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Article

Deviation of Needling Depth of Heart Meridian Acupuncture Points in Underweight and Overweight People

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Abstract: The depth of needle insertion is determined by the acupuncturist during the procedure based on the patient's sensory responses and motor responses that may occur at the tip of the inserted needle (De-qi reaction). Despite the existing specific recommendations and standards for the selection of acupuncture depth for almost all acupuncture points, the difficulty of performing acupuncture in patients with significant deviations in body weight from the norm remains. In this regard, we decided to determine the De-qi needling depth (DND) by the needling method and the safe needling depth (SND) by the ultrasound method of acupuncture points: HT1, HT2, HT3, HT4, HT5, HT6, HT7 in healthy people taking into account the body mass index (BMI). Materials and methods: 90 volunteers were examined by needling method to determine DND and by ultrasound to determinate the depth of underlying neurovascular structures and SND after converting individual Cun to millimeters. Results: DND of HT1, HT2, and HT3 were more superficial in UWG compared to HWG at 1.83 mm and deeper in OWG compared to HWG at 4.9 mm. In contrast, the DND deviation of HT4, HT5, HT6, HT7 was significant but mild in both groups, with a slight decrease in UWG compared to HWG of only 0.54 mm and a slight increase in OWG compared to HWG not exceeding 1.5 mm. Conclusion: The depth of the acupuncture points of the heart meridian HT1, HT, HT3 strongly depends on the degree of obesity in overweight people and is less responsive to body weight in underweight people. At the same time, changes in the points HT4, HT5, HT6 and HT7 have slight deviations in underweight and overweight people compared to people with healthy weight. Moreover, the depth of the heart meridian points is directly related to the depth of the underlying neuroarterial structures and weakly correlates with the Cun value in millimeters.

Keywords: *acupuncture; heart meridian, Cun, deqi, jiquan, qingling, shaohai, lingdao, tongli, yinxi, shenmen.*

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1. INTRODUCTION

The Heart Meridian (HT) is one of the 12 principal meridians that regulate body functions in traditional East Asian medicine [1]. HT Includes 9 points on each arm, starting from the medial surface of the shoulder and ending with the ulnar side of the distal forearm and hand [2] (Figure 1). According to the basic concept of acupuncture theory, it is believed that HT ensures the vital activity of the heart and all vessels located in an inextricable functional unity. [2, 3]. As stipulated in traditional Chinese medicine (TCM), the normalization of Yin energy in the HT, in addition to improving the condition of the heart and hemodynamics, has a positive effect on the speech and emotional functions of the brain [4]. In modern medicine, experimentally and clinically the impact on HT acupuncture points has a reliable therapeutic effect in treatment of heart diseases, [6, 7, 8], anxiety, [9, 10], insomnia [11], motor aphasia [12], dysarthria [13] and cognitive disorders [14].

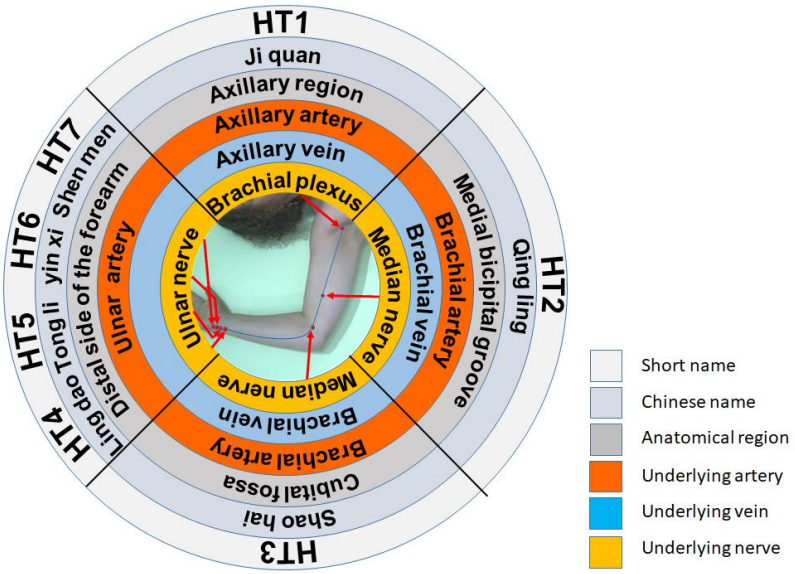


Figure 1. Information about the acupuncture points of the heart meridian and the anatomical structures located along the path of needle insertion.

