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Original Article

Appropriate needle insertion depth for trigger point injections of the parascapular region

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ABSTRACT

Objectives: This study aims to determine the appropriate needle insertion depth for the parascapular region.

Patients and methods: This retrospective study was conducted with 1,015 participants (536 males, 479 females; mean age: 57.1±14.9 years; range, 18 to 95 years) between December 2017 and December 2019. The distances from the skin to the pleura and the skin to the muscle were measured at the reference points according to the literature for the upper trapezius and rhomboid major muscles from the chest computed tomography images of the patients. The midpoint of these two points was determined as a third point. In addition, the thinnest point in the medial of the scapula was determined as the fourth point, and depth measurements were made from these four points. Measurements were compared among groups stratified by age, sex, and body mass index.

Results: The measured depths from the skin to the muscle and the skin to the pleura significantly differed between groups (p<0.01). At three of the measurement points, the skin-to-pleura distances of females were shorter than that of males, while the skin-to-muscle distances were longer (p<0.01). The mean, minimum, and maximum values of the depths were determined for the groups.

Conclusion: We recommend clinicians who apply injection to the parascapular region consider the patients' age, sex, and body mass index. The tables provided in this study may help guide clinicians performing the procedure.

Keywords: Appropriate depth, dry needling, pneumothorax, rhomboid major, trigger point, upper trapezius.

Myofascial pain syndrome is a painful condition caused by trigger points in the muscle,[1,2] and a common cause of shoulder, neck, and upper back pain.[3,4] Trigger points are hyperirritable areas in taut muscle bands.[1] Myofascial trigger points have been reported to affect 85% of the population.[5]

Medications, trigger point injections, exercise, and other alternative therapies (e.g., kinesiotaping, transcutaneous electrical nerve stimulation, shockwave, and laser therapy) can be used to treat myofascial trigger points.[6-9] Trigger point injection has been proven effective in treating painful active myofascial trigger points and is widely used.[10]

Adverse effects of trigger point injections such as vascular injury, systemic anesthetic toxicity, allergic reaction to the anesthetic agent, infection, bleeding, and pain have been described previously.[10,11] In addition, pneumothorax, a severe adverse effect, may develop in trigger point injections or dry needling in the parascapular region due to the proximity of the muscles to the pleura.[10,12-14] Even in acupuncture treatments and some needle electromyography (EMG) applications, there is a risk of pneumothorax.[15-17] A systematic review of the Chinese literature published between 1956 and 2010 reported 307 cases of pneumothorax after acupuncture. Acupuncture was performed on these patients for diseases such as intercostal neuralgia, stiff neck, and shoulder pain.[16] Another systematic review concluded pneumothorax and

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hepatitis to be the most common significant events in acupuncture.[15]

For trigger point injection to be effective, the needle should not remain in the skin-subcutaneous tissue, and to be safe, it should not cross the relevant muscle. In trigger point injections of the parascapular region, the risk of pneumothorax occurs when the needle is advanced beyond the muscle and enters the pleura. The manual palpation method for the rhomboid muscles has been indicated to have an accuracy rate of only 66.3%.[18] This risk is greater in trapezius and rhomboid major muscles due to their anatomical adjacency to the pleura, and these muscles are also among those with more frequent trigger points.[18-20]

Knowing the appropriate needle insertion depth in the parascapular region, where trigger points are frequently observed, can make this procedure both more effective and safer. As far as we know, there are no studies examining the appropriate needle insertion depth for the parascapular muscles according to age, sex, and body mass index (BMI).

Computed tomography (CT) is one of the methods used for skin-subcutaneous tissue and muscle measurements. An advantage of CT over ultrasonography (USG) is that it allows morphometric analysis of more patients in the same time period using retrospective scanning from previously taken images.[21-23] A study reported that age, sex, and BMI may affect the skin, subcutaneous tissue, and muscle thickness on CT images.[21]

This study aimed to perform a morphometric analysis to determine the appropriate and safe needle insertion depth for the rhomboid major and upper trapezius muscle reference points and the region medial to the scapula, considering factors such as age, sex, and BMI. Another aim of this study was to examine the relationships between the depth measurements made for the rhomboid major muscle, upper trapezius muscle, and the thinnest point medial to the scapula with age, sex, and BMI.

PATIENTS AND METHODS

This retrospective study was conducted at the Kırşehir Ahi Evran University Faculty of Medicine. Patients over the age of 18 who underwent chest CT between December 2017 and December 2019 were called by phone, detailed information was provided to the patients, and those who agreed to participate in the study were included. The data regarding the patient's sex, age, and comorbidities were recorded from the hospital information system. In addition, patients were asked about their height, weight, surgery, trauma, and fracture history by telephone. The study did not include patients with chronic infection, Cushing's syndrome, immunodeficiency, history of cancer, neck, shoulder, back fracture, or surgery. Patients with a structural disorder, such as scoliosis, or visible muscle or bone tissue disorders on imaging were also excluded. One thousand five hundred twenty-seven patients were evaluated for inclusion in the study. One hundred fifty-eight patients were excluded from the study since they

