Considering skin-to-muscle depth for successful intramuscular injections in an increasingly obese population

Abstract

Background

Intramuscular injection [IMI] practice is an essential nursing skill. Current practice relies on clinical judgement to determine needle length (unless specified in the medicine product licence). Obesity is increasing in the global population, but guidelines have largely ignored how to select needle length to meet individual patient need.

b. Aim and objective/s of the study

Our aim was to systematically review the skin to muscle depth required to achieve injection into muscle in adults. Our objectives were to identify any implications of obesity status when selecting an appropriate needle length and site in clinical practice.

c. Search and review methodology

We performed our review according to the PRISMA statement. Studies of subjects above the age of 18 years using observational or experimental designs where the distance from the skin to muscle had been measured at any IMI site, and obesity status was reported were included in our search strategy. The primary outcome of interest was the distance from skin surface to muscle penetration.

D. Findings

14 studies were identified that investigated the dorsogluteal, ventrogluteal, deltoid and vastus lateralis sites, all used cross sectional observational designs. Ten used ultrasound, five three computer tomography and one magnetic resonance imaging. Obesity status was reported as BMI or hip to waist ratio. In all studies there was a correlation between obesity status and the distance from skin surface to muscle. In females this exceeded 37mm at both gluteal sites, independent of obesity status.

e. Conclusions and implications

There should be an assessment of obesity status before selecting needle length for intramuscular injections in both genders. Needles greater than the standard 37mm length are recommended for all females, whatever their obesity status for any gluteal site. Injections into gluteal sites should be avoided in females who are obese. Deltoid injections are more likely to achieve muscle penetration in both genders, and in patients who are overweight or obese. Further high-quality research is required.

Key Words: Intramuscular Injection; Obesity; Gender; Needle Length; Nursing

Introduction

Obesity

Described as a pandemic obesity has increased markedly in recent times (Suraweera et al, 2017). According to the World Health Organisation (WHO) worldwide obesity has trebled since 1975, and in 2016 more than 1.9 billion adults 18+ (39%) were overweight with 650 million people (13%) described as obese (World Health Organisation (WHO), 2018). Overall, there is an increase with age with a peak prevalence worldwide between 40 and 60 years of age in developing countries (Kanter & Caballero, 2012). In the UK, obesity is recorded as from 13-24% of all men and 16-26% in all women (National Institute of Clinical Excellence, 2014). Global obesity is estimated to apply to 18% of men and more than 21% of women by 2025 (NCD Risk Factor Collaboration, 2016).

Obesity is linked strongly as high risk to comorbidities with physical conditions such as type 2 diabetes, cardiovascular diseases, respiratory disorders, infertility, and some forms of cancers (Global Burden of Disease 2015 Obesity Collaborators, 2017). Furthermore, statistics show that being overweight or obese in 2010 caused 3.4 million deaths, a decrease in life expectancy of 4 years and a further 4 years of disability adjusted life years (DALYs), (Lim, Vos, and Flaxman *et al.,* 2012).

There is a growing recognition in nursing and healthcare in general that needle length needs further consideration when injecting medicine intramuscularly in people who are overweight or obese (Strofhus et al, 2018; White et al, 2018). Obesity and needle length also is an issue in other injection sites (see Kehrl et al, 2016). Gender is an important consideration because women have more subcutaneous fat as opposed to muscle than men. Thus, when considering which needle to use it appears logical to select a longer needle in overweight and obese populations, with an important consideration in all women (Palma & Strohfus, 2013). This IMI issue that has been identified for some time in nursing literature related to mental health nursing practice (e.g., Poland et al, 1997; Nisbet et al, 2006) but does not seem to have been yet fully embedded into guidance for the administration of intramuscular injections. For example, there is no guidance nationally in the UK from the National Institute of Clinical Excellence, or worldwide through the World Health Organisation. This paper presents a review of the evidence considering needle length for overweight/obesity and the impact of gender on accurate intramuscular injection administration.

Intramuscular injections

An intramuscular (IM) injection is the administration of medication through the dermis, cutaneous and subcutaneous tissue layers, into a skeletal muscle. Intramuscular injections

are used where there is a risk that the medicine or its excipient may cause local, neural, vascular or tissue injury, for medication that requires relatively quick but reliable absorption and/or where a prolonged therapeutic action is desired (Ogston-Tuck, 2014: Wynaden et al, 2015). In this final example the muscle acts as a store or "depot" releasing the medicine over time.

There are five main muscle sites used for intramuscular injection: the deltoid, dorsogluteal, ventrogluteal and vastus lateralis. The rectus femoris site was once used but has been removed from recent clinical guidelines due to concerns about risk of damage to the femoral nerve (particularly in young adults) (Nakajima et al, 2020). Product licenses may specify which sites or muscles are to be used for particular medicines but where the site is not specified the practitioner is expected to consider patient factors, including individual physiology and preference and adhere to guidance about the recommended maximum volume that can be injected into the particular site chosen.

