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DEVELOPMENT AND SIMULATION OF MEASUREMENT TOOL FOR INTRAMUSCULAR DRUG APPLICATION IN VENTROGLUTEAL SITE

İNTRAMÜSKÜLER İLAÇ UYGULAMADA VENTROGLUTEAL BÖLGE ÖLÇÜM ARACI GELİŞTİRME VE SİMÜLASYONU

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ABSTRACT

Objective: In this study aimed to design and simulate a measurement tool that can facilitate the detection of a safe area in the ventrogluteal site.

Methods: In the methodological study, first of all, measurements were performed on healthy individuals (N = 135) in the ventrogluteal site in accordance to the body mass index. The data obtained from these measurements were analyzed, and the dimensions required for designing the measurement apparatus were determined. The measurement tool was designed using a 3D modeling program.

Results: Of the individuals participating in the study, 57% (n=77) were female and 46.7% (n=63) were of normal weight. We found that the thickest point of muscle mass was different from that measured by V and G methods and the thickest point of muscle mass was found to be located more to the right and below as compared. Results showed that the method used does not lead to a difference in the measurements of hip length in the right and left sites, distance of the muscle, thickness of the thickest part of the minimus muscle, and the total muscle thickness at the thickest point of the muscle.

Conclusions: According to the obtained data and simulation results, there is no obstacle in the production of the measurement tool. The measurement tool was planned to have two different parts, namely, right and left. However, in order to ensure its reliability, it is necessary to carry out controlled safety tests on real patients after the production of the measurement tool.

Keywords: Intramuscular injection, measurement tool, simulation, ventrogluteal site, nursing.

ÖZET

Amaç: Çalışmada, ventrogluteal bölgede güvenli bir alan tespitini kolaylaştırabilecek bir ölçüm aracı tasarlanması ve simüle edilmesi amaçlanmıştır.

Yöntem: Metadolojik olan çalışmada, öncelikle sağlıklı bireylerde (N=135) vücut kitle indeksine göre ventrogluteal bölgeden ölçümler yapıldı. Bu ölçümlerden elde edilen veriler analiz edildi ve ölçüm aparatının tasarımı için gerekli olan boyutlar belirlendi. Ölçme aracı, 3D modelleme programı kullanılarak tasarlandı.

Bulgular: Çalışmaya katılan bireylerin %57'si (n=77) kadın ve %46.7'si (n=63) normal kilodadır. Kas kütlesinin en kalın noktasının V ve G yöntemleriyle ölçülenden farklı olduğu ve kas kütlesinin en kalın noktasının karşılaştırıldığında daha sağda ve aşağıda yer aldığı tespit edildi. Sonuçlar, kullanılan yöntemin sağ ve sol bölgedeki kalça uzunluğu, kas mesafesi, gluteus minimus kasının en kalın kısmının kalınlığı ve en kalın yerdeki toplam kas kalınlığı ölçümlerinde farklılığa yol açmadığını göstermiştir.

Sonuç: Elde edilen veriler ve simülasyon sonuçlarına göre ölçme aracının üretilmesinde herhangi bir engel bulunmamaktadır. Ölçme aracı sağ ve sol olmak üzere iki farklı bölümden oluşacak şekilde planlanmıştır. Ancak güvenilirliğini sağlamak için ölçme aracının üretilmesinden sonra gerçek hastalar üzerinde kontrollü güvenlik testlerinin yapılması gerekmektedir.

Anahtar Kelimeler: Kas içi enjeksiyon, ölçüm aracı, simülasyon, ventrogluteal, hemşirelik.

INTRODUCTION

Nurses use various ways to administer drugs such as oral, topical, and parenteral (Salari et al., 2018). Intramuscular drug administration, which is one of the parenteral drug administration routes, involves the administration of drug into the deep muscle tissue (Dogu, 2016). The risks of intramuscular drug application are more common in the dorsogluteal site; therefore, current evidence emphasizes the need to prefer the ventrogluteal site (Cocoman and Murray, 2010; Kaya et al., 2012; Kilic et al., 2014; Su and Bekmezci, 2020; Walsh and Brophy, 2011).