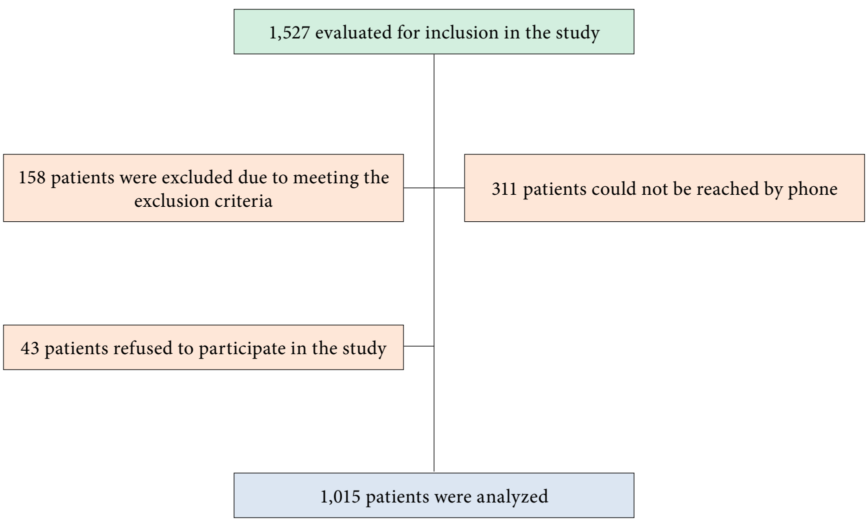

Figure 1. The flowchart of participants in this study.

met at least one of the exclusion criteria. Three hundred eleven patients could not be reached by phone. Forty-three patients contacted by phone refused to participate in the study. As a result, 1,015 participants (536 males, 479 females; mean age: 57.1±14.9 years; range, 18 to 95 years) were analyzed (Figure 1). Written informed consent was obtained from all participants. The study protocol was approved by the Kırşehir Ahi Evran University Faculty of Medicine Clinical Research Ethics Committee, (Date: 05.11.2019, No: 2019-19/183). The study was performed per the ethical standards specified in the Declaration of Helsinki.

Using the CT images of the participants, measurements were made for the skin-pleural distance (e.g., the maximum depth that can be reached without risk of pneumothorax) and the skin-muscle distance (minimum depth for needle insertion) from the points accepted as reference points in the literature for the trapezius and rhomboid major muscles.[13,24] While measuring the skin-pleural distance from the determined points, the distance from the pleura closest to the skin at that point was recorded. Similarly, the distance from the skin to the muscle closest to that point was measured while measuring the skin-muscle distance. Since it was

