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Original Article

Comparison of the G and V methods for ventrogluteal site identification: Muscle and subcutaneous fat thicknesses and considerations for successful intramuscular injection

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ABSTRACT: *The ventrogluteal site is increasingly recommended for long-acting antipsychotic intramuscular injections; however, it remains infrequently utilized due to nurses' lack of confidence in site identification. The more recent G (geometric) method of ventrogluteal site identification is less subjective and likely more reliable than the V method for successful intramuscular injection outcomes. Knowledge of muscle and subcutaneous fat thicknesses, and the influence of sex and anthropometry on theoretical injection outcome, is necessary to support evidence-based use of the ventrogluteal site. In the presents study, we compared the V and G methods for injection site subcutaneous fat, muscle, and total tissue thicknesses, and theoretical injection outcome (bone injury, intramuscular or subcutaneous), and determined anthropometric predictors of injection outcome. Subcutaneous fat and muscle thicknesses were measured* via *ultrasound, bilaterally at V and G method sites (28 males, 32 females). Muscle and total tissue were significantly thicker, and successful intramuscular injection significantly more likely, using the G versus V method (75% versus 57%). Females had significantly thicker subcutaneous fat than males at both sites. Even using the G method, 92% of males but only 59% of females, would have a successful intramuscular injection, with remaining females at risk of bone injury (16%) or subcutaneous injection (25%). The G method site is more reliable for successful intramuscular injection, with less risk of bone injury than the V method site. Appropriate needle-length selection is essential for females with a body mass index (BMI) <23 kg m^{-2} and weight <60 kg (to avoid bone injury), and BMI >30 kg m^{-2} and hip >90 cm (to avoid subcutaneous injection).*

KEY WORDS: *antipsychotic, G method, injection, intramuscular, ultrasound, ventrogluteal.*

INTRODUCTION

Intramuscular depot injections of long-acting antipsychotic medications are commonly administered to patients with schizophrenia (Berwaerts *et al.* 2015; Chan *et al.* 2015; Manchanda *et al.* 2013; Rossi *et al.* 2012; Schooler 2003). Because most long-acting injectable antipsychotic medications are oily suspensions of large volume, they are commonly prescribed for gluteal intramuscular injection (Gillespie & Toner 2013). Although this has traditionally described or implied administration at the dorsogluteal site, there are safety concerns regarding the use of the dorsogluteal site, and consequently, it is increasingly recommended to avoid the dorsogluteal site in favour of the ventrogluteal site (Cocoman & Murray 2008; Nicoll & Hesby 2002;

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Rodger & King 2000). However, despite such recommendations, the majority of nurses remain reluctant to use the ventrogluteal site, mostly due to unfamiliarity and a lack of confidence in site identification (Wynaden *et al.* 2006). Employing the more recently-described G (geometric) method of identification (Meneses & Marques 2007), instead of the original V method, facilitates a directed and less subjective approach towards site identification, which could increase clinicians' confidence in, and use of, the ventrogluteal site.

Although the ventrogluteal injection site is increasingly recommended over the dorsogluteal site for gluteal intramuscular injections, there is scarcity of research on the thickness of injection site subcutaneous fat and muscle, which directly influence injection outcome, and empirical research is much needed to establish guidelines and encourage evidence-based practice (Brown *et al.* 2015; Wynaden *et al.* 2006). The present study characterizes and compares the subcutaneous fat, muscle, and total tissue thicknesses at the ventrogluteal site, as identified by both the V and G methods, and with respect to theoretical injection outcome. These data can be used to provide better knowledge of, increase confidence in, and promote an evidence-based approach for use of, the ventrogluteal site.

Background

The ventrogluteal intramuscular injection site targets the gluteus medius muscle, which is large and well developed in children and adults, and therefore, suitable for large-volume intramuscular injections, including long-acting antipsychotics (Gillespie & Toner 2013; Greenway 2004; Nicoll & Hesby 2002). Anatomically, the ventrogluteal site is superolateral to the dorsogluteal site, which has advantages in relation to injury risk and accessibility. The ventrogluteal site is deemed safer than the dorsogluteal site because it is further from, and thereby associated with less potential risk of injury to, the sciatic nerve and gluteal vessels (Cocoman & Murray 2008, 2010; Cornwall 2011; Elsom & Kelly 2009; Greenway 2004; Hopkins & Arias 2013; Zimmermann 2010). Its superolateral location also means that the ventrogluteal site is accessible with the patient in a supine, prone, or lateral position, as opposed to the dorsogluteal site, which can only be accessed when the patient is prone or lateral (Greenway 2004; Nicoll & Hesby 2002). Consequently, the ventrogluteal site is increasingly taught as the preferred gluteal intramuscular injection site, and its use is endorsed by several health policies (Elsom & Kelly 2009; Payne *et al.* 2014; Sim 2012; South Eastern Sydney Local Health District 2011).