Two methods were used to detect the ventrogluteal site. In the first method, the practitioner's palm was placed over the greater trochanter of the individual and the wrist was perpendicular to the femur. If the injection was to be applied to the left ventrogluteal site of the individual, the right hand of the practitioner was used, and if it was to be applied to the right ventrogluteal site, the left hand was used. The thumb pointed toward the individual's groin, the index finger pointed toward the anterior superior iliac spine, and the middle finger was extended as far back as possible. The drug was applied in the middle of the "V" angle formed by the index and middle fingers (Figure 1) (Kaya and Palloş, 2014; Masuda et al. 2016). This method is known as the "V method" because of the angle used for application.

The other method used was the Geometric method (G method). The area determined by using this method was reported to be a 100% safe site by Larkin et al. (2018). To determine the ventrogluteal site using this method, an imaginary line is drawn from the greater trochanter to the iliac tubercle crest and from there to the anterior superior iliac spine, then from the greater thoracic to the anterior superior iliac spine as per the bone protrusions; with these imaginary lines, a triangle is formed. Then, median lines are formed at the center of the triangle for each corner of the triangle. The injection site is the center of these median lines (Figure 1) (Kaya et al., 2015).

In these methods, the hand structure of the practitioner and the use of imaginary lines make it difficult to determine the safe drug administration site in the ventrogluteal site. In addition, the body mass index (BMI) of the individual to be treated may affect the detection of the safe site because the reference points considered in both the methods are directly related to the physical structure of the practitioner (Burbridge, 2007; Larkin et al. 2018; Palma and Strohfus, 2013; Sahebkar et al, 2021).

The development of subcutaneous tissue and muscles in the human body varies according to sex and race (Masuda et al., 2016; Sakamaki et al., 2013). Considering the sex-related structural differences, body fat distribution is concentrated in the abdominal and hip sites in men and women, respectively (Burbridge, 2007; Larkin et al., 2018; Sakamaki et al., 2013; Strohfus et al, 2022). Further, women have more fat tissue thickness and less muscle mass than men (Chan et al., 2006; Güneş et al., 2008; Kaya et al., 2015; Larkin et al., 2018). In addition, that there may be differences between the right and left sites; however, there are very few studies showing these differences.

Coşkun et al. (2016) reported no difference between the muscle and subcutaneous measurements of the right and left ventrogluteal sites, a significant difference between the vein and artery distance, and the left site was farther away. It is recommended to evaluate the physical characteristics (like BMI) of the individual and to prefer the left ventrogluteal site during intramuscular drug administration in this study. Thus, it is important to solve the problems faced in detecting the ventrogluteal site as the first intramuscular drug administration site by nurses and to safely perform drug administration.

Nurses have to perform drug administration individually, and the length of the needle used for drug administration may vary according to the individual; however, the method for locating the administration site is same for all individuals. We designed and simulated a measurement tool that will facilitate and standardize the detection of the ventrogluteal site, which is important for ensuring and maintaining patient safety, thus increasing the rate of use of this drug administration site by nurses.

METHODS

Purpose and Research Type

The research was planned and implemented as a methodological study to develop and simulate a measurement tool that would ignore practitioner differences in the detection and use of the ventrogluteal site for drug administration.

The Population-Sample of the Study

As a result of the power analysis made in the study, it was aimed to reach at least 100 individuals with a deviation of ±0.05 at a power level of 0.80 and a margin of error of 0.05. The study sample comprised 135 healthy individual who agreed to participate in the study; were ≥18 years of age; open to communication; did not have any wound, deformity, etc. in the ventrogluteal area; and had a BMI between 18.5 and 40. The study was conducted between May 2018-April 2019, with individuals who voluntarily agreed to participate in Sakarya.

Data Collection Tools

The data collection form created by the researchers in line with the literature was used to collect the data (Gülnar and Çalışkan, 2014; Kaya and Palloş, 2014; Korkmaz et al., 2015). This form included the individual's age; sex; weight, height, and waist–hip measurements; BMI; subcutaneous tissue thickness; presence of any health problem in the right or left ventrogluteal site; previous injection status; length, width, and deepest area measurement of the gluteus medius and minimus muscles in the area.

Data Collection

BMI of the volunteers who participated in the study were calculated. The first interview was completed by giving the volunteers the day and time of the planned radiological measurement to be performed by the radiologist. In the second interview, the right and left ventrogluteal site measurements were performed by the radiologist using a USG device. In addition to the examination of organs and tissues in the human body using piezoelectric crystal probes with high frequency sound waves, muscle–bone structure and subcutaneous tissue images were taken using 7.5-mHz linear array transducer on Sonoline Elegra System USG device. All measurements were recorded.