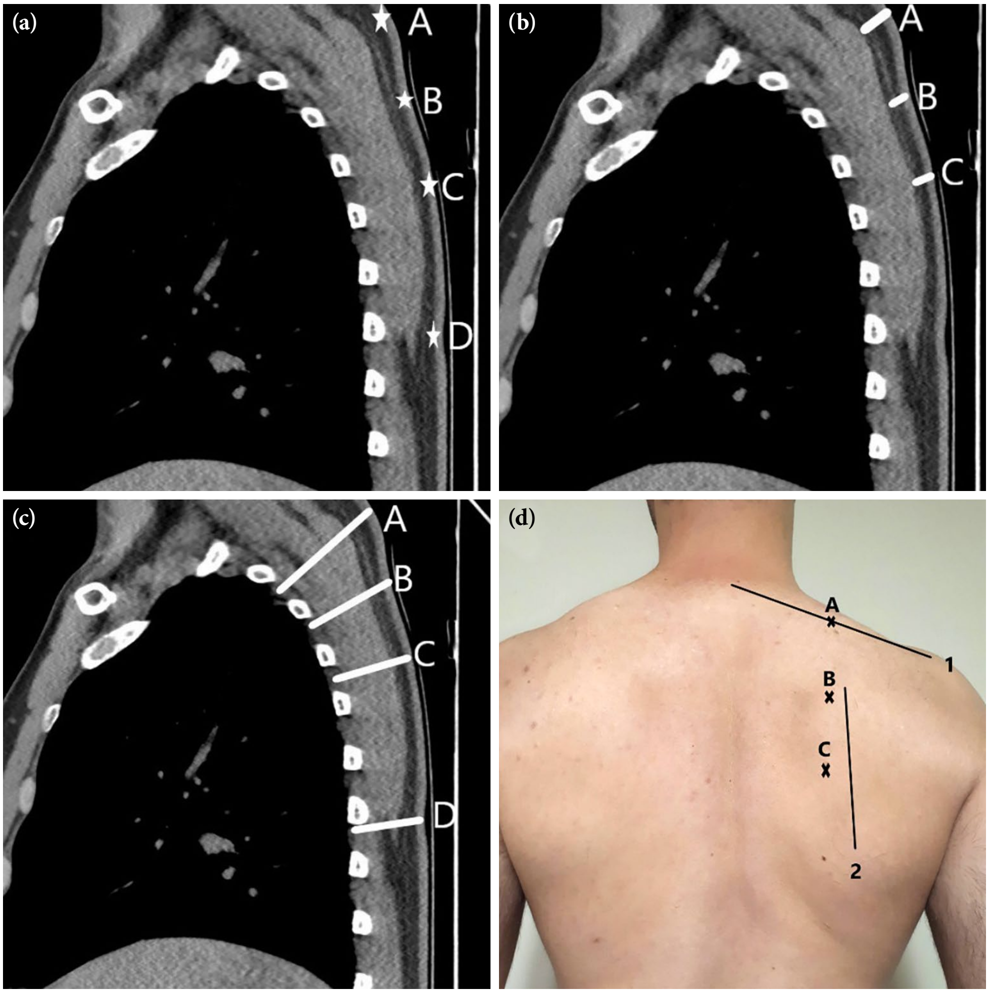

Figure 2. **(a)** Localizations of points A, B, C, and D on the chest CT image. **(b)** Distances from the skin to muscle at points A, B, and C. **(c)** Distances from the skin to pleura at points A, B, C, and D. **(d)** The localization of points A, B, and C in the dorsal region are shown. Line 1 is the line connecting the acromion and the spinous process of the seventh cervical vertebra. Point A is the midpoint of this line and is the reference point for upper trapezius muscle injections. Line 2 represents the medial edge of the scapula. Point C is located 1 cm medial to the midpoint of line 2 and is the reference point for injections of the rhomboid major muscle. Point B is located at the midpoint of the line connecting points A and C.

previously demonstrated that there was no difference in thickness between dominant and nondominant parascapular muscles, the measurement was made only from the right side.[25] For the upper trapezius muscle, measurement was made in the middle of the line connecting the spinous process of the seventh cervical vertebra and the acromion, and this place was named the A point.[24] For the rhomboid major muscle, a measurement was made 1 cm medial to the midpoint of the scapula's medial edge, which was determined as the C point (Figure 2).[13]

All patients underwent chest CT with a 16-slice CT device (Alexion 16; Toshiba Medical Systems Co Ltd., Otowara, Japan) in the same supine position with a 3-mm slice thickness and appropriate thorax protocol (kV: 100-120; mAs: 50-100). Axial CT images were converted into coronal and sagittal planes by reconstruction, and the measurements were made. Axial, coronal, and sagittal plane images were used to determine the localization of the measurement points. Depth measurements were made on sagittal plane images (Figure 2).

Injections made into the dorsal regions of the scapula, that is, lateral to the medial edge of the scapula, are safe for pneumothorax since the scapula prevents the needle from reaching the pleura. The region medial to the scapula, where trigger points are frequently observed, is an area where pneumothorax can be observed more frequently during injection.[13] Therefore, to determine more generalizable, more reliable, and clinically pertinent data for the region medial to the scapula, the authors planned to add two other measurement points to these two points. The midpoint of the two reference points mentioned above was also determined as a third measurement point and named the B point. In addition, the distance from the skin to the pleura was measured for the point with the thinnest skin-pleural distance (D point) in the region medial to the scapula. Since most patients did not have a measurable muscle distance at point D, only the distance from the skin to the pleura was measured. Measurements were performed by an experienced radiologist (Figure 2).

Participants were divided into groups according to their age as young adults (18 to 39 years), middle-aged adults (40 to 59 years), and old adults (60 and over).[26] According to BMI, they were classified as underweight (BMI <18.5), normal weight (18.5≤ BMI <25), overweight (25≤ BMI <30), obese (30≤ BMI <40), and morbidly obese (BMI ≥40 kg/m^2).[27]

Statistical analysis

Statistical analyses were performed using IBM SPSS version 25.0 software (IBM Corp., Armonk, NY, USA). The assumption of normality was analyzed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Homogeneity of variances was assessed using Levene's test before conducting analysis of variance (ANOVA) and t-tests. Since Levene's test indicated homogeneity of variances, standard ANOVA and t-tests were applied without additional corrections. The descriptive statistics of the variables were summarized as mean ± standard deviation (SD) values (Min-Max). The independent sample t-test and one-way ANOVA were used to compare the differences between the groups. When the F test was statistically significant as a result of the ANOVA, post hoc tests were used to determine from which group the difference originated. The Duncan test was used in this study since it is the most sensitive among post hoc tests. A p-value <0.05 was considered statistically significant in all statistical analyses.

Fuzzy regression analysis was conducted using R software version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria) with the frbs package, which was used for modeling fuzzy regression. Modeling methods such as fuzzy logic decision support systems and fuzzy regression models were used to determine the safe injection depth. Fuzzy logic is a mathematical tool used to solve uncertain situations and was developed in 1965. Fuzzy logic concerns with uncertain information, performs a

TABLE 1
Demographic data of the participants

	Total (n=1,015)	Male (n=536)	Female (n=479)	
	Mean±SD	Mean±SD	Mean±SD	*p**
Age (year)	55.40±13.73	54.78±14.03	56.12±13.36	0.134
BMI (40 kg/m^2)	26.65±4.08	26.43±3.94	26.91±4.22	0.074

SD: Standard deviation; * Independent t-test.