Needle length is indicated on every needle pack in inches and/or millimeters along with the gauge (a measure of the internal diameter of the needle bore that is usually colour coded). A variety of lengths are available from manufacturers for each specific gauge. If a medicine for intramuscular injection does not include needles and specific instructions about their intended use (in a pack assembled by the manufacturer and part of the product licence) the practitioner is expected to select the appropriate needle from the clinical supplies they have available to them at the time.

Injections and weight

An assessment of the length of needle required to reach the muscle for the site selected should be made by an assessment of the individual patient, taking into account the depth of their subcutaneous fat (Lister et al, 2021). Practitioners, however, may select a standard needle length regardless of the physiology of the patient. For example, a 35mm length needle is commonly selected for the administration of antipsychotic long-acting injections into the dorsogluteal site because this will be how many practitioners were taught and assessed as competent and confident in the administration procedure (Wynaden et al, 2015). This practitioner may then go on to demonstrate this practice and teach it to others. Another example is the practice of leaving approximately 2-3mm of the needle length exterior to the skin to allow the needle to be removed if it were to "break". Today's single use hypodermic needles are subject to robust quality control on manufacture and as a result are unlikely to break (Moustafa et et al, 2021). A practice that anticipates the risk of needle

breakage appears to be related to a time when needles were used multiple times and autoclaved between use Several clinical nursing textbooks and authors perpetuate this practice by including it in examples of good IM injection technique, even though this appears to be based on the opinion of one author commonly cited in support of this technique (Workman et al, 1999). Where manufacturers have introduced longer needles in an administration pack as part of their product licence, post marketing surveillance has revealed a reluctance amongst practitioners to select the longer needle or utilise its full length due to a perception that a longer needle will inflict pain (Soloman et al, 2019). Selection of a needle length that fails to reach the intended muscle on administration increases the risk of medicines being delivered into adipose tissue (Strohfus et al, 2018), rather than the muscle. Reports of “granulomas” at injection sites are well documented and some methods of intramuscular drug delivery have a known increased risk of abscess if delivered into fat (Palma and Strohfus, 2013). Injection into fat is also likely to alter the intended pharmacokinetics of the medicine potentially limiting effectiveness and increasing the risk of adverse events post injection (Nisbet, 2006; Zayback et al, 2007; Correll et al ,2021).

Intramuscular injections the nurses’ role

Administering injections is an accepted part of the registered nurses’ role (e.g. Beyea & Nicoll, 1995; Nursing and Midwifery Council, 2018). Administration of intramuscular injections is taught in nurses’ pre-registration education but adherence to guidelines means the choice of needle length is unlikely to be emphasised, risking the perpetuation of ritualised practice that relies on an evidence base that is not revisited (Malkin, 2008; Palma and Strohfus, 2013; Wynaden et al; 2015). Needle length is taught within the University setting through online platforms for example using resources from Clinical skills.net and professional guidance, for example that developed for the administration of long-acting antipsychotic medication (White, 2022). There also have been some studies starting to address this trenchant issue (Boyd et al. 2013; White et al, 2018; Strohfus et al 2018) There is no stated national or international needle length for the body weight of a patient, although stated in good practice guides (White 2022; Lister, 2021). The authors found no national or international (WHO) agreed directions for different weight size and requiring different size of needle, and this has been recognised for some time (Elsom and Kely, 2009). Although reviewed for the deltoid site (Kearns et al, 2023), there is no documented systematic review of the evidence of needle length and whether it reaches the muscle in intended site for people who are obese or very obese for all suitable injection sites.

Review Aim

Our aim was to systematically review the skin to muscle depth required to achieve injection into muscle in adults. Our objectives were to identify any implications of obesity status when selecting an appropriate needle length and site in clinical practice.

Methods

We performed a systematic review of the literature according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2009). Adapted critical appraisal tool were used to assess the included papers (CASP, 2021).

Inclusion and exclusion criteria

The target population consisted of adults above the age of 18 years of any gender who had intramuscular injection. We included studies of subjects recruited from any (in-patient or community, tertiary, secondary or primary care) setting.

Study designs

We did not set out to exclude any specific study designs but considered randomised controlled trials (RCTs), observational (cross-sectional, cohort or case-control) and experimental designs cohort studies whether prospective or retrospective in design, and audits were suitable for inclusion. Key textbooks and previously conducted narrative reviews, systematic reviews, and evidence-based clinical practice guidelines relating to the length of needle required for intramuscular injection were considered. Conference papers, poster abstracts, opinion papers and case studies were excluded. No constraints were placed on language of publication or date of publication.