Despite the ventrogluteal site being increasingly advocated, it continues to be used less frequently than the dorsogluteal site (Cocoman & Murray 2008; Elsom & Kelly 2009; Floyd & Meyer 2007; Gillespie & Toner 2013; Greenway 2004; Walsh & Brophy 2011; Wynaden *et al.* 2015). Indeed, the use of the ventrogluteal site among Australian mental health nurses was only 12% in 2006 and 10% in 2012, with nurses reporting reluctance to change from using the dorsogluteal site (Wynaden *et al.* 2006, 2015). A common reason given by nurses for avoiding the ventrogluteal site is perceived difficulty of, and less confidence in, site identification (Greenway 2004; Hopkins & Arias 2013; Kaya *et al.* 2015; Walsh & Brophy 2011; Wynaden *et al.* 2006). Identification of the ventrogluteal site uses prominent bony landmarks (greater trochanter of the femur, the anterior superior iliac spine (ASIS), and the iliac crest or iliac tubercle), which should make site identification easier and more reliable (Cocoman & Murray 2010; Kara *et al.* 2015; Nicoll & Hesby 2002; Wynaden *et al.* 2006; Zelman 1961). However, the need for the nurse administering the injection to use their hand to determine the injection site increases the ambiguity of site selection.

The ventrogluteal site and the V method of its identification were first described by Hochstetter in the 1950s (Hochstetter 1954). The palm or heel of the opposite hand to the patient's hip is placed on the greater trochanter, with the index and middle fingers extended in a V shape towards the ASIS and iliac crest, respectively, with the injection site between the fingers at the level of the knuckles (Greenway 2004; Nicoll & Hesby 2002). However, whether the palm or the heel of the hand is used, as well as the size of the clinician's hand, will affect the exact site location (Kaya *et al.* 2015), particularly in terms of proximity to the iliac crest. An improvement on this method is to use the G (geometric) method of identification, first described by Meneses and Marques (2007), which removes the variable influence of the clinician's hand size and placement. The greater trochanter, iliac tubercle, and ASIS are palpated, a triangle drawn between them, and the midpoint of each side connected to the opposite vertex to form a triangle, with the centroid as the injection point (Meneses & Marques 2007). A recent study that characterized and compared injection site muscle and subcutaneous fat thicknesses using the G and V methods concluded that the G method was more reliable (Kaya *et al.* 2015). Increased awareness of the G method and more detailed data in relation to ventrogluteal injection site tissue characteristics could encourage clinicians' confidence in, and use of, this site.

The thickness of subcutaneous fat and muscle at an injection site will determine whether or not an intramuscular injection is successful. If subcutaneous fat is thicker than 25 mm, an intramuscular injection with a standard 32-mm (1¼ inch) needle will result in the medication being deposited into the subcutaneous fat rather than intramuscularly, resulting in slower drug absorption, reduced effectiveness, and local tissue damage (Cocoman & Murray 2008; Dayananda *et al.* 2014; Greenway 2004; Wynaden *et al.* 2006). In terms of long-term antipsychotic medications, a lack of anticipated response could result in the dose being inappropriately increased (Payne *et al.* 2014). Because of thick subcutaneous fat, a large proportion of individuals are likely to have a subcutaneous rather than an intended intramuscular injection at the ventrogluteal site (Dayananda *et al.* 2014; Nisbet 2006; Zaybak *et al.* 2007). In contrast, total tissue thickness (skin–bone margin, incorporating the thickness of muscle and subcutaneous fat) should be at least 35 mm to ensure a 5-mm safety margin to prevent a 32-mm needle hitting the bone and causing pain or injury (Cook 2015). Only one study (Kaya *et al.* 2015) has determined the skin–bone margin at the ventrogluteal site, and the minimum thickness reported indicates that some individuals are indeed at risk of bone injury with an intramuscular injection at the ventrogluteal site.

It is regularly suggested that body mass index (BMI), weight, muscle mass, and subcutaneous fat thickness at an injection site should be considered with respect to choosing the most appropriate needle length (Cocoman & Murray 2008; Kaya *et al.* 2015; Palma & Strofhus 2013; Rai & Nandan 2006). Sex, age, and anthropometry influence gluteal region subcutaneous fat and muscle thicknesses (Chan *et al.* 2006; Dayananda *et al.* 2014; Kaya *et al.* 2015; Nisbet 2006; Zaybak *et al.* 2007), which in turn directly determine whether a gluteal intramuscular injection will be successful, subcutaneous, or risk bone injury. Further, it is important to ascertain intra- and inter-individual variability in muscle, subcutaneous fat, and total tissue thicknesses at the ventrogluteal site, as identified by both the V and G methods as a measure of site reliability.

The aim of the present study was to characterize and compare the V and G methods of ventrogluteal site identification in terms of (i) injection site subcutaneous fat, muscle, and total tissue thicknesses; (ii) the proportion of individuals who would have a theoretical injection outcome of a successful intramuscular injection versus subcutaneous injection versus bone injury; and (iii) anthropometric data that can predict theoretical injection outcome.