TABLE 2
Depth measurements from the skin to muscle and skin to pleura at points A, B, C, and D in categories separated by age, sex, and BMI

		A skin-muscle (mm)		A skin-pleura (mm)		B skin-muscle (mm)		B skin-pleura (mm)		C skin-muscle (mm)		C skin-pleura (mm)		D skin-pleura (mm)	
	n	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max
Underweight BMI <18.5 kg/m^2	19	5.3±3.8[a]	1.9-17.5	37.8±8.2[a]	21.8-55.1	4.1±2.8[a]	1.4-13.9	31.4±8.9[a]	17.3-53.0	3.4±14.8[a]	1.6-7.8	28.9±7.7[a]	13-45.1	21.2±6.1[a]	10.1-33.6
Normal weight 18.5 ≤ BMI <25 kg/m^2	296	8.6±4.2[b]	1.6-30.2	47.6±9.6[b]	20.3-84.5	7.3±3.9[b]	1.4-28.9	40.4±9.0[b]	19.4-68.5	7.0±3.7[b]	1.4-22.9	37.8±8.5[b]	18.1-64.1	26.4±6.8[b]	10.4-44.7
Overweight 25 ≤ BMI <30 kg/m^2	413	11.0±4.8[b]	2.1-32.8	54.2±10.4[c]	31.0-91.3	9.7±4.6[c]	1.8-44.8	45.5±9.6[c]	20.4-74.7	9.6±4.8[c]	1.3-39.2	43.1±8.4[c]	20.9-69.6	31.4±7.3[c]	13.2-54.8
Obesity 30 ≤ BMI <40 kg/m^2	276	14.8±5.9[c]	2.3-44.5	59.9±10.7[d]	34.4-96.5	14.1±5.9[d]	2-41	50.7±9.9[d]	23.5-81.5	14.5±5.6[d]	4.1-36.4	48.5±9.0[d]	24.6-73.8	37.7±8.3[d]	17.6-66.3
Morbid obesity BMI ≥40 kg/m^2	11	15.8±6.9[c]	10.5-34.2	60.2±14.9[d]	45.9-92.4	17.6±10.0[e]	10.3-44.4	53.6±17.4[d]	33.9-89.3	20.3±8.2[e]	10.1-40.4	56.9±12.9[e]	38.3-79.4	49.6±8.2[e]	34.8-62.2
p-value[1]		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	
Young adults (18-39 year)	136	9.6±5.5[a]	1.9-34.2	51.9±12.5	24.5-92.4	8.9±5.7[a]	1.4-44.4	44.4±11.6[a]	17.7-89.3	8.9±6.5[a]	1.4-40.4	42.1±10.3[a]	22.6-79.4	30.9±8.9	10.1-58.3
Middle-aged adults (40-59 year)	416	11.2±4.9[b]	1.6-28.4	54.4±10.6	20.3-84.9	10.1±5.2[b]	1.4-31.0	46.4±10.1[b]	20.8-79.8	10.5±5.6[b]	1.3-32.9	44.3±9.3[b]	18.1-70.8	32.2±8.4	10.4-66.3
Old adults (60 years and above)	463	11.9±6.0[b]	1.8-44.5	53.4±11.9	21.8-96.5	10.7±5.9[b]	1.4-44.8	44.5±10.6[a]	17.3-81.5	10.3±5.5[b]	1.7-36.4	41.9±9.9[a]	13-73.8	31.4±9.2	11.4-65.4
p-value[1]		0.001		0.086		0.006		0.017		0.014		0.001		0.203	
Sex															
Male	536	10.1±5.0	1.8-44.5	54.7±11.6	24.9-95.1	8.9±4.8	1.4-44.4	46.3±10.4	19.5-89.3	8.7±4.8	1.4-40.4	43.8±9.4	20.7-79.4	31.0±8.3	11.4-66.3
Female	479	12.6±5.8	1.6-39.1	52.4±11.3	20.3-96.5	11.6±6.1	1.4-44.8	44.0±10.6	17.3-81.5	11.8±6.2	1.3-39.2	42.0±10.1	13-73.8	32.5±9.3	10.1-65.4
p-value[2]		<0.001		0.002		<0.001		<0.001		<0.001		0.003		0.006	

A point: Upper trapezius muscle reference point; B point: Midpoint of the line connecting points A and C; C point: Rhomboid major muscle reference point; D point: Thinnest point medial to the scapula; BMI: Body mass index; SD: Standard deviation; 1: ANOVA, 2: Independent t-test, According to Duncan's results, There was no significant difference between the means shown with the same letter in the same column (p>0.05).

TABLE 3
Depth measurements from the skin to muscle and skin to pleura at points A, B, C, and D in categories separated by age and BMI of male participants