Exposure and outcomes

Clinical exposure was to a medical test that generates images of the structure of the soft tissue (i.e. ultrasound [US], magnetic resonance imaging [MRI] or computed tomography [CT]). We included studies where the distance from the skin to muscle was measured at a site where an intramuscular injection could be administered (i.e. deltoid, ventrogluteal, dorsogluteal, vastus lateralis or rectus femoris muscle), where an established standardised, reliable and validated method of measurement and obesity status was reported.

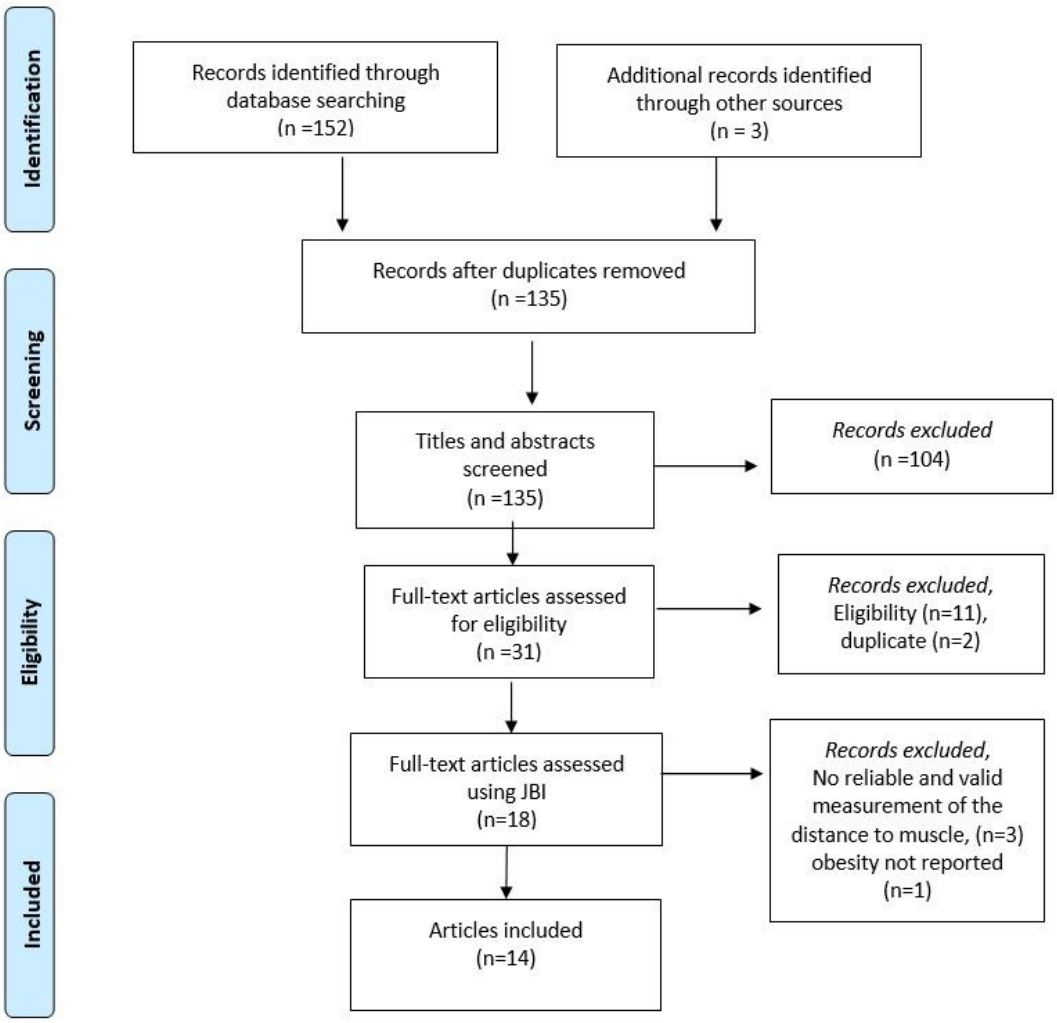
Search strategy

Embase (1974 to 12.2022), Medline (1946 to 12.2022), CINAHL (1981 to 12.2022) were searched using keywords and medical subject headings (mesh) determined by the authors: (“INTRAMUSCULAR INJECTION” OR “IM”. ti,ab) AND (“BODY MASS INDEX” OR “BMI” .ti,ab). The study team also searched the reference lists of all the studies that met the selection criteria for the review. Where only abstracts were available, we attempted to contact the study authors to identify if the full paper was available. Duplicate studies were excluded.

Study selection

Two reviewers (SH and JW) independently screened titles and abstracts. Full text of all articles that were included at the title/abstract screening stage were retrieved and judged for eligibility by the same two reviewers (SH and JW). Discrepancies were resolved by discussion, involving the third reviewer (SL) for a final opinion where necessary. Reasons for excluding studies were recorded. Reviewers were not blinded to any aspect of the studies designs or authorship (Figure 1.)