The site, which differs in each individual, was measured in different groups for standardization of the detection of administration site, and an average value was taken according to BMI. The dimensions of the measurement tool were determined as a reference. The dimensions of the measurement tool were determined by standardizing the length and width from the obtained data according to BMI of the entire sample. The deepest area was intended to be the entry point of the needle to be applied and a hole area in the measurement tool, which was designed as a disposable tool. Thus, the auxiliary tool was designed to ignore the hand structure of the practitioner in detecting the ventrogluteal site.

Rhinoceros 6 program was used for designing the tool. Further, to assist in designing the tool, a computer-modeled 3D human model was used as a template for medical designs including anatomical and body systems. Finally, the tool was simulated *in silico* on this 3D human model.

Analysis

The statistical package for the social sciences 21 package program was used to analyze the data. Demographic data are expressed as numbers and percentages. One-way ANOVA was used to examine the difference between the right and left ventrogluteal sites according to BMI, and Independent samples *t*-test was used to examine differences in sex. The significance was considered as $p<0.05$ and confidence interval 95%.

Limitations of the Study

The fact that the research was carried out only this population is the limitation of the research.

Ethical Dimension

This study was conducted according to the principles of the Declaration of Helsinki, and the study was approved by the Acıbadem University and Acıbadem Healthcare Institutions Medical Research Ethics Committee (ATADEK) (2017/7-8). The purpose of the study was explained to the individuals who met the inclusion criteria, and their verbal and written consents were obtained.

RESULTS

Sociodemographic Data

The sociodemographic data of healthy individuals is shown in **Table 1**. Further, 85.9% participants stated that they did not have any previous medication application in the ventrogluteal site and 97.8% stated that they did not experience any problem in this region.

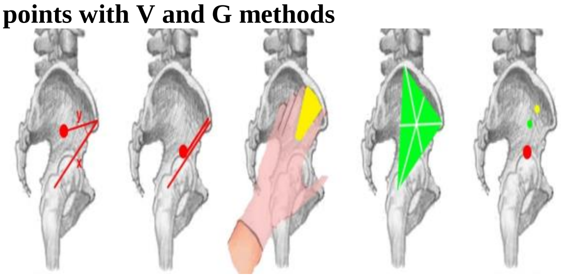
Table 1. Demographic characteristics of the individuals participating in the study (N = 135)

		N	%
Sex	Male	58	43
	Female	77	57
BMI	Underweight (BMI < 18.5)	10	7.4
	Normal weight (18.5 ≤ BMI < 25)	63	46.7
	Overweight (25 ≤ BMI < 30)	34	25.2
	Obese (30 ≤ BMI)	28	20.7
Age (Mean ± S.D.)		27.68 ± 7.78	

Detection of the Ventrogluteal Site

To determine the thickest point of muscle mass where the gluteus minimus and medius muscles overlapped, the anterior superior iliac spine and greater trochanter protrusion were considered as reference points. An imaginary line drawn between these two points (**Figure 1x**) was considered as the length expressed as hip length. The distance of the muscle was recorded as a second line indicating the distance between the thickest point of the muscle and the anterior superior iliac spine (**Figure 1y**). Further, the angle between these lines was recorded.

Figure 1. Comparison of new measurement points with V and G methods



The angle between the X and Y lines was found to be close to zero degree. The X and Y lines overlapped, and the thickest point of the muscle mass was located almost above these two lines. Therefore, this angle can be neglected. We found that the thickest point of muscle mass was different from that measured by other methods. The thickest point of muscle mass was found to be located more to the right and below as compared to other methods (V and G methods). In addition, we determined the thickness of subcutaneous tissue at the point where the muscle was the thickest. The differences in measurements in the right and left sites by BMI and sex are shown in **Table 2**. There was significant difference in the BMI groups in terms of hip length, distance of the muscle, muscle thickness, and mean thickness of the subcutaneous tissue at the thickest point of the muscle ($p < 0.05$). In addition, there was a significant difference in the right hip length, thickness of the right and left subcutaneous tissue at the thickest point of the muscle, and sex ($p < 0.05$). However, there was no significant difference according to sex, except for the thickness of subcutaneous tissue (**Table 2).**