		A skin-muscle (mm)		A skin-pleura (mm)		B skin-muscle (mm)		B skin-pleura (mm)		C skin -muscle (mm)		C skin-pleura (mm)		D skin-pleura (mm)	
Male	n	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max
Young adult (18-39 year)	84														
BMI <18.5 (kg/m^2)	2	4.7±1.1	3.9-5.4	44.4±8.8	38.2-50.6	3.8±1.0	3.1-4.5	41.4±9.9	34.4-48.4	4.2±1.6	3.1-5.3	41.1±5.7a	37.1-45.1	25.9±6.5a	21.3-30.5
18.5≤ BMI <24.9 (kg/m^2)	35	7.2±3.2^{a}	3-15.4	48.6±9.5^{a}	31.5-68.3	6.2±3.3^{a}	2.8-15.2	42.3±8.9^{a}	26.0-64.6	6.1±3.0^{a}	2.3-11.5	41.3±7.6^{a}	26.1-64.1	27.6±5.4^{a}	17.0-39.3
25≤ BMI <29.9 (kg/m^2)	31	9.1±4.8^{a}	2.1-22.7	55.4±12.0^{b}	36.1-87.6	7.9±2.9^{b}	2.3-13.7	47.9±10.3^{b}	27.5-74.7	7.4±3.1^{b}	1.4-14.1	45.2±8.1^{ab}	27.0-63.1	31.9±6.8^{a}	20.2-45.5
30≤ BMI <40 (kg/m^2)	15	13.0±6.0^{c}	6-26	65.6±10.9^{c}	49.8-91.0	13.4±4.6^{c}	7.5-22.5	54.6±8.0^{c}	45.2-71.7	12.2±5.3^{c}	4.1-22.9	51.0±7.3^{b}	37.1-64.5	40.9±7.0^{b}	31.3-57.3
p-value^{1}		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	
Middle-aged adults (40-59 year)	212														
BMI <18.5 (kg/m^2)	4	4.3±2.1^{a}	2.7-7.4	36.4±1.1^{a}	34.8-37.2	3.4±2.1^{a}	2.1-6.5	29.2±4.5^{a}	24.6-34.1	3.4±1.1^{a}	2.3-4.6	29.1±3.1^{a}	26.4-33.1	18.8±2.8^{a}	15.0-21.5
18.5≤ BMI < 24.9 (kg/m^2)	52	7.8±3.1^{a}	2.6-15.2	49.5±8.4^{b}	24.8-69.8	5.9±2.9^{ab}	1.7-15.0	42.6±8.6^{b}	23.6-65.2	5.9±2.8^{a}	2.0-13.8	40.0±7.7^{b}	21.8-52.7	25.1±6.4^{ab}	12.0-40.5
25≤ BMI < 29.9 (kg/m^2)	95	9.3±3.2^{bc}	3.1-19.8	55.9±9.5^{bc}	33.9-82.4	7.9±3.0^{bc}	2.6-22.3	47.5±8.8^{bc}	27.5-68.5	7.6±2.9^{a}	2.2-19.1	45.3±7.9^{bc}	23.9-67.9	31.4±6.3^{bc}	16.6-45.3
30≤ BMI < 40 (kg/m^2)	59	12.9±4.7^{c}	2.3-24.3	61.6±11.8^{c}	40.7-84.9	12.1±4.9^{d}	4.0-27.5	53.6±9.9^{c}	36.2-79.8	13.2±5.4^{b}	5.1-27.2	50.5±9.3^{c}	32.4-70.8	36.7±8.3^{c}	24.6-66.3
BMI ≥40 (kg/m^2)	2	11.8±0.2^{bc}	11.6-11.9	46.0±2.2^{ab}	45.9-46.2	11.7±2.1^{cd}	11.6-11.7	38.5±4.1^{bc}	35.6-41.4	16.7±2.2^{b}	15.1-18.3	51.6±10.0^{c}	44.5-58.6	49.9±12.7^{d}	40.9-58.9
p-value^{1}		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	
Old adults (60 years and above)	240														
BM I <18.5 (kg/m^2)	3	2.3±0.3^{a}	2.0-2.6	37.2±4.0^{a}	33.0-41.0	2.7±0.6^{a}	2.2-3.3	30.3±1.9^{a}	28.1-31.7	2.2±0.3^{a}	1.9-2.6	23.8±1.7^{a}	22.0-25.4	21.7±2.4^{a}	19.0-23.6
18.5≤ BMI <24.9 (kg/m^2)	74	7.7±3.4^{b}	1.8-16.8	47.8±9.7^{b}	24.9-66.9	6.8±3.4^{b}	1.4-18.4	40.5±8.6^{b}	19.5-61.2	6.0±2.9^{b}	2.0-16.0	37.8±8.8^{b}	20.7-55.9	26.7±6.7^{ab}	11.4-44.7
25≤ BMI <29.9 (kg/m^2)	113	11.0±4.7^{bc}	3.1-29.6	55.1±10.6^{bc}		9.9±4.4^{bc}	3.0-23.9	46.6±9.9^{b}	20.4-73.8	9.3±4.3^{bc}	2.0-25.8	43.2±8.4^{bc}	20.9-69.6	30.5±7.3^{bc}	15.6-49.7
30≤ BMI <40 (kg/m^2)	50	14.6±6.4^{c}	5.3-44.5	61.8±11.2^{c}		12.3±5.6^{c}	3.8-41.0	48.9±10.0^{b}	23.5-77.6	12.5±4.4^{c}	5.2-31.0	47.4±8.6^{c}	31.0-73.7	36.0±9.2^{c}	17.6-62.0
p-value^{1}		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	

A point: Upper trapezius muscle reference point; B point: Midpoint of the line connecting points A and C; C point: Rhomboid major muscle reference point; D point: Thinnest point medial to the scapula; BMI: Body mass index; SD: Standard deviation; 1: ANOVA, According to Duncan's results, There was no significant difference between the means shown with the same letter in the same column (p>0.05).