Figure 1: PRISMA Flow Diagram Page MJ et al (2020)



Risk of bias in individual studies

The Joanna Briggs Institute [JBI] checklist for the quality appraisal of cross-sectional analytical studies (Moola et al, 2017) was used to summarise the quality of the studies (Table 1). This checklist includes eight domains where the reviewer is asked to make a yes/no/unclear/not appropriate judgement about the methodology used i.e. 1) definition of inclusion criteria, 2) details of subjects and setting, 3) valid and reliable measurement of the exposure, 4) use of objective standardised measurement criteria, 5) identification of confounding factors, 6) strategies for dealing with confounding factors, 7) valid and reliable outcome measurement, 8) appropriate statistical tests

The study inclusion criteria defined subjects and setting as valid and reliable measurements of tissue. This involved objective standardised measurement criteria to account for confounding factors, including valid and reliable outcome measurements. Finally, appropriate statistical tests also needed to be reported Total n /8.

Table 1: Quality appraisal of included studies

Study	inclusion criteria defined	subjects and setting described	valid and reliable measurement of tissue	objective standardised measurement criteria used	confounding factors identified by authors	strategies for accounting for confounding factors reported	valid and reliable outcome measurement reported	appropriate statistical tests reported	Total n /8
Bhala et al, 2013	1	1	1	1	1	1	1	1	8
Boyd et al, 2013*	1	1	1	1	1	1	1	1	8
Chan et al, 2006	1	1	1	1	1	1	1	1	8
Cook et al, 2006	1		1	1	1	1	1	1	7
Holliday et al, 2016	1	1	1	1	1	1	1	1	8
Johnston et al, 2015	1	1	1	1			1	1	6
Larkin et al, 2017	1	1	1	1	1	1	1	1	8
Ozen et al, 2019	1	1	1	1			1	1	6
Poland et al, 1997	1	1	1	1	1	1	1	1	8
Shankar et al, 2014	1	1	1	1	1	1	1	1	8
Song et al, 2005	1	1	1	1	1	1	1	1	8
Tsai et al, 2014	1	1	1	1	1	1	1	1	8
Zayback et al, 2007	1	1	1	1	1	1	1	1	8
Zayback et al, 2015	1	1	1	1			1	1	6

Results

Our literature search identified 155 published papers, of which 20 were duplicates. Initial screening of the titles and abstracts excluded 104 records. The remaining 31 articles were assessed for eligibility. 13 articles were excluded at this stage, including duplicate where the same study had been reported in two different publications. A total of 18 articles were appraised using the JBI checklist where more detailed scrutiny of the methodology led to a further four exclusions (three because there was no reliable and valid measurement of the distance to the muscle, one because obesity status was not reported). 14 papers were included in the final analysis.

Data extraction

A data extraction form was developed to collect data on citation details, study design, setting, sample size, participant characteristics, details of the exposure, any documented adverse effects and the results. The form was pre-piloted on 4 of the identified articles to make sure both reviewers recorded identical data. All data was then recorded in duplicate (by SH and JW), and any discrepancies resolved by discussion involving all review authors.

Table 2: Study Characteristics

Author (date)	**Country of study**	**Design**	**Muscle(s) investigated**	**Measurement used/reported for obesity**	**Medical test used for soft tissue measurement***	**Sample Size** M:F	**Sample type**	**Comments**
USA		Prospective Cross sectional	VL	BMI Also measured thigh circumference (not included in our review as not a measure of obesity).	US Compared measurement to autoinjector needle length (15.9 mm)	120 M:F 60:60	Convenience Recruited from low or moderate acuity patients who could stand up from emergency department of one hospital	Pilot study (no power calculation) considered min-max pressure when taking US measurement.
Boyd et al (2013)	USA	Retrospective Cross sectional [phase 1] Phase 2 is QI study (post education re guidelines) not included as does not meet inclusion criteria.	Gluteal (DG or VG)	BMI	Pelvic CT within 2/12 of IMI	103 49:66 M:F	Convenience Reviewed notes of patients who had pelvic CT scans within 2 months of gluteal IM injection (hormone treatment).	Autoinjectors only consider the data in the depth to muscle part of the study (Phase 1) Proportion of DG:VG note reported.
Chan et al (2006)	Ireland	Prospective Cross sectional	DG Did not measure skin to muscle depth, rather reported location of air bubble.	BMI	Pelvic or abdominal CT 1-hour post IMI	50 25:25 M:F	Convenience Single tertiary referral hospital Patients requiring CT pelvis for abdominal pain who had received IM analgesia	included but measured “distance to injection site” * by location of air bubble on scan. CT images reviewed by two radiologists to determine the position of the air bubble and reach a consensus. Nothing reported about this (e.g. degree of agreement).
Cook et al (2006)	Australia	Prospective Cross sectional	Deltoid Recorded dominant or non-dominant arm	BMI Also measured arm circumference (not included in our review as not a measure of obesity).	US	256 134:124 M:F	Convenience Not clear where sample was recruited from, authors affiliations suggest from one hospital – and a single sonographer performed scans and measurements.	65 years and over only! Did not describe setting Single sonographer performed US in all