METHODS

The present study was of cross-sectional design. After gaining ethics approval (University of Wollongong Human Research Ethics Committee, Wollongong, Australia, no. HE15/223), participants were recruited locally through the university campus and online communications. Participants were healthy volunteers, and the only inclusion criteria were that participants needed to be aged at least 18 years of age and physically able to stand for anthropometric and ultrasound measurements. The only exclusion criterion was having a known allergy to skin-safe markers or ultrasound gel. Upon arrival to the Clinical Research Trials Unit at the Illawarra Health and Medical Research Institute (Wollongong, NSW, Australia), each participant gave signed, informed consent and was assigned a unique identification code, such that all associated data were confidential and anonymous.

The only demographic variables collected were sex and age. All anthropometric data were measured and recorded by a single investigator (a registered nurse). Anthropometric data collected included height and weight, from which the BMI was calculated; body fat percentage (Tanita InnerScan Body Composition Monitor Scale, Tanita Australia, Kewdale, Australia); circumferences of mid-thigh (halfway between the gluteal sulcus and popliteal crease, bilaterally), upper thigh (immediately below the gluteal sulcus, bilaterally), hip (level of the greater trochanter), and waist (midpoint between the iliac crest and lowest rib); and distances between the greater trochanter, ASIS, and iliac tubercle. The mean of the left and right upper thigh and mid-thigh circumferences, and distances between the bony landmarks was calculated for each participant. The BMI of each participant was classified as underweight (<18.5 kg m^{-2}), normal (18.5–24.99 kg m^{-2}), overweight (24.99–29.99 kg m^{-2}), or obese (>29.99 kg m^{-2}).

The registered nurse investigator then identified the VG site bilaterally, using first the V method and then the G method for all participants, and marked each site on the skin surface using a skin-safe marker. The V method of site identification was performed first, before the bony landmarks were marked on the skin, to avoid bias. For V method identification, the heel of the nurse's hand was placed on the greater trochanter of the participant's opposite side, the index finger extended towards the ASIS, the middle finger towards the iliac tubercle, and the injection point marked at the level of the proximal interphalangeal joint. For G method identification, the ASIS, iliac tubercle, and greater trochanter were identified by palpation, and each was marked on the skin. A triangle was drawn by connecting adjacent marked landmarks, and the centroid of this triangle established using a measuring tape by drawing a line from the mid-point of each side of the triangle to the opposite vertex.

Ultrasound imaging analysis was conducted at both of the V and G method sites bilaterally (Sonoscape S6 Portable Digital Colour Doppler Ultrasound System; Sonoscape, Shenzhen, Guangdong, China) by a different researcher. Depending on the thickness of subcutaneous fat and muscle at each individual site, the linear array transducer (L7-42; 5–12 MHz, maximum depth 7 cm) or convex array transducer (C3-44; 2–5 MHz, maximum depth 30 cm) was placed in contact with the skin in a longitudinal plane. Subcutaneous fat thickness (between skin and superficial muscle fascia) and muscle thickness (between superficial muscle fascia and ilium) were measured and recorded to the nearest 0.01 mm. Ultrasound is a reliable method for quantification of subcutaneous fat and muscle thicknesses (DuPont *et al*. 2001; Wagner 2013). Intra-rater reliability of ultrasound measurements, as determined by calculating the coefficient of variation of 10 repeated measurements, was 7.3% for subcutaneous fat thickness, 7.1% for muscle thickness, and 5.2% for total tissue thickness.

Total tissue was calculated as the sum of subcutaneous fat and muscle thicknesses. Theoretical injection outcome was defined per individual for each of the V method and G method, as 'intramuscular' when subcutaneous fat was thinner than 25 mm and total tissue was at least 35 mm thick, bilaterally; and 'bone' when the total tissue thickness was less than 35 mm unilaterally or bilaterally; 'subcutaneous' when the subcutaneous fat was at least 25 mm unilaterally or bilaterally, at the respective site.

All statistical analyses were conducted using IBM SPSS Statistics version 21 (IBM SPSS, Armonk, NY, USA) and Microsoft Excel (Microsoft, Redmond, WA, USA). Values are reported as mean ± SD, with a significance level of $P < 0.05$. As a measure of intra-individual variability, the coefficient of variation was calculated per participant for their bilateral measures of each of subcutaneous fat, muscle, and total tissue thicknesses. Comparisons were made between the V and G methods (Student's paired *t*-tests), between sexes (Student's independent *t*-tests), and between injection outcome groups (analysis of variance (ANOVA) with Tukey's post-hoc analysis); χ^2 analysis was conducted to determine any influence of site or sex on the distribution of participants across the theoretical injection outcome categories. A power calculation for χ^2 analysis with 2° of freedom (injection method vs theoretical injection outcome), with 80% power, 0.5 effect size, and 0.05 significance level, showed that a sample size of $n = 39$ was necessary. The aim was to recruit 50 participants, with approximately equal numbers of males and females.