Table 2. Comparison of findings and differences according to BMI and sex

Region			**Hip length**	**Distance of muscle**	**The thickness of the thickest point of the medius muscle**	**The thickness of the thickest point of the minimus muscle**	**The total muscle thickness at the thickest point of the muscle**	**The thickness of the subcutaneous tissue at the thickest point of the muscle**
			Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
Left	BMI	Underweight	100.05 ± 7.74 (a)	58.92 ± 4.96 (a)	20.16 ± 3.05 (a)	11.44±2.13	32.77 ± 3.54 (a)	7.92 ± 1.96 (a)
		Normal weight	99.01 ± 5.62 (a)	62.11 ± 5.14 (a)	23.26 ± 4.49 (b)	11.53 ± 3.35 (a)	33.98 ± 4.48 (a)	10.27 ± 4.34 (b)
		Overweight	109.95 ± 7.54 (b)	65.62 ± 6.36 (b)	25.09 ± 3.36 (b)	12.80±2.49	37.92 ± 4.23 (b)	12.59 ± 4.70 (b)
		Obese	114.11 ± 9.53 (b)	67.17 ± 6.35 (b)	28.55 ± 4.90 (b)	13.83 ± 2.42 (b)	42.06 ± 5.09 (c)	18.86 ± 8.56 (c)
		Total	104.97±9.66	63.81±6.19	24.59±4.82	12.32±3.01	36.56±5.55	12.46±6.44
	Statistical analysis (F/p)		**36.226/0.000**	**8.658/0.000**	**14.016/0.000**	**4.704 / 0.004**	**24.269 / 0.000**	**18.513 / 0.000**
	Sex	Male	103.19±8.69	61.42±5.07	24.39±3.92	12.78±3.40	36.57±5.18	8.77±3.64
		Female	106.31±10.17	65.61±6.38	24.73±5.41	11.98±2.66	36.55±5.84	15.25±6.71
		Total	104.97±9.66	63.81±6.19	24.59±4.82	12.32±3.01	36.56±5.55	12.46±6.44
	Statistical analysis (t/p)		-1.877/0.063	**-4.122/0.000**	-0.421/0.675	1.533/0.128	0.023/0.982	**-7.195/0.000**
Right	BMI	Underweight	100.68 ± 8.69 (a)	59.54 ± 5.01 (a)	19.98 ± 2.86 (a)	11.83 ± 2.36 (a)	31.48 ± 4.21 (a)	7.97 ± 2.28 (a)
		Normal weight	98.70 ± 5.47 (a)	62.43 ± 4.92 (a)	23.90 ± 4.10 (b)	11.35 ± 2.19 (a)	34.54 ± 4.90 (a)	9.98 ± 4.43 (b)
		Overweight	109.76 ± 8.48 (b)	65.87 ± 5.81 (b)	25.92 ± 2.76 (b)	13.30 ± 2.67 (b)	38.65 ± 3.54 (b)	12.33 ± 4.59 (b)
		Obese	113.37 ± 10.13 (b)	66.00 ± 7.29 (b)	28.39 ± 4.71 (c)	14.55 ± 2.24 (b)	42.86 ± 4.54 (c)	18.20 ± 8.03 (c)
		Total	104.67±9.88	63.82±6.02	25.05±4.44	12.54±2.66	37.07±5.70	12.13±6.23
	Statistical analysis (F/p)		**30.753 / 0.000**	**5.942 / 0.000**	**15.083/0.000**	**13.816/0.000**	**29.009 / 0.000**	**17.670 / 0.000**
	Sex	Male	102.22±8.00	62.17±5.62	24.31±3.28	12.76±2.63	37.08±4.44	8.41±3.62
		Female	106.52±10.77	65.06±6.05	25.61±5.10	12.38±2.68	37.07±6.53	14.92±6.33
		Total	104.67±9.88	63.82±6.02	25.05±4.44	12.54±2.66	37.07±5.70	12.13±6.23
	Statistical analysis (t/p)		**-2.663/0.009**	**-2.829/0.005**	-1.790/0.076	0.822/0.413	0.009/0.993	**-7.534 / 0.000**

a, b, c: different lowercase letters indicate significant differences between the means of the groups (a = highest mean). F: One-way ANOVA test. t: Independent sample t-test

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Dependent sample's *t*-test results showed that the method used does not lead to a difference in the measurements of hip length in the right and left sites, distance of the muscle, thickness of the thickest part of the minimus muscle, and the total muscle thickness at the thickest point of the muscle. The used method leads to a difference in the thickness of the medius muscle in the right and left sites ($p = 0.041$) and the thickness of the subcutaneous tissue at the thickest point of the muscle ($p = 0.024$; Table 3).