Holliday (2016)	USA	Retrospective Cross sectional Review of MRI pelvic scans	VG Ventro gluteal fat thickness (also measured gluteal muscle layer thickness – useful to judge over penetration risk- but not included as not in our inclusion criteria])	BMI	MRI	250 126:224 M:F	Convenience Patients attending one hospital who had received an MRI of their pelvis	Analysis by one of two certified radiographers blinded to physical parameters (e.g. BMI).
Johnston et al (2013)	UK	Prospective	VL Anterolateral and lateral thigh measurements	BMI	US Skin to muscle depth Compared measurement to autoinjector needle length (15.02 mm)	28 M:F 5:23 V small sample with disproportionate n females.	Convenience Allergy patients attending one tertiary clinic who were prescribed autoinjectors [EpiPen] in 2013	Single observer (trained by consultant radiographer) Did not consider any other possible confounder (e.g. rater reliability). V high statistical significance [P-value] reported for F gender but there were only 5/28 men in the sample
Larkin et al (2017)	Australia	Prospective Cross sectional	DG VG	BMI Waist circumference Hip to waist ratio	US Skin to muscle (facia) i.e. depth	145 M:F 62:83	Convenience University student sample >18	Single researcher trained and supervised by practicing clinical sonographer (checked measurement reliability but did not report the results of this in the paper). No significant difference in BMI for gender or age (only for SC fat at both sites for females).No gender difference for total tissue thickness or muscle. Also classified body shape (endomorph etc. but not to be included in our analysis as not an inclusion criteria for the SR)
Orzen et al (2021)	Turkey	Prospective Cross sectional	DG	BMI	US Evaluated location of administered medication	60 M:F 33:27	Convenience Patients who underwent dorsogluteal IM injection	Single radiographer performed all US examinations.

					(whether IM or in SAT) and the SAT thickness at the DG injection site.			
Poland et al (1997)	USA	Prospective Cross sectional	Deltoid	BMI	US Skin to muscle depth Muscle to bone also measured to assess risk of penetration, but not included as not in our inclusion criteria]	220 M:F 94:126	Convenience Mayo clinic health care workers presenting for HEP B vaccine to oe immunization clinic in Minnesota.	Single but registered/certified sonographer. Also measured arm circumference and skin fold thickness (not included in our SR as not a measurement of obesity).
Shankar et al (2014)	India	Prospective Cross sectional	Deltoid Investigated both arms in each subject (dominant and non-dominant arm recorded)	BMI	US Skin to muscle depth [Muscle to bone also measured to assess risk of penetration, but not included as not in our inclusion criteria]	200 M:F 100:100	Convenience Purposeful (to try to include subjects of varying BMI and age groups and dominant arm). Tertiary medical college hospital in Bangalore. Radiotherapy patients under investigation at one clinic >18 years attending at times when researchers were present.	Single co-investigator performed US and interpreted results. Only study included that reported a power calculation. Aimed to include 200 subjects (100 M, 100 F) with equal distribution of R:L dominant arm. Reported reliable technique to calculate BMI (one set of scales, wall mounted height measure).
Song et al (2005)	USA	Retrospective Review of CT scans in database of patients who	VL Anterolateral aspect of thigh	BMI	CT Skin to muscle depth	100 M:F 50:50	Convenience Actively serving or retired from the military who had attended one military hospital in Washington, DC.	Mean BMI showed the sample was skewed towards the overweight category.

		had anterolateral thigh CT and had height and weight recorded in their medical notes (up to 6 months before the CT)			Compared measurement to autoinjector needle length (14.30 mm)		CT scans had been for presumptive diagnosis of deep vein thrombosis [DVT]	
Tsai et al (2014)	Canada	Prospective Cross sectional	VL Anterolateral aspect of right thigh.	BMI	US Skin to muscle depth under minimum and maximum pressure Compared measurement to autoinjector needle length (15.20 mm)	100 M;F 31:69	Convenience Consecutive patients with confirmed food allergy attending an allergy clinic who needed to be prescribed an epinephrine autoinjector.	considered min-max pressure when taking US measurement.
Zayback et al (2007)	Turkey	Prospective Cross sectional	DG VG	BMI On consent and then recalculated just before scan.	US Skin to muscle (facia) i.e. depth Compression of skin by probe was avoided.	119 M:F 60:59	Convenience University hospital recruited healthy adults	Single observer, standard methods (for BMI and US). No other details (e.g. of training or supervision) reported.
Zayback et al (2015)	Turkey	Prospective	DG VL Rectoris femoris		US Skin to muscle depth	54 M:F 18:36	Convenience of obese adults Sample recruited from all ambulatory patients who were admitted to the ultrasound unit at one hospital. Research took place in research US room after diagnostic	