RESULTS

Data from a total of 60 participants (28 males and 32 females) were collected and analysed. Recruitment continued to include 60 rather than 50 participants to even out the sex balance after more females than males initially volunteered. Participants' demographic and anthropometric data are presented in Table 1. The only significant differences between sexes were that males were taller, weighed more, and had a larger waist circumference, while females had a higher body fat percentage. The majority of participants ($n = 37$; 62%) were of normal BMI, while 12 (20%) were overweight and 11 (18%) were obese.

Mean thicknesses of muscle, subcutaneous fat, and total tissue at the V and G method sites are presented in Table 2. Muscle and total tissue were both significantly thicker at the G method site for the cohort (males and females), but subcutaneous fat thickness was not significantly different between the two sites. Females had significantly thicker subcutaneous fat then males at both sites, but there were no significant differences between sexes for muscle thickness or total tissue thickness at either site. The coefficients of variation for participants' mean subcutaneous fat, muscle, and total tissue thicknesses (inter-individual variation) were 75%, 20%, and 25%, respectively, using the G method, and 80%, 30%, and 35%, respectively, using the V method. In terms of intra-individual variation between left and right sides, the coefficient of variation for total tissue thickness was significantly higher for the V method than the G method (14.5 ± 14.7% vs 9.4 ± 8.4%, $P = 0.008$; Student's paired *t*-test). In contrast, there was no significant difference between the V and G methods for the coefficient of variation for

TABLE 1: *Demographic and anthropometric data*

Variable	Cohort (n = 60)	Males (n = 28)	Females (n = 32)	Males vs females (P)
Age (years)	35 ± 14 (18–71)	34 ± 12 (21–70)	36 ± 15 (18–71)	0.50
Weight (kg)	73 ± 13 (54–110)	78 ± 12 (63–110)	68 ± 12 (54–98)	<0.01
Height (cm)	170 ± 8 (156–188)	177 ± 6 (168–188)	165 ± 6 (156–175)	<0.01
BMI (kg m^{-2})	25 ± 4 (21–37)	25 ± 4 (21–36)	25 ± 4 (20–37)	0.98
Body fat (%)	26 ± 10 (12–50)	19 ± 5 (12–32)	32 ± 8 (19–50)	<0.01
Waist circumference (cm)	83 ± 11 (67–114)	86 ± 8 (74–114)	80 ± 12 (67–113)	0.038
Hip circumference (cm)	102 ± 8 (90–125)	100 ± 6 (90–115)	104 ± 9 (93–125)	0.057
Upper thigh circumference (cm)	59 ± 6 (43–64)	59 ± 5 (43–64)	60 ± 6 (45–58)	0.51
Mid-thigh circumference (cm)	50 ± 4 (45–72)	50 ± 5 (50–71)	50 ± 3 (45–72)	0.72
Greater trochanter: ASIS (cm)	13.6 ± 1.8 (11.0–19)	13.2 ± 1.4 (11.0–16.0)	14.0 ± 2.0 (11.0–19.0)	0.068
Greater trochanter: iliac tubercle (cm)	16.8 ± 1.9 (13.5–21.5)	16.1 ± 1.4 (13.5–21.0)	17.4 ± 2.1 (14–21.5)	0.010
ASIS: iliac tubercle (cm)	10.8 ± 0.9 (8.5–13.0)	10.9 ± 0.9 (8.5–13.0)	10.6 ± 0.8 (9.5–13.0)	0.231

Mean ± SD, range in parentheses. Comparison between sexes: Student's independent t-test. BMI, body mass index.

subcutaneous fat thickness (20.1 ± 17% vs 18.3 ± 13.4%, P = 0.34) or muscle thickness (17.8 ± 17.7% vs 13.8 ± 12.2%, P = 0.10). The sites determined by the V and G methods were identical in 34 participants (bilaterally in 19 participants and unilaterally in 15 participants). When the sites identified by the two methods differed, the V method site was more superior in 82% of cases.

There was a significant effect of identification method on theoretical injection outcome distribution ($\chi^2(2)$ = 6.793, P = 0.033, χ^2 analysis), with more participants likely to have a successful intramuscular injection using the G method rather than the V method. At the V method site, 57% of participants would have a successful intramuscular injection, while 28% were at risk of bone injury and 15% would have a subcutaneous injection. At the G method site, 75% of participants would have a successful intramuscular injection, 10% were at risk of bone injury, and 15% would have a subcutaneous injection. There was also a significant influence of sex on distribution across the injection outcome categories ($\chi^2(3)$ = 9.034, P = 0.029, χ^2 analysis). The majority of males, but less than 50% of females, would have a successful intramuscular injection at both the V and G method sites (Table 3).