Table 3. Comparison of differences between left and right sites by BMI and sex

Variables		Hip length	Distance of muscle	The thickness of the thickest point of the medius muscle	The thickness of the thickest point of the minimus muscle	The total muscle thickness at the thickest point of the muscle	The thickness of the subcutaneous tissue at the thickest point of the muscle
Underweight	Left-Right (t / p)	-0.802/0.443	-0.819/0.434	0.278/0.787	-1.712/0.121	2.169/0.058	-0.107/0.917
Normal weight	Left-Right (t / p)	1.151/0.254	-0.952/0.345	**-2.087/0.041**	0.474/0.637	-1.083/0.283	1.616/0.111
Overweight	Left-Right (t / p)	0.380/0.706	-0.352/0.727	-1.630/0.113	-1.113/0.274	-0.883/0.384	1.164/0.253
Obese	Left-Right (t / p)	1.175/0.250	1.382/0.178	0.311/0.758	-2.003/0.055	-0.819/0.420	1.353/0.187
Male	Left-Right (t / p)	**2.979 / 0.004**	-1.640/0.106	0.242/0.810	0.046/0.964	-0.945/0.349	**2.077 / 0.042**
Female	Left-Right (t / p)	-0.683/0.497	1.409/0.163	**-2.951/0.004**	-1.953/0.054	-0.98/0.33	1.447/0.152
Total	Left-Right (t / p)	1.325/0.188	-0.045/0.964	**-2.063/0.041**	-0.967/0.335	-1.357/0.177	**2.288 / 0.024**

t: Dependent sample t-test

When the subcutaneous tissue and muscle thicknesses in the right and left ventrogluteal sites were examined, the values were found to be very close to each other. In individuals with normal weight, there was a significant difference between the thickness of the right and left medius muscles at the thickest point of the muscles ($p < 0.05$). The same was observed in the comparison of all individuals. A significant difference was observed in the right and left hip lengths in men ($p < 0.05$). Further, there was a significant difference in men in terms of the thickness of the right and left subcutaneous tissue at the thickest point of the muscle. In women, there was a significant difference in the thickness of the right and left medius muscles at the thickest point (Table 3).

Thus, we found a correlation between hip length and the distance of the muscle; hip length was the parameter with a significant effect. As the presence of a longer hip bone due to the human anatomy is expected to produce such a result in terms of the location of the muscles, this correlation was transformed into a regression to create a cause and effect relationship. The left and right values were separately examined. As a result of simple linear regression, the left hip length value had a significant effect on the left muscle distance value in the sex and BMI groups ($p < 0.05$); accordingly, when the left hip length increased by 1 unit in all individuals, the distance of the muscle increased by 0.325 units. The adjusted R2 value was 0.251 and the explanatory power of the model was at the level of 25%. This level of explanatory value is sufficient for product development, which is the main purpose of the study. Further, the deviation is sufficient for the applicability of the product at 95% confidence interval. Thus, the regression formula for the parameters of the left site for all individuals was formed as follows:

Distance of the left muscle = 29.693 + (0.325 × left hip length)

When the results were examined according to sex and BMI values, the adjusted R2 value in men was 0.280. The R2 value in women increased to 0.201 and the explanatory value decreased. The R2 value was 0.339 for underweight individuals and 0.090 for those with normal weight. The R2 value was 0.103 in overweight participants and 0.121 in obese. However, statistically significant results were obtained in obese and overweight groups, and the deviations were sufficient for applicability of the product.