							ultrasound (e.g. abdominal) was complete.	
14 papers post JBI	USA = 5 Australia = 2 Turkey = 3 India, Ireland, Uk, Canada = 1	3 retrospective, all others prospective All cross sectional All observational (descriptive) designs	VL=5 (one of these also measured at DG) DG and/or VG = 6 (one of these also measured at rectos femoris) Deltoid = 3 VL studies compared to autoinjector needle length (although note difference in Song et al study (nearly a whole mm shorter than others), probably doesn't matter compared to difference in reaching muscle if this is much larger than a mm but worth checking	All reported BMI	US x 10 CT x 3 MRI x 1	Could potentially group (and sum) total sample size for each muscle but still too heterogenous in terms of design to undertake meta analysis.	All convenience – did attempt purposeful selection in one (Shankar et al, 2013). Two studies recruited from general population (health workers or students)	

Discussion

Study characteristics

The studies identified are summarised in Table 2. All included studies explored distance to the muscle at intramuscular sites (deltoid, ventrogluteal, dorsogluteal, vastis lateralis and/or rectus femoris) but all of the sites were not explored in every study. A range of different anatomical landmarking methods was used across the studies to determine the site for measurement, different medical tests (US, MRI or CT) and measurement methods (e.g. digital callipers, lasers). Obesity was either reported as body mass index, or hip to waist ratio. All the included articles used cross sectional observational designs. One study included an experimental design to test an educational intervention that aimed to improve adherence to guidelines but only data from the earlier phase (3) where depth to muscle had been measured was included (Boyd et al. 2013).

Design, context and sample.

The types of the design of the studies were both retrospective (n = 3), all others prospective (n =11). All studies reported using cross sectional methods. All the studies included observational (descriptive) designs. In terms of the included studies were conducted across the globe with USA (n = 5), Australia (n = 2), Turkey (n =3), India, Ireland, UK, Canada (n = 1 each). All studies used a convenience sample with the exception of Shankar et al, 2013, who did attempt a purposeful selection of varying BMI groups. Zayback et al (2015) was the only study that actually targeted a sample of people in the obese category.

Risk of bias in individual studies

Results of JBI process (Table 1) – 10 achieved the highest possible score 8/8, one failed to report the context of the research, three failed to consider any confounding variables, with only one study (Holliday (2016), reportedly using 2 clinicians (radiographers) to ratify that skin to muscle was achieved. Future studies would need to ensure some form of inter-rater reliability to negate such bias.

Measurement of skin to muscle

The 14 studies identified used medical tests to generate images of the soft tissue enabling measurement of the distance between tissue boundaries. Obesity status in the samples was reported, in all studies as per Body Mass Index (BMI). Included studies characteristics. All included studies reported using the BMI criteria to class Obesity. All used medical devices to screen the potential needle reaching muscle Ultrasound-US (10); Computed Tornography - CT (3); and Magnetic Resonance Imaging-MRI (1). Although one procedure (US) was used more than the others there was no evidence emerging that that or the other two ways of measuring the skin to muscle held any advantage over the other two. The need to identify

boundaries between tissue types, rather than relying on the observational skill of the radiographer/sonographer is paramount to whatever medical device is used. Finding an accurate and inexpensive device is surely something that would aid the need for truly intramuscular injection and the drug reaching the target area as appropriate when administering to the person defined as Obese as per BMI (Soliman et al, 2018). Strothus et al (2021) stated at least for dorsogluteal injections if skin to muscle depth is questionable then an ultrasound is appropriate, but did not discuss the other alternatives.

Intramuscular Administration Sites

The reviewed studies had included the Vastus Lateralis (VL) (N=5) although one of these also measured at the Dorsogluteal site (DG). The Ventrogluteal site (VG) (N=6) was also measured also involving or as a stand alone, although one of these also measured at Rectos Femoris site (Zaybak et al's, 2015 study was conducted before current guidelines recommended avoiding this site). The Dorsogluteal site (DG) also featured 3 times. The Vasutus Lateralis (VL) studies compared to autoinjector needle length although one study Song et al (2005) study was nearly a whole mm shorter than others, although this may have been affected by the needle length availability been shorter in 2005 than other studies conducted up to 10 years later. In all studies there was a correlation between obesity status and the distance from skin surface to muscle. In females this exceeded 37mm at both gluteal sites, independent of obesity status.

The following themes related to obesity and intramuscular injection emerged:

Skin to muscle measure considered along the lines of obesity.