There were four different combinations of theoretical injection outcomes at the ventrogluteal site, as determined by both the V and G methods (Table 3). Most participants would have the same injection outcome independent of method of site identification using either the V or G method, 57% would receive an intramuscular injection, 15% would receive a subcutaneous injection, and 10% were at risk of bone injury. However, for the remaining 18% of participants, injection outcome differed between the methods; they were at risk of bone injury using the V method, but would receive an intramuscular injection using the G method. Weight; BMI; body fat percentage; and waist, hip, mid-thigh, and upper thigh circumferences were all significantly different between the four injection outcome groups (ANOVA, Table 3). Males (n = 6) who had a theoretical injection outcome of bone injury using the V method, but intramuscular using the G method, had significantly thicker muscle at the G method site (39.4 ± 4.8 mm vs 25.3 ± 9.3 mm, P = 0.008), but subcutaneous fat thickness was not significantly different between the G and V methods (8.5 ± 3.7 mm vs 6.3 ± 2.0 mm, P = 0.07). Females (n = 5) who were at risk of bone injury using the V method, but would receive an intramuscular injection using the G method, had significantly thicker muscle (35.6 ± 5.8 mm vs 31.7 ± 4.3 mm, P = 0.016) and subcutaneous fat (11.21 ± 3.64 mm vs 8.93 ± 3.48 mm, P = 0.006) at the site identified by the G method compared with the V method.

Data analysis pertaining to theoretical injection outcome based on the evidently better G method only revealed that 92% of males and 59% of females would have a successful intramuscular injection at the ventrogluteal site, as identified by the G method. All females (n = 5, 16%) who were at risk of bone injury using the G method of ventrogluteal site identification had a BMI less than 23 kg m^{-2} and weighed less than 60 kg, although an additional three females who met these parameters would have had a successful intramuscular injection. All females (n = 8, 25%) who would have bilateral subcutaneous injections at the ventrogluteal site had a BMI greater than 30 kg m^{-2}

TABLE 2: *Subcutaneous fat, muscle, and total tissue thickness at the ventrogluteal site, as identified by the V and G methods*

	Subcutaneous fat thickness			Muscle thickness			Total tissue thickness		
	V method (mm)	G method (mm)	V method vs G method (*P*)	V method (mm)	G method (mm)	V method vs G method (*P*)	V method (mm)	G method (mm)	V method vs G method (*P*)
Cohort	12.9 ± 10.2 (2.5–54.4)	13.3 ± 9.9 (2.5–50.5)	0.170	36.9 ± 11.2 (7.9–62.1)	40.2 ± 8.1 (25.4–62.1)	0.001	49.8 ± 17.2 (14.6–89.3)	53.5 ± 14.2 (32.8–86.4)	<0.0001
Male	9.8 ± 6.6 (3.1–35.7)	9.9 ± 5.3 (3.9–25.4)	0.743	36.1 ± 11.3 (7.9–54.7)	40.9 ± 7.6 (28.1–57.4)	0.006	45.9 ± 15.3 (14.6–89.3)	50.8 ± 10.8 (32.8–82.8)	0.009
Female	15.6 ± 12.0 (2.5–54.4)	16.2 ± 12.0 (2.5–50.5)	0.092	37.6 ± 11.3 (8.5–62.1)	39.6 ± 8.7 (25.4–62.1)	0.032	53.2 ± 18.3 (25.5–85.6)	55.8 ± 16.5 (33.3–86.4)	0.014
Males vs females (*P*)	0.022	0.010		0.612	0.548		0.100	0.164	

Mean ± SD, range in parentheses. Comparisons between sites: Student's paired *t*-tests; comparisons between sexes: Student's independent *t*-tests.

and a hip circumference exceeding 90 cm. For females who would receive a successful intramuscular injection (n = 19; 59%), their BMI ranged between 20 kg m^{-2} and 28 kg m^{-2}, but they all had a hip circumference less than 90 cm. All but two males would have a successful ventrogluteal intramuscular injection using the G method, preventing the identification of any meaningful anthropometric discriminators. Interestingly, the only male to have a subcutaneous injection had a BMI greater than 35 kg m^{-2}, while the BMI of those in the theoretical intramuscular injection outcome group ranged between 21 and 32 kg m^{-2}.

DISCUSSION

Using the G method to identify the ventrogluteal site is more reliable for a successful intramuscular injection than the V method. The G method was better than the V method in terms of site tissue thicknesses, theoretical injection outcome, and intra-individual variability. In particular, using the G method to identify the ventrogluteal injection site reduces the risk of bone injury due to significantly thicker muscle and total tissue at this location. However, even using the G method, there remains a sex disparity in terms of theoretical injection outcomes; while 92% of males would receive a successful intramuscular injection, this is the case for only 59% of females. The results are clinically relevant, and can be used to promote use of the G method of ventrogluteal site identification in the mental health nursing setting, and guide intramuscular injection site selection based on sex and easily-obtained patient anthropometric data.