TABLE 4
Depth measurements from the skin to muscle and skin to pleura at points A, B, C, and D in categories separated by age and BMI of female participants

		A skin - muscle (mm)		A skin - pleura (mm)		B skin - muscle (mm)		B skin - pleura (mm)		C skin - muscle (mm)		C skin - pleura (mm)		D skin - pleura (mm)	
Female		Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max
Young adult (18-39 year)	52														
BMI <18.5 (kg/m²)	4	4.0±1.6a	1.9-5.6	35.9±10.6a	24.5-47.5	6.0±5.6a	1.4-13.9	30.4±15.5a	17.7-53.0	2.6±0.7a	1.6-3.3	29.1±8.1a	23.7- 41.0	18.6±8.6a	10.1-28.9
18.5≤ BMI <24.9 (kg/m²)	21	8.2±3.7ab	2.4-15.2	42.7±8.5ab	28.6-59.3	6.9±2.9ab	2.4-12.9	35.7±8.8ab	19.4-55.6	6.4±3.3ab	2.5-14.7	32.3±6.5ab	22.6-44.6	24.1±6.5a	11.9-37.6
25≤ BMI <29.9 (kg/m²)	20	11.3±3.5b	6.2-18.0	51.3±8.6b	33.0-67.1	10.3±3.8b	4.1-18.5	42.1±8.1b	29.3-56.8	12.5±8.8b	4.2-39.2	39.5±9.2b	26.5-64.6	32.3±7.2b	21.8-51.7
30≤ BMI <40 (kg/m²)	6	17.9±7.7c	6.0-28.5	60.2±7.3c	51.8-70.7	19.1±6.4c	11.1-27.0	54.7±7.4c	46.7-66.0	20.9±5.6c	13.4-26.6	55.3±6.4c	47.1-64.2	43.7±7.3c	34.8-54.6
p-value[1]		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	
Middle-aged adults (40-59 year)	204														
18.5≤ BMI <24.9 (kg/m²)	42	9.2±4.0a	1.6-18.5	48.0±10.3a	20.3-68.7	8.0±4.0a	1.4-24.2	40.9±10.0a	24.8-64.8	8.1±4.1a	1.4-22.7	37.6±9.1a	18.1-53.6	26.6±7.5a	10.4-40.1
25≤ BMI <29.9 (kg/m²)	80	11.8±4.4ab	3.0-23.9	52.4±10.2ab	32.5-84.0	10.4±4.4a	1.8-23.6	43.7±9.6ab	20.8-69.9	10.6±4.8a	1.3-24.7	42.4±8.0b	27.2-62.1	32.0±7.0b	16.2-46.8
30≤ BMI <40 (kg/m²)	77	15.2±5.1bc	5.8- 8.4	56.8±8.0bc	42.2-76.0	14.7±5.6b	2.0-31.0	48.7±8.5bc	29.3-75.9	15.7±5.2b	6.9-32.9	47.3±8.3c	24.6-68.1	37.4±6.7bc	24.5-63.1
BMI >40 (kg/m²)	4	16.5±4.2c	10.5-20.1	60.0±10.7c	51.2-75.1	18.1±6.2b	10.3-25.2	53.1±13.0c	40.2-70.1	20.4±6.3c	11.3-25.9	53.0±12.3d	38.3-68.4)	49.5±3.0c	46.7-53.6
p-value[1]		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	
Old adults (60 years and above)	223														
BMI <18.5 (kg/m²)	5	8.8±5.9a	2.5-17.5	38.2±12.6a	21.8-55.1	3.8±1.4a	1.8-5.8	31.0±8.8a	17.3-41.9	3.5±1.0a	1.9-4.5	26.9±10.2a	13.0-41.5	22.0±8.0a	11.4-33.6
18.5≤ BMI <24.9 (kg/m²)	72	10.7±5.5ab	2.3-30.2	46.8±10.1ab	24.4-84.5	9.1±4.7ab	2.3-28.9	38.9±8.9ab	20.7-68.5	8.6±4.3b	1.7-22.9	36.3±8.2b	20.6-59.0	27.1±7.3ab	13.0-43.8
25≤ BMI <29.9 (kg/m²)	74	12.9±6.0ab	2.9-32.8	52.9±10.8bc	31.4-83.0	11.8±6.4bc	2.5-44.8	43.1±9.3bc	20.4-63.2	11.8±5.1bc	2.3-24.6	41.2±8.6bc	23.5-63.3	31.5±8.8bc	13.2-54.8
30≤ BMI <40 (kg/m²)	69	16.4±6.4b	4.6-39.1	59.5±11.8c	38.6-96.5	16.0±6.6c	5.1-35.2	50.5±11.0cd	32.1-81.5	15.7±6.2cd	5.4-36.4	47.8±9.9c	28.8-73.8	39.1±9.0c	22.7-65.4
BMI ≥40 (kg/m²)	3	12.9±1.8ab	11.0- 14.7	62.9±12.0c	49.1-70.8	14.3±1.6bc	12.9-16.0	58.9±12.0d	50.1-72.6	19.2±2.5d	16.9-21.9	62.6±10.8d	51.2-72.6	51.6±9.3d	45.1-62.2
p-value[1]		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	