The included studies support the idea that obesity status results found a longer measurement of skin to muscle therefore longer needles are required (see Table 3).

Table 3: Skin to muscle measure and obesity

Needle Site	Authors
Deltoid	Poland et al, 1997; Shankar et al, 2014.
Dorsogluteal	Ozen et al, 2019; Boyd et al, 2013; Chan et al, 2006.
Thigh	Ozen et al, 2019; Boyd et al, 2013; Chan et al, 2006) thigh (Bhall et al 2013; Johnstone et al 2015; Song et el, 2005; Tsai et al, 2014.
Ventro Gluteal	Holliday et al, (2016)
Dorsogluteal and Ventrogluteal	Larkin et al, 2017; Zaybak et al, 2007
Dorsogluteal and Thigh	Zayback et al, 2015

Skin to muscle measure considered along the lines of gender/s

It is clear that from the included studies support the idea that females who naturally have more subcutaneous fat than males and therefore larger skin to muscle measure. Bhalla et al (2014) from a 50% split of genders (n=60 females, n=60 males) found women 6.4 times more likely to not to reach the intended muscle site). Boyd et al, (2013) sample (n=66 females, n=49 males) calculated that successful injections were for 66% men, and only 31% women. Chan et al, (2006) sample (n= 25 females, n=25 males) reported a projected 56% success with males and only 8% females. Cook et al, (2006) (n=124 females and n= 134 females) found men had lower subcutaneous layers than females and higher muscle layers in the deltoid. Holliday et al, (2016), (n=224 females, n=126 males) from their study recommended longer needles needed in the VG site for women with a BMI of 30 and above in women versus men which is 35., Johnstone et al, (2015) with a small sample disproportionately more females (n=23 females, n=5 males) showed females had a greater skin to muscle depth), Larkin et al, (2017) (female n=83, male n=62) and Zaynbak et al', (2007) samples (n=59 females, n=60 males) had considerably thicker subcutaneous fat at the DG and VG sites). Poland et al, (1997) (n=126 females and n=94 males) and Shankar et al (2014) for the deltoid, females had a significant fat pad thickness than males, thus for the deltoid a longer needle would be needed), Song et al, (2006), Tsai et al (2014) and Zayback et al, (2015) (n=100 female, n=100 male) distance form skin to muscle in the thigh greater for women versus men. Ozen et al, 2019 (n=27 females, n=33 male) did not report differences between genders but recorded that 38.3% of the sample (n=23) did not reach the muscle. Therefore, although some the sample were low it clearly shows in 13/14 studies a longer needle needs to be considered for females in all common injection sites.

Choice of intramuscular administration sites, gender, obesity and needle site.

For the DG there was definite evidence that both Obesity and the female gender has a high correlation with sub optimal administration. Chan found only 8% (2/25) of the sample of 25 females had an injection intramuscularly versus 56% (14/25) males. Ozen et al, 2019, found that 13/50 (215) of their sample had injections in the sub adipose tissue rather than muscle, and that obesity as the key factor interfering with the success of the injection. The success of the injections can be can be improved significantly for both genders with better technique (landmarking, quick needle insertion and use on non syringe hand to compress the injection site with an improvement for both genders (66-75% male, 38-75% females) using a 38mm needle (Boyd et al. 2013). When comparing DG and VG, Larkin et al, (2017) recommended both gluteal sites should be avoided for people in the obese category, however a 32mm injection needle for all males and normal weight females in the DG site, and 38mm needle for all females at the VG site, and for all males and 98% of females at the DG site. Zaybak et

al, (2007), had similar results to Larkin and colleagues, concluding that the DG is effective for obese and overweight men, whereas the VG site was only effective for men who are in the overweight category, it would be sub optimal both administration sites for women. When comparing DG and thigh Zayback et al, (2015) found that the stated standard needle length of 38mm would not reach the muscle administered for a person with a BMI of 24.9, but would reach muscle in both genders in the thigh. Zayback etal (2015) also stated the thigh site was preferable for obese (both genders), and a longer needle than 38mm in females with severe obesity when injecting into the thigh. One included study focused on the VG site (Holliday et al, 2016), and, for a BMI of 30 female and 35 male a needle length greater than 38mm would be needed for a successful delivery to the muscle. For studies on administration into the thigh, Bhall et al (2013) found the standard 15.9mm autoinjector needle for anaphylaxis was inadequate for 31% of their sample and a higher BMI and female gender being the main reasons; Song et el, (2005) (14.3mm needle). Johnstone et al (2015) and Tsai et al (2015) (15.02mm needle) came to the same conclusion. For the Deltoid site evidence was provided that a 25mm needle would suffice usually, but a 1.5 inch (38mm) needle would be needed for women who weighed more than 90kg (Poland et al, 1997; Shankar et al, 2014).