Moreover, acupuncture is carried out according to certain schemes (acupuncture point prescriptions), consisting of various points, which in most cases are part of different meridians [15]. In this regard, the indications for the use of meridian points are much broader and cover many other symptoms, such as dysphagia [16], urinary incontinence [17], shoulder pain, elbow and wrist joints [18], migraine [19, 20], autism spectrum disorders [21] and alcohol or cigarette withdrawal symptoms [22].

The depth of needle insertion for each acupuncture point are selected individually according to strict rules (guidelines) that have existed for thousands of years. These rules were established by traditional medicine acupuncturists to help practitioners achieve maximum effect from the procedure [23]. As stated by TCM the measurement unit or Chinese anatomical inches for distance determination is finger Cun. This unit corresponds to breadth of the acupuncture recipient's thumb at the knuckle. On the one hand, such a unit of measurement takes into account the individual relationships characteristics between anatomical structures, and on the other hand, it does not consider the individual features of skeletal muscle mass and body mass index. Therefore, it is not surprising that the safe needling depth (SND) at acupuncture points in a modern acupuncture textbook is different or confused with the recommendations of ancient TCM [24]. In a number of work was found that acupuncture points were located with a large deviation from the recommended localization with a field area from 2.7 cm^2 to 41.4 cm^2 [25, 26].

The location of acupuncture points is usually determined by the superficial anatomy; in fact, they are not located on the surface, but deeper under the skin at a certain distance, where the active centers of these points are localized. Almost all authors describe recommended depths for each acupuncture point ranging from minimum to maximum. Within this range, the acupuncturist must find (catch) the center of the acupuncture point. According to many authors, the essence of acupuncture theory lies in the stimulation of these active points [27]. An important criterion for successful stimulation of these points is the De-qi sensation [27, 28]. Penetration of a needle into an acupuncture point may cause one or more of these sensations: aching or tenderness (suan), numbness or tingling (ma),

fullness or pressure (zhang), and heaviness (zhong) [27, 28]. Simultaneously, the acupuncturist feels tension and resistance around the tip of the needle. [29]. However, these sensations are subjective and in many cases they are excessive and in others they are almost unnoticeable [30]. It has been proven that pathology of the peripheral and central nervous system can significantly reduce the De-qi sensation in the innervated area. In one of previous studies was found that De-qi sensation in response to ST36 acupuncture was significantly reduced in patients with peroneal neuropathy on the affected side [31]. The same observation was noted when performing acupuncture on the HT points in patients with brachial plexitis [4]. Likewise, the acupuncturist may not always feel obvious resistance, especially in weakened patients and when targeting off-center [32].

The number of overweight people has been rising rapidly in recent years: since 1990, obesity rates among adults worldwide have more than doubled, and obesity rates among adolescents have quadrupled. Currently, every eighth person in the world suffers from obesity [33]. On the other hand, although the prevalence of underweight has not increased as much as overweight, in some countries in Asia and Africa the rates remain high, reaching 13.9% in India, 24.3% in Ethiopia, 19.2% in Niger and 18.2% in Madagascar [34]. With such a deviation of weight from the norm, acupuncturists face certain difficulties in determining the necessary depth to achieve the maximum therapeutic effect - De-qi needling depth (DND) without damaging the underlying neurovascular structures.

Despite the fact that cases of damage to nerves and blood vessels in the practice of acupuncture are extremely rare [35, 36], these cases can develop due to the incorrect choice of localization and depth of the injection point [37, 38]. According to a report by Lin Cl, a study of 14.5 million acupuncture procedures in Taiwan found that post-acupuncture nerve injuries accounted for 0.057% of procedures, 37.7% of which occurred in the shoulder girdle and upper extremities [39]. In this regard, there is an urgent need to study the DND and SND of various acupuncture points in people of different body types.