A point: Upper trapezius muscle reference point; B point: Midpoint of the line connecting points A and C; C point: Rhomboid major muscle reference point; D point: Thinnest point medial to the scapula; BMI: Body mass index; SD: Standard deviation; 1: ANOVA, According to Duncan's results, There was no significant difference between the means shown with the same letter in the same column (p>0.05).

specific analysis, and offers the best decision in the presence of uncertain and incomplete data. Fuzzy logic has recently been used as a decision support system in many fields.[28] Fuzzy regression is a fuzzy type of classical regression analysis. Tanaka et al.[29] developed fuzzy linear regression as a tool for modeling temporal relationships in systems where human judgment or uncertainty prevents an exact measurement of the dependent variable. Fuzzy regression is used in many areas of decision-making system development.[30]

RESULTS

Demographic data of the patients are presented in Table 1. The skin-pleural and skin-muscle depth measurements differed significantly according to BMI categories and sex. It was determined that some measurements in age groups were significantly different between groups (Table 2). In males, the distance from skin to muscle at points A, B, and C was significantly less than in females, but the distance from skin to pleura was significantly greater ($p<0.005$). The skin-to-muscle distances of points A, B, and C in males were 10.1±5.0, 8.9±4.8, and 8.7±4.8, respectively. The skin-to-pleura depth distances of points A, B, C, and D in males were 54.7±11.6, 46.3±10.4, 43.8±9.4, and 31.0±8.3, respectively. The skin-to-muscle distances of points A, B, and C in females were 12.6±5.8, 11.6±6.1, and 11.8±6.2, respectively. The skin-to-pleura depth distances of points A, B, C, and D in females were 52.4±11.3, 44.0±10.6, 42.0±10.1, and 32.5±9.3, respectively. The distances from the skin to the muscle at points A, B, and C of the young adult group were significantly lower than those of the middle-aged adult group and the old adult group. ($p<0.005$) The distance from the skin to the pleura at points A and D was similar for all age groups ($p=0.086$ and $p=0.203$ for points A and D, respectively). Depth distances of all measurement points were significantly different in BMI groups. Depth distance increased as BMI increased ($p<0.001$).

The patients were first divided into two groups according to their sex. Afterward, patients these two groups were divided into three separate age groups. Afterward, each age group was divided into five separate BMI groups. Thus, all patients were divided into 30 groups in total. There was only one patient in the young adult, male, and morbidly obese group. There were no patients in the old adult, male, and morbidly obese group. There was only one patient each in the young adult, female, and morbidly obese group and in the middle-aged adult, female, and underweight group. These four groups had an insufficient number of patients, and statistical analyses could not be performed in these groups, as the standard deviation could not be calculated. Depth distances of points A, B, C, and D belonging to subgroups are given in Tables 2, 3, and 4.

We attempted to use fuzzy logic decision support systems and fuzzy regression models to determine a safe injection depth. However, a suitable model could not be developed with these data and methods.

DISCUSSION

The present study demonstrated that the skin-to-muscle and skin-to-pleural distances in the parascapular region were significantly different in different sexes, ages, and BMI categories. This study is the first to present these measurements for the upper trapezius, rhomboid major muscle reference points, and the region medial to the scapula by age, sex, and BMI. The skin-to-muscle distance represents the minimum distance required for needle insertion, and the skin-to-pleura distance represents the maximum distance. In methods such as trigger point injection, dry needling, and needle EMG tests, the needle should reach the muscle but not the pleura to avoid risks such as pneumothorax.

Seol et al.[13] divided a total of 62 patients into three groups according to their BMI: BMI <23 kg/m^2 (underweight or normal group), 23≤ BMI <25 kg/m^2 (overweight group), and BMI ≥25 kg/m^2 (obese group). They measured skin-muscle and skin-rib distances only for the rhomboid major muscle. They determined the appropriate needle insertion depths according to these groups. When forming the groups, they did not consider age and sex. In the current study, unlike Seol et al.,[13] age and sex were also considered while determining the groups because age and sex can influence skin, subcutaneous tissue, and muscle thickness. The measurements were calculated in five different BMI groups, including the underweight and morbidly obese groups, since BMI significantly affects tissue thickness. Considering that tissue thickness differs significantly between normal and underweight individuals and between obese and morbidly obese individuals, this division into five BMI groups increases the reliability of the data. In addition to the reference point of the rhomboid major muscle, measurements were also made for the reference point of the upper trapezius muscle because the upper trapezius muscle is also a region where trigger points are frequently observed. In addition, the number of measurement points was increased to make trigger point injection safer and increase the generalizability and safety of the data. Depths were also determined from the middle of the two reference points mentioned above (B point) and the thinnest point (D point) in the region medial to the scapula, which is considered the riskiest area for pneumothorax. Although reference points for the upper trapezius and rhomboid major muscles have been determined in the literature, clinicians apply injection or dry needling from the point where they detected the trigger point, not just from the reference points. It is well established that the skin-subcutaneous tissues and muscles are not of a homogeneous thickness and have different thicknesses at different points. Therefore, knowing the insertion depth of the patient's most risky area for pneumothorax may also help the clinician perform the procedure more safely. Since the scapula is between the pleura and the needle, the risk of pneumothorax is lower in trigger points on the dorsal scapula. Therefore, the region medial to the scapula is riskier for pneumothorax.[13]

While Seol et al.[13] performed the study with 62 participants, measurements were made in 1,015 participants in the current study. In addition, Seol et al. measured the skin-to-rib distance, not the skin-to-pleura, whereas the needle must reach the pleura for a pneumothorax to occur. Therefore, the distance from the skin to the pleura is a more accurate measurement for the risk of pneumothorax.