The values on the right site of the body were similar to those on the left site. The adjusted R2 values taken from the right site in overweight and obese individuals were higher than those taken from the left (R2 = 0.284). Thus, the regression formula for right zone parameters for all individuals was formed as follows:

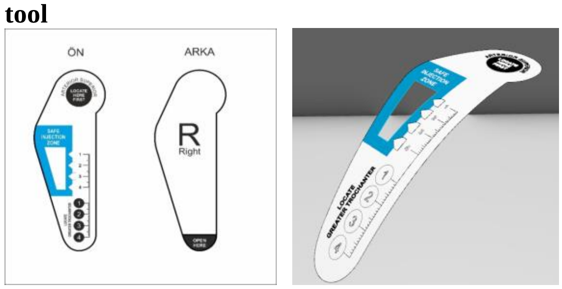
Distance of the right muscle = 29.541 + (0.327 × right hip length)

A regression equation and cause and effect relationship can be established between the hip length and distance of the muscle. However, when it comes to product development, the deviation values in the regression are important for the reliability of the developed product. Huge differences between the values predicted by the formula and the actual values will impair the reliability of the product. However, extreme values are also important because determining a reliable injection site for healthy individuals/patients with extreme values is necessary for the reliability of the product. Therefore, the deviation values in the data obtained from 135 participants were compared using the regression formula. The extreme values with the highest deviation were 13.6 and 13.9 mm on the left and right, respectively. Compared to the length of the muscles in the ventrogluteal site, these values showed sufficient deviation for the reliability of the product.

Simulation of the Ventrogluteal Site Measurement Tool

The measurement tool was planned to have two different parts, namely, right and left. Performing both right and left measurements with a single product misleads the user. When a double-sided product is developed, its reliability is reduced due to the difference in both right and left dimensions, and the use of suitable adhesives becomes difficult. In addition, production processes become expensive. Further, patients will usually be injected on one side; therefore, using a product having both sides at the same time will lead to confusion in its use and unnecessary waste of the product. Accordingly, many options regarding the product design were evaluated and the final version was designed as shown in **Figure 2**.

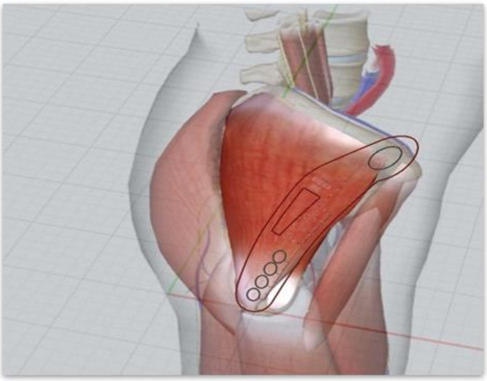
Figure 2. Preliminary design of the measurement tool



Another problem in designing the tool was where the first reference point should be. Initially, we discussed whether the anterior superior iliac spine or the greater trochanter protrusion should be considered as a reference point. It was decided that the most easily found point in the patient was the anterior superior iliac spine and this point should be selected first. Therefore, after selecting the anterior superior iliac spine in the product, the product guides the user where to perform injection using numbers that correspond to the major trochanter protrusion.

To simulate the design of the measurement tool *in silico* based on the measurements taken with USG on a realistic 3D human model, the size and location of the bones and muscles were revised and the tool was placed on the 3D model in three dimensions. The point marked by the tool indicates a safe point where the muscle is the thickest (Figure 3). It should be kept in mind that all design decisions stated in this section can change when the prototypes of the product are produced and tested in healthy individuals/patients because of new problems that might arise. Therefore, this tool will continue to evolve, similar to other products.

Figure 3. Relationship of the product with the gluteus medius muscle on the 3D model.



DISCUSSION

When the studies on the determination of the ventrogluteal site in intramuscular injection in the literature are examined, it is seen that the purpose of these studies is to determine the reliability of different methods (Güneş et al., 2008; Kaya et al., 2015; Larkin et al., 2018; Sakamaki et al., 2013; Tanioka et al., 2018; Zaybak et al., 2007). Therefore, only the lengths of the reference points in the ventrogluteal site and muscle and subcutaneous tissue thickness were examined in studies, and the data obtained were compared in terms of right–left comparisons, BMI, and sex variables. In this study, we aimed to develop a tool that can ensure reliable injections in the ventrogluteal site and detailed measurements were obtained to create its dimensions. Thus, this is the first such study in the literature.

It has been reported that the ventrogluteal site is in the center of the triangle obtained with the G method (Kaya et al., 2015; Larkin et al., 2018; Tanioka et al., 2018) and in the center of the triangle between the fingers in manual measurement performed with the V method (Larkin et al., 2018). However, the most important finding of the study is that the thickest muscle mass in the ventrogluteal site is at a very close distance to the line defined as the hip length, defined as X in Figure 1.