To the best of our knowledge, no scientific studies have been conducted on DND or SND of HT acupuncture points. In response to this challenge, we decided to devote this work to establishing the DND by the needling method and the SND by the ultrasound method of acupuncture points: HT1, HT2, HT3, HT4, HT5, HT6, HT7 in healthy people taking into account the body mass index (BMI).

2. MATERIAL AND METHODS

2.1. Study design and population

In this cross-sectional, single-center study, we examined 90 healthy subjects using needling and ultrasound methods to determine the effective and safe depth ranges of needle insertion into HT acupuncture points on both arms.

Inclusion criteria in the study:

1. european;
2. adult men and women from 21 to 60 years old;
3. signed voluntary informed consent to participate in this study;
4. presence of a De-qi reaction during acupuncture of HT1, HT2, HT3, HT4, HT5, HT6, HT7 in both arms;
5. 30 persons with BMI less than 18.5 kg/m^2
6. 30 persons with BMI 18.5 kg/m^2 and more, but less than 24.9 kg/m^2.
7. 30 persons with BMI 24.9 kg/m^2 and more, but less than 30 kg/m^2.

Exclusion criteria in the study:

1. presence of upper extremity edema;
2. severely cognitive disorders;
3. arthritis or deforming arthrosis of the shoulder, elbow or wrist joints;
4. vascular diseases of the upper extremities;

5. brachial plexitis and/or neuropathy of the median or ulnar nerves;
6. muscular dystrophies of the upper extremities;
7. history of shoulder dislocation, fracture of the shoulder, forearm or hand;
8. motor deficit of upper extremities;
9. tenosynovitis and/or peritendinitis of the wrist and forearm;
10. diabetes mellitus;
11. pregnancy;

After explaining the purpose of the study and the safety of needling and ultrasound examination, all patients signed voluntary informed consent for the study.

The study received approval from the ethical commission of the Russian Medical Dental Institute (protocol No. 29AS of 07/12/2023). All procedures were carried out in accordance with the recommendations of the 1984 Declaration of Helsinki and its subsequent amendments. All patients confirmed their consent to the publication of the article after reading it in full, including the text, figures and additional material, by written consent. No remuneration was paid to participants or investigators in this study. The study was carried out within the framework of the scientific program of the Department of Restorative Medicine and Neurorehabilitation of the Russian Medical Dental Institute.

A total of 126 subjects (F: 63, M: 62) passed the eligibility assessment. Of these, 32 were excluded due to the absence of De-qi reaction at one or more of acupuncture points, and 4 subjects were excluded due to withdrawal of consent.

As a result, only 90 healthy subjects (F=46, M: 44) completed this research to the end (Figure 2). In this study, inclusion of participants was controlled by BMI: 30 patients were included in each group, with approximately equal numbers of men and women in each group. Thus, the patients were divided into 3 groups: 30 (F: 15, M: 15) persons were in the underweight group (UWG), 30 (F: 16, M: 14) persons were in the healthy weight group (NWG), and 30 (F; 15, M; 15) persons were in the overweight group (OWG).