When the G method was used to identify the ventrogluteal site, there was less intra-individual variability in bilateral total tissue thickness and less inter-individual variability in each of subcutaneous fat, muscle, and total tissue thicknesses. Therefore, this method can be considered more reliable than the V method, as previously claimed (Kaya *et al.* 2015). Interestingly, total tissue thickness at the G method site was similar when the results of Kaya *et al.* (2015) were compared with those of the current study (57.4 ± 13.2 mm vs 53.5 ± 14.2 mm, respectively), but at the V method site this was considerably different: 62.0 ± 14.3 mm vs 49.8 ± 17.2 mm, respectively. Further, there was a larger range of total tissue thickness using the V method than the G method in both studies. Taken together, it is evident that within and between studies, there is more variability in site identification using the V method, as this is clinician dependent, while the G

TABLE 3: *Demographic and anthropometric data per theoretical injection outcome group at the ventrogluteal site using the V and G methods of identification*

	Theoretical injection outcome				ANOVA	
					$F_{3,56}$	P-value
V method	Bone	Bone	Intramusclar	Subcutaneous		
G method	Bone	Intramuscular	Intramuscular	Subcutaneous		
Cohort	n = 6 (10%)	n = 11 (18%)	n = 34 (57%)	n = 9 (15%)		
Males	n = 1 (4%)	n = 6 (21%)	n = 20 (71%)	n = 1 (4%)		
Females	n = 5 (15.5%)	n = 5 (15.5%)	n = 14 (44%)	n = 8 (25%)		
Age (years)	27.3 ± 6.3	40.6 ± 11.9	33.1 ± 14.0	41.8 ± 13.9	2.362	0.081
Height (cm)	166.8 ± 9.1	170.4 ± 6.1	172.3 ± 8.3	165.7 ± 7.5	2.109	0.109
Weight (kg)	59.8 ± 6.5[a]	70.0 ± 11.2[a]	72.9 ± 10.7[a]	86.6 ± 13.5[b]	7.795	<0.0001
BMI (kg m^{-2})	21.4 ± 1.0[a]	24.1 ± 3.1[a]	24.5 ± 2.6[a]	31.4 ± 3.4[b]	20.807	<0.0001
Body fat (%)	22.0 ± 4.3[a]	23.0 ± 6.2[a]	23.5 ± 7.5[a]	41.6 ± 6.6[b]	18.006	<0.0001
Waist (cm)	70.9 ± 3.6[a]	79.6 ± 6.5[a,b]	82.3 ± 7.9[b]	98.2 ± 11.4[c]	16.131	<0.0001
Hip (cm)	94.6 ± 2.5[a]	99.9 ± 4.7[a]	100.8 ± 5.7[a]	116.0 ± 6.6[b]	24.482	<0.0001
Upper thigh (cm)	55.6 ± 1.8[a]	59.0 ± 4.4[a]	58.1 ± 5.3[a]	66.2 ± 3.8[b]	8.452	<0.0001
Mid-thigh (cm)	47.1 ± 1.3	48.7 ± 4.3	50.1 ± 4.4	52.5 ± 2.0	2.654	0.057
GT: ASIS (cm)	12.5 ± 1.0	13.2 ± 1.1	13.7 ± 1.7	14.7 ± 2.8	2.164	0.102
GT: IT (cm)	16.1 ± 1.4	16.0 ± 1.3	16.8 ± 1.7	18.1 ± 2.8	2.560	0.064
ASIS: IT (cm)	9.9 ± 0.3[a]	11.0 ± 0.6[b]	10.7 ± 0.9[a,b]	11.2 ± 0.85[b]	3.754	0.016

Different superscripts in the same row indicate significantly different values ($P < 0.05$, ANOVA with Tukey's post-hoc tests). ANOVA, analysis of variance; ASIS, anterior superior iliac spine; GT, greater trochanter; IT, iliac tubercle.

method is more reliable. This is because the location of the injection site, as determined using the V method, depends on the size of the clinician's hand relative to the patient's pelvic height, which is compounded by inconsistent descriptions of placement of the heel, palm, or ball of the hand on the greater trochanter (Kaya *et al.* 2015; Nisbet 2006; Zimmermann 2010). Using the G method lessens the ambiguity of ventrogluteal site selection and is more reliable for a predictable and successful intramuscular injection. However, even using this preferred method, only 75% of participants would receive a successful intramuscular injection; therefore, it is important to be able to predict who is at risk of subcutaneous injection or bone injury.

An ongoing concern with gluteal intramuscular injections is that thick overlying subcutaneous fat will prevent the needle from reaching the target muscle. The results of the present study demonstrated that subcutaneous fat thickness was not different between the G and V methods, and using either method of identification, 15% of participants are at risk of subcutaneous injection at the ventrogluteal site. The only other paper that has compared the ventrogluteal identification methods (Kaya *et al.* 2015) reported significantly thicker subcutaneous fat using the V method (21.3 ± 10.9 mm) compared with the G method (17.4 ± 9.7 mm). In the current study, the range of subcutaneous fat thickness at the ventrogluteal site (using either method of identification) was similar, but mean subcutaneous fat was thinner compared to previous studies (Kaya *et al.* 2015; Nisbet 2006). This is likely due to the higher proportion of females in the two comparable studies: 66% (Kaya *et al.* 2015) and 61% (Nisbet 2006) compared with 53% in the current study, as a consistent finding is that females have significantly thicker subcutaneous fat than males at the ventrogluteal site (Kaya *et al.* 2015; Nisbet 2006; Zaybak *et al.* 2007). This was confirmed in the current study, and was the case when both the V and G methods were used to identify the ventrogluteal site.