In the current study, females had significantly longer skin-to-muscle distances than males at points A, B, and C, but skin-to-pleura distances were significantly less than males. This result indicates that females have thicker subcutaneous tissue and thinner muscle tissue. Therefore, it can be concluded that it is more difficult to insert the needle into the muscle tissue in females than in males and that more care should be taken in terms of pneumothorax in females. The distances at all points were significantly different between sexes and BMI groups. However, the skin-pleural distances of A and D points were statistically similar between age groups. This condition reveals that skin and muscle thickness is more significantly affected by sex and BMI than age.

The current study used different modeling methods such as fuzzy logic decision support systems and fuzzy regression models to determine the safe injection depth. However, a model that can detect injection depths could not be developed with these data and these modeling methods. If we developed a decision support system or fuzzy regression model that predicts safe injection depth in line with the primary purpose of the study, it would be possible to provide injection practitioners with much more accurate injection depth information through these models. This result indicated that the appropriate injection distance differed greatly from individual to individual. Therefore, these data help practitioners estimate approximate insertion depth but do not guarantee the appropriate depth.

Mitchell et al.,[25] in a study on 60 patients, measured the distance from the skin to the ribs and muscle thickness for the levator scapula, rhomboid major, and rhomboid minor muscles. They concluded that these measurements differed between BMI categories and sexes. They also reported that placing a support under the shoulder provides a significant increase in depth for the lung. The present study determined that the measured depths were different between BMI categories and sexes. In addition, in the present study, some depth measurements differed between the categories separated by age. However, our study did not evaluate the depth measurement differences between different positions.

A study by Salavati et al.[24] in 32 patients evaluated the intra- and interexaminer reliability of the upper trapezius muscle thickness measured by USG. However, they did not determine the appropriate depth measurements according to age, sex, and BMI. Folli et al.[18] performed independent and sequential measurements in 26 patients to determine the inter-rater reliability of measuring the depth of different trunk muscles (e.g., rhomboid, lower trapezius, iliocostalis, and pectoralis major) between an expert and two novice practitioners. As a result, it was concluded that USG could be used safely for novice practitioners in dry needling applications in these areas, and adverse effects such as pneumothorax could be reduced by USG. They did not present appropriate needle insertion depths by age, sex, and BMI. Ultrasonography can be used to increase the effectiveness and safety in applications such as trigger point injection, dry needle, and needle EMG in these regions. Nevertheless, we know well that many practitioners still have to perform these procedures blindly without USG. Therefore, the data presented by this study can help practitioners who perform such procedures without using USG find the appropriate depth. The reliability of the data of this study should be confirmed by other imaging studies, as well as real injection studies, on cadavers and actual patients.

This study had some limitations. Participants were divided into 30 groups according to age, sex, and BMI, and statistical analysis could not be performed because there were not enough participants in four of these 30 groups. However, these four groups have a low rate in the general population.[31,32] Therefore, the 26 groups analyzed cover a massive part of the general population. For the thinnest point observed in the region medial to the scapula, only the skin-pleura measurement was made, and the skin-muscle distance measurement could not be made since a significant number of patients did not have a distinct muscle structure that could be measured at the thinnest point medial to the scapula. Although it was previously indicated that there was no difference in thickness and depth between the nondominant and dominant sides of the parascapular muscles,[25] the fact that only the right side was measured can be counted as one of the limitations of the study. Although the findings of this study provided data that may help clinicians make appropriate injections, the inability to develop a model, such as a decision support system, was one of the limitations of this study. The distances to the pleura differ in different positions. However, in this study, measurements were performed in one position. Although CT was performed with the same protocol and thin sections (3-mm slice thickness) in all patients, the retrospective nature of the study introduces some uncertainty as to whether the cross-sectional range was kept the same for all patients. In addition, due to the nature of CT imaging, the projections of the measured sections on the body cannot be anatomically clarified. These limitations may cause a lack of standardization and may cause slight differences between the measured values and the actual distances in injection applications. Despite all these limitations, the strengths of this study are that it is the first study to present skin-muscle and skin-pleural distances for parascapular injections according to age, BMI, and sex, and the inclusion of a large sample. This study provides data that can help estimate the appropriate needle depth for the upper trapezius, rhomboid major reference points, and the region medial to the scapula according to age, sex, and BMI categories.

In conclusion, we recommend that clinicians who apply trigger point injection to the parascapular region, dry needling, acupuncture, and EMG consider the patients' age, sex, and BMI, and examine the tables of this study before the procedure. In addition, this study determined that the skin-muscle and skin-pleural distances in these regions were significantly different according to age, sex, and BMI.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

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