One issue that could affect the choice of site in the future for nurses is because of the sexual dimorphism in which males carry more subcutaneous fat around the abdomen and women in the gluteal-femoral region (Palmer et al 2015). This in turn can affect how a drug is absorbed in the body (Chang et al, 2018), and, importantly the effectiveness of intramuscular injections (Cooke et al, 2009). This will affect all sites predominantly but less pronounced in the deltoid region and lateral thigh sites. Added to this, the Deltoid site has the smallest skin-to-muscle depth, it would appear logical that in cases where the patient is obese, and especially female, there is an argument to favour the deltoid when injecting intramuscularly. Further research would be needed to assess the administration of IMs in the Deltoid v thigh v DG and VG sites.

Discussion

This review confirms what is already known or stated that people in the obese category (Dayananda et al, 2015, McWilliam et al, 2014; Painter et al, 2015; Sakamaki et al, 2013) and the female gender of medium BMI and above have a higher greater chance of receiving a sub optimal dose of medicine (Soliman et al, 2018; Strofhus et al 2021). This has been highlighted in the nursing literature as an issue all nurses need to be aware of (Malkin, 2008; Strohfus et al, 2017) with focus on selection of needle and injection technique (Boyd et al, 2018; Palma and Strohfus, 2013, White et al, 2018; Wynaden et al, 2015). However, evidence accrued from this review with obesity both confirms that this needs to have a

greater emphasis in nursing decision making and in the decision about site of administration, needle size chosen for the person who is obese and female with a BMI of 29 and above. It is noted that there has been an emphasis on the gluteal muscle and finding ways to improve the potential of the medicine through injection reaching the muscle in the gluteal site (Boyd et al, 2013; Strohfus et al, 2021; White et al, 2018; Sahebkhar et al, 2022). However, from this review it is suggested that the gluteal sites for females of medium BMI and above will be sub optimal. Whilst respecting that the choice of a 40mm needle length and correct landmarking can help toward reaching the muscle in the gluteal muscles, it is the Vastus Lateralis and particularly Deltoid sites that need to be used for the injection to have the full potential of being truly intramuscular. This has implications for the licensing of sites as for example in psychiatry the majority of Long Acting Intramuscular Injections are in the gluteal muscle (Soliman et al, 2018). A choice of needle sizes also needs to be available so as to allow the nurse to assess, plan and implement an injection fit for purpose-intramuscularly. Nursing needs to move away from rituals toward intramuscular injection and use the latest evidence (Greenway, 2014; White, 2022). This will allow the potential of the medicine administered to be optimised.

Limitations

In conducting the search strategy, it may not have captured all published evidence (e.g. Grey evidence). Secondly there were different study populations across the studies and all convenience samples, with patients either with suspected conditions attending an outpatient clinic for investigation and diagnosis, or with a known condition attending for intramuscular treatment or (healthy) student volunteers. Thus, negating the potential validity and reliability of studies included in this review. Studies included three papers at least ten years old limiting the recency of the review. The studies only included descriptive analysis and although some inference was attempted, no real power calculations were undertaken. There was not one gold standard measurement distance between soft tissue boundaries, with different methods used by researchers, thus not providing a standardised procedure to undertake this. There were also methodological reporting problems identified in three studies that highlighted risk of bias. Finally, a major limitation to this is the review are that the designs were heterogenous to support a meta-analysis.

Conclusion

Although anecdotally there is some change in practice regarding addressing the needle length and the obese population a review of included and excluded studies have suggested IMIs may have not reached the muscle target in many occasions. Thus, for patients who

meet the obese category and who most of the time will have a comorbid health problem this has implications as if the injection does not reach the intended muscle site and in essence is sub cutaneous then there are implications. Firstly, that the medicine injected does not induce the expected therapeutic response, added to this there may be tissue damage that may lead to pain and discomfort in the short and long term.
In conclusion, sub optimal administration leads to reduced likelihood of positive health outcomes for the person receiving the injection whether obese or not.

Implications

Nurses need to assess obesity status before selecting needle length for intramuscular injections in both genders in adults. Weight is not a commonly completed element on observation charts, and BMI is not always documented at admission, in electronic records within hospital settings or in patients' homes. This needs consideration by employing healthcare organisations and individual nurse who administer medication as part of their role. Secondly, where female patients have an overweight or above BMI a needle length of at least 40mm should be selected. Thirdly, consideration needs to be given toward the deltoid or vastus lateralis site in obese or very obese females (if the product licence allows) as dorsogluteal injection have shown to be sub cutaneous rather than intramuscular. Fourthly, Deltoid injections are most likely to achieve muscle penetration in both genders. Fifthly national and international recognised standards to guide this important area of nursing practice needs to be actioned.
Finally high quality (experimental) research is needed to determine if achieving muscle penetration improves health outcomes.

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