For nine participants (15% of the cohort; 25% of females and 4% of males), subcutaneous fat at both ventrogluteal injection sites was too thick for a successful intramuscular injection with a 32-mm needle. Palma and Strofhus (2013) reported that incorrect needle length was the cause of more than 50% of failed injections in overweight and obese individuals. In the current study, injection site subcutaneous fat was thicker than 33 mm in six of these participants; therefore, even a 38-mm needle would not reach the muscle. Two of these females had subcutaneous fat thicker than the limit for successful intramuscular injection using a 50-mm needle. Therefore, it is suggested that for females with a BMI greater than 30 kg m^{-2} and a hip circumference greater than

90 cm, an alternate injection site should be utilized, or if this is not possible, a 50-mm needle used.

Needle length is also an important consideration that has perhaps been overlooked with respect to lean individuals who have thinner total tissue thickness in the gluteal region. A novel finding in the present study was the high likelihood of bone injury at the ventrogluteal site, particularly when employing the V method of site identification (28% of participants). This contradicts claims that the ventrogluteal site is not close to the bone (Beecroft & Redick 1990; Donaldson & Green 2005; Kara *et al.* 2015; Nicoll & Hesby 2002), and highlights the need for empirical data to support such claims. Using the G method instead of the V method targeted a site of a significantly thicker part of the muscle, and accordingly, only 10% of participants were at risk of bone injection using the G method. The potential for bone injury is particularly a concern given that Australian mental health nurses are more frequently using longer needles, but at the same time, less than 55% of these nurses consider the size and weight of the patient with respect to needle-length selection (Wynaden *et al.* 2015). Even using the G method of ventrogluteal site identification, a 25-mm needle rather than a 32-mm needle should be selected for females who weigh less than 60 kg and have a BMI less than 23 kg m^{-2} to avoid bone injury.

Males and females for whom injection outcome differed based on method (bone injury using the V method versus intramuscular injection using the G method) had significantly thinner muscle at the V method injection site, particularly so for males. The V method site was more superior in the majority of cases, and therefore, closer to the iliac crest where the muscle is thinner. Because males had a significantly smaller distance between the greater trochanter and the iliac tubercle than females, placement of the same clinician's hand would result in their injection site being even more superior with thinner muscle. This was contrary to expectation, based on data that males have greater distances between these bony landmarks when measured on cadaveric specimens after removal of subcutaneous fat (Elgellaie 2015). However, *in vivo*, the thicker subcutaneous fat in females increases this distance between the palpable bony landmarks.

While most of the anthropometric data differed between injection outcome groups, post-hoc analyses revealed that in nearly all cases, these were only significantly different between the subcutaneous injection outcome group and the others. When examined per sex with respect to the G method of ventrogluteal site identification, for females BMI, weight, and hip circumference were able to predict which individuals were at risk of bone injury or subcutaneous injection. These parameters are all easily measured in the clinical setting and can be used to guide site selection for optimal intramuscular injection outcomes. An association between BMI and gluteal subcutaneous thickness has been previously reported (Kaya *et al.* 2015), and this is relevant in the context of increasing rates of obesity and schizophrenia (McEvoy *et al.* 2005; Mitchell *et al.* 2013).

The proportions of overweight and obese participants in the current study (20% and 18%, respectively), as well as the mean body fat percentage for females (31.9 ± 0.1%) and males (19.2 ± 0.1%), are similar to those reported by Correll *et al.* (2014) from 404 individuals with schizophrenia, of whom 26% were overweight and 22% were obese, with a similarly significantly higher body fat percentage for females than males (32.5% vs 19%). In addition, the mean age and BMI of the current study are also similar to those of a recent meta-analysis that encompassed data of 1674 individuals with schizophrenia (Stubbs *et al.* 2016): 35 ± 14 years versus 34.6 ± 6.8 years, and BMI of 25.1 ± 3.9 kg m^{-2} versus 25.2 ± 3.1 kg m^{-2}, respectively. Therefore, the results of the current study are clinically relevant to this population in whom long-acting antipsychotic medications are regularly administered *via* gluteal intramuscular injections.