Kikukuchi et al. (2009) found a strong correlation between subcutaneous tissue thickness and BMI. In their study examining the differences in the ventrogluteal and dorsogluteal sites according to sex, BMI, and body structure, Larkin et al. (2018) reported that while subcutaneous tissue thickness was 11.2 ± 5.0 mm in normal weight individuals, this rate was 28.1 ± 9.6 mm in obese individuals. They measured 15.6 ± 12.0 mm subcutaneous tissue thickness in women and 9.8 ± 6.6 mm in men. Consistent with the literature, when the measurements were performed according to sex, it was observed that the subcutaneous tissue was thicker in women than in men (**Table 2**). The study also revealed that, unlike other studies, the subcutaneous tissue was thinner at the thickest point of the muscle. It is thought that an injection performed with the measurement tool developed in the study will increase the possibility of safe drug administration.

In the study conducted by Güneş et al. (2008), there was a significant difference between subcutaneous tissue and muscle thickness in the ventrogluteal site according to the BMI of individuals ($p < 0.05$). Kaya et al. (2015) measured the medius and minumus muscles in their study and reported a significant relationship between BMI and obtained values ($p < 0.05$). In their study, the thickness of the right and left subcutaneous tissue at the thickest point of the muscle showed a significant difference, and as BMI increased, the subcutaneous tissue thickness increased as expected.

Coşkun et al. (2016) reported that the mean thickness of the gluteus medius muscle was 23.17 ± 6.21 mm in the right ventrogluteal site, while it was 22.22 ± 5.84 mm in the left site ($p > 0.05$) and there was no significant difference. However, the study was not performed on healthy individuals, and it was also measured as muscle thickness between skin and muscle. In the study conducted by Sakamaki et al. (2015) on healthy individuals, they found that the thickness of the right gluteus medius muscle was 40.13 ± 7.77 mm, the left gluteus medius muscle was 39.46 ± 8.59 mm, the right gluteus minumus muscle was 18.07 ± 4.35 nm, and the left gluteus minumus muscle was 17.21 ± 4.67 mm. The point that should be underlined in the study is that comparisons were made between the thickest area of the gluteus medius and minumus muscles on the right and left and the thickest muscle point formed by the combination of the two muscles (Table 3).

Conclusions

The measuring tool was designed by considering BMI groups, sex, and right-left size differences, and meeting all these differences. With this tool, healthcare professionals will have more self-confidence in using the ventrogluteal site for injection, the measurement principles of this region will be transferred more easily in education, and the tool will contribute to the widespread use of this area over time, thus contributing to the application of safe injection. The importance of the use of the ventrogluteal site is supported by the literature, and abandoning questionable hand measurement technique will be ensured by replacing it with a more reliable measurement tool. Using the measurement tool, which is an objective way in line with the measurement statistics, it will provide a standard in practice. Medical errors will decrease with the widespread use of the measurement tool.

It is recommended to investigate the effect of tissue thickness on the development of product design. When the muscle and subcutaneous tissues overlap at the thickest point of the muscle, it forms a thickness. The majority of this thickness remains within the cavity of the iliac bone. Accordingly, in the examinations performed on underweight and normal weight participants, it was observed that these tissues were trapped in the cavity of the iliac bone and did not affect the surface thickness. Therefore, when a straight line is drawn between the anterior superior iliac spine and the greater trochanter protrusion while these participants are in the supine position, the tissues remain below this line. However, as BMI increases, the thickness of these tissues increases and forms a convex structure on the surface. In future studies, it should be examined whether this convex structure requires a revision in the design of the product, especially in obese individuals.

The measurement tool revealed in the study can be developed from different aspects with researches after production. The awareness of the ventrogluteal site in injection and the widespread use of the site should be constantly monitored, and different studies investigating the contribution of the product to the application should be planned. In line with the measurements made in the study, since the measurement tool was designed only by simulation, it is strongly recommended to apply it on individuals clinically and to conduct a reliability study.

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Author Contributions

Study design: U K, Ö D, I A, E YC

Data collection and/or analysis: U K, Ö D, A K, I A, E YC, C C

Preparation of the article: U K, Ö D, E YC, CC

Conflict of interest

No conflict of interest has been declared by the authors.

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