injection site, gender and BMI. Subcutaneous fat was thicker at the dorsogluteal site than the ventrogluteal site, which agrees with literature claims (Greenway, 2004; Cocoman and Murray, 2010) and the results of Nisbet (2006), but contradicts the findings of Dayananda et al (2014), who reported no difference between the sites. However, this was quantified with participants in a supine position, which may have caused lateral displacement of subcutaneous fat. Females had thicker subcutaneous fat than males, significant at the ventrogluteal site and almost significant (p=0.051) at the dorsogluteal site, which is in line with previous studies (Nisbet, 2006; Burbridge, 2007; Zaybak et al, 2007; Dayananda et al. 2014; Kaya et al, 2015). There was significant correlation between BMI and subcutaneous fat thickness at each injection site, as previously reported for the dorsogluteal site (Chan et al, 2006; Boyd et al, 2013) and ventrogluteal sites (Kaya et al, 2015).

Accordingly, more participants were at risk of a subcutaneous rather than a successful intramuscular injection at the dorsogluteal site than at the ventrogluteal site, most of these were females, and overweight or obese individuals. At the dorsogluteal site, almost one third of participants were at risk of receiving a subcutaneous injection, which is a sizeable proportion, although less than in previous studies (Chan et al, 2006; Burbridge, 2007). Despite there being more participants with subcutaneous fat thicker than 25 mm at the dorsogluteal site, their mean BMI was significantly smaller than those who had subcutaneous fat thicker than 25 mm at the ventrogluteal site, indicating that a subcutaneous outcome is less predictable at the dorsogluteal site.

There were no gender differences for the predominant muscles, that is gluteus medius and gluteus minimus at the ventrogluteal site, and gluteus maximus and gluteus medius at the dorsogluteal site. This concurs with the findings of the only other study that has determined this at the ventrogluteal site (Kaya et al, 2015); there were no studies to compare for the dorsogluteal site. There was significant correlation between BMI and gluteus maximus thicknesses at each site, and with gluteus medius thickness at the dorsogluteal site and at the G-method ventrogluteal site. The significant correlation between BMI and gluteus medius thickness, the significantly thickest muscle at each site, at the dorsogluteal site and the G-method ventrogluteal site is indicative of greater predictability of muscle and therefore total tissue thickness at these sites; this is an important clinical consideration in terms of site selection. In contrast, the lack of correlation between BMI and gluteus medius thickness at the V-method ventrogluteal site is indicative of higher variability at this site in terms of muscle and total tissue thickness.

Conclusion

This study is the first to report on characterisation and comparison of the dorsogluteal and the two ventrogluteal intramuscular injection sites. Overall, the dorsogluteal site is reliable for targeting gluteus maximus and had a thicker muscle layer than both of

the ventrogluteal sites. However, this site was also characterised by thicker subcutaneous fat, and was associated with a higher risk of a subcutaneous, rather than intramuscular, injection. Therefore, it is recommended that, particularly for females who are overweight or obese, the ventrogluteal site be used instead of the dorsogluteal site.

The G-method ventrogluteal site is more reliable than the V-method ventrogluteal site in terms of gluteus medius presence, muscle thickness and likelihood of successful intramuscular injection. There was greater variability at the V-method ventrogluteal site, particularly in terms of muscles other than the target muscles, and more individuals were at risk of the needle reaching the bone here. Accordingly, it would be beneficial for nurses to become familiar with, and to practise, the G method of ventrogluteal site identification. The G method should be used over the V method for leaner individuals for a successful intramuscular injection without the risk of bone contact.

Overall, because of the significant influences of gender and BMI on subcutaneous fat thickness, these characteristics may be useful discriminators to assist with site selection and needle length for successful intramuscular injection outcomes. Nurses should base their site selection and needle size choices based on an assessment of patient characteristics, including gender and BMI. More research to support evidence-based decisions is warranted. **BJN**

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Conflicts of interest: none declared

KEY POINTS

- Little research has confirmed the reliability of the gluteal intramuscular injection sites in terms of the presence or thickness of all the muscles and subcutaneous fat at these injection sites
- Gluteus maximus was present in 100% of cases at the dorsogluteal site, and was thicker at this site than the ventrogluteal sites; therefore, the dorsogluteal site reliably targets gluteus maximus
- Gluteus medius was present in 100% of cases and thicker at the G-method than the V-method ventrogluteal site; therefore, the G-method ventrogluteal site is more reliable than the V-method ventrogluteal site to target gluteus medius muscle
- The V-method ventrogluteal site is less reliable and more variable, with gluteus medius present in 95% of cases and tensor fascia latae muscle present unilaterally in 20% of participants
- An intended intramuscular injection given at the dorsogluteal site would be deposited in the subcutaneous fat or gluteus medius for 27% and 15% of participants, respectively

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CPD reflective questions

- Do you use the G method of ventrogluteal site identification instead of the V method?
- Does your clinical setting need to including training for nursing staff on use of the G method for ventrogluteal site identification?
- Can you assess the BMI of patients before giving a gluteal intramuscular injection for better site and needle length selection?