The present study was limited in terms of participant numbers, in particular among some of the subgroups based on sex and theoretical injection outcome. Nevertheless, the results provide important data with respect to tissue thickness at the ventrogluteal site, including significant influences of site identification method and sex. Further, notwithstanding that larger studies are needed to more conclusively establish the clinical significance of using anthropometric data, such as BMI, weight, and waist and hip circumferences to guide injection site and needle-length selection, this is the first research to examine comprehensive anthropometric data as potential predictors of theoretical injection outcome. An additional limitation was that the site identified using the V method was already marked, and thus visible on the skin when the G method was subsequently used for site identification. However, to minimize site identification bias, the clinician identifying the sites utilized a measuring tape to identify the site, as per the G method, and did not participate in ultrasound quantification. There are multiple avenues for future research that can benefit clinicians and patients alike: larger studies incorporating greater participant numbers of diverse body size and with a more even spread across BMI categories, examination of clinicians' inter- and intra-individual variability and reliability in site identification, and subsequent tissue thickness and theoretical injection outcome using the V and G methods, and comparisons across different time points where previous site identification markings are not visible.

CONCLUSION

Using the G method to identify the ventrogluteal site was more reliable for a successful intramuscular injection (75% of participants) than the V method (57% of participants), because the G method of site identification targets a location with thicker muscle tissue. There was an influence of sex on injection outcome, and using the G method, 92% of males but only 59% of females would receive a successful intramuscular injection. At the site identified by each method, females had significantly thicker subcutaneous fat than males, and consequently, 25% of females would receive a subcutaneous injection using either method. Clear guidelines that describe the G method of site identification could be easily developed to encourage clinicians' confidence in, and use of, the increasingly recommended ventrogluteal intramuscular injection site.

RELEVANCE FOR CLINICAL PRACTICE

Using the G method of identification, the ventrogluteal site would result in a successful intramuscular injection using a standard 32-mm needle in 92% of males and 59% of females, significantly more than the V method (71% and 44%, respectively). Although relatively new, and therefore, less familiar to most clinicians, the G method is more objective and reliable than the V method. As this defined method requires palpating and marking the bony landmarks, this reinforces and provides haptic confirmation of the anatomy, and therefore, the target muscles, and facilitates evidence-based practice. Several anthropometric data proved to be useful discriminators with respect to theoretical injection outcome, particularly for females. Indeed, the ventrogluteal site should be avoided in females who weigh less than 60 kg and have a BMI less than 23 kg m^{-2} because of risk of bone injury, and in females with a BMI greater than 30 kg m^{-2} and a hip circumference greater than 90 cm.

Based on the results reported here, the G method was more reliable for a successful intramuscular injection outcome. Therefore, nurses should use this method in favour of the traditional V method of ventrogluteal site identification. The G method for ventrogluteal site identification should be promoted and incorporated in educational programmes for current nursing students. In addition, targeted training should be developed for nurses who are already qualified and practicing. Nurses should also be encouraged to determine the weight and BMI of their female patients (and hip circumference in those with a BMI greater than 30 kg m^{-2}) to facilitate decision-making at the clinical level with respect to needle-length and injection-site selection. A poster illustrating G method site identification, the three bony landmarks (vertices of the triangle) and the injection site (centroid), alongside a guide for needle-length selection based on sex, BMI, and weight or hip circumference (Fig. 1), could increase nurses' utilization of, and confidence in, this more reliable

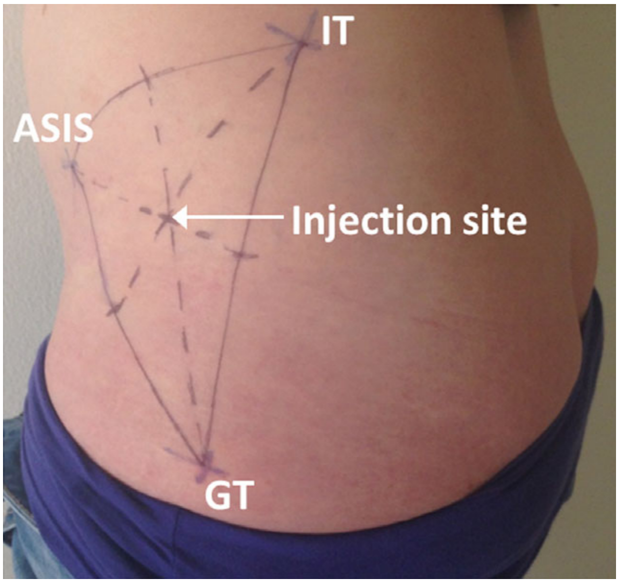

FIG. 1: *G method for ventrogluteal site identification. Why? Could be more reliable for successful intramuscular injection outcome than the V method. How? (i) identify the anterior superior iliac spine (ASIS), iliac tubercle (IT), and greater trochanter (GT), and mark on the skin with a skin-safe marker; (ii) mark the midpoint of the distance between each of these three landmarks; (iii) join each landmark with the midpoint of the opposite line; and (iv) centroid of the triangle is the injection site. Further research is necessary to guide needle-length selection for a successful intramuscular injection based on sex, body mass index, and anthropometric data. [Colour figure can be viewed at wileyonlinelibrary.com]*

method for successful intramuscular injection at the ventrogluteal site.

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