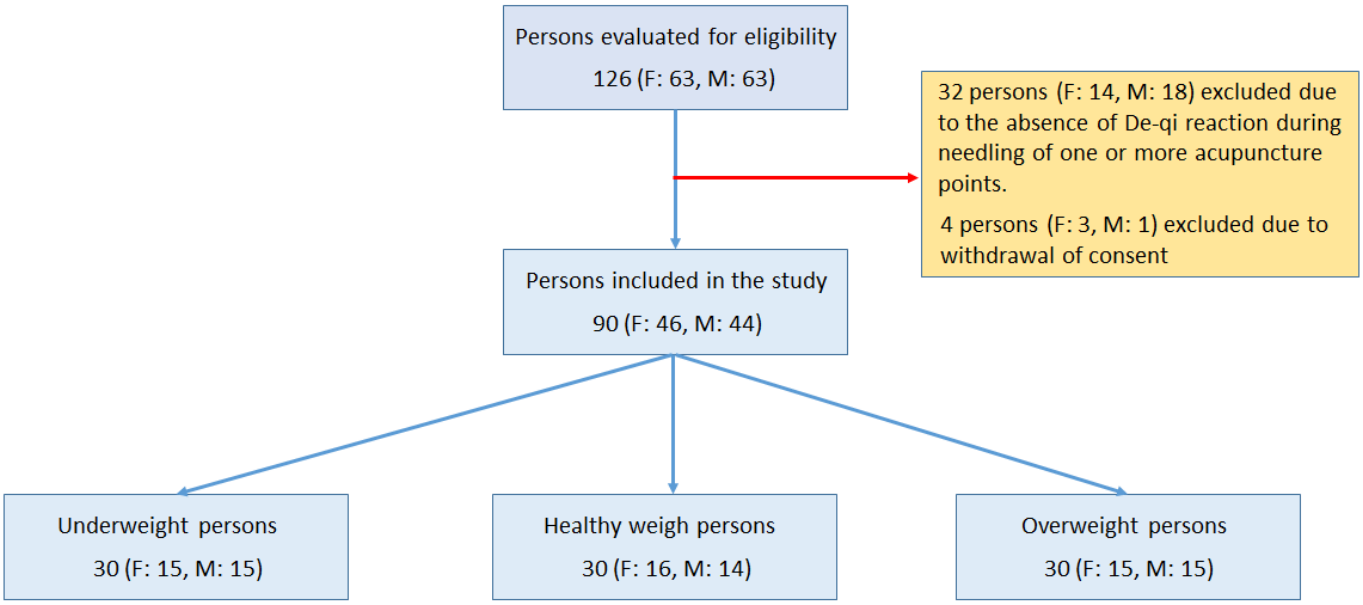


Figure 2. Flow chart of study population selection.

2.2. Sample Size Calculation

In a prior study, the safe needle depth of Fengfu (GV 16) was determined in healthy people with different BMI, and it was found that the safe needle depth for a group of

moderate weight people was (27.73 ± 3.45) mm, which is 11% deeper than for a group of thin people [40]. According to these results, the sample size of our study was calculated using the sample size calculator at https://clincalc.com/stats/samplesize.aspx [41]. As a result, sample size calculation with power value = 90%, probability of type I error = 0.01 and expected significance level (p value) = 0.05 showed 28 patients or more.

2.3. Acupuncture Point Localization

Localization of acupuncture points HT1, HT2, HT3, HT4, HT5, HT6, HT7 was performed by 3 certified acupuncturists with more than 15 years of experience based on acupuncture guidelines. [2, 43]. The procedure is performed in supine position with the arm raised and abducted and the elbow slightly flexed. The location of each acupuncture point was based on anatomical landmarks, such as arteries, bones, muscles and tendons. In all measurements we used finger Cun. Following the rules for localization acupuncture points, it was necessary to identify the acupuncture points out of order. HT1 was localized first. However, to identify HT2 it is necessary to find HT3. On the forearm, HT6, HT5, HT4 are located above HT7. In this regard, it is recommended to first identify HT7, then HT6, HT5, H4. (Figure 3).

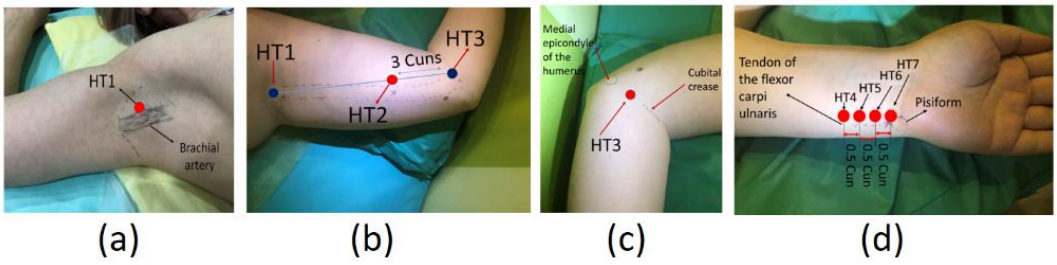


Figure 3 . Localization of HT1 (a), HT2 (b), HT3 (c) and HT4, HT5, HT6, HT7 (d).

HT1: After palpation of the axillary artery in the center of the axillary fossa, HT1 was localized at the medial border of the axillary artery.

HT3: After palpating the medial epicondyle of the humerus and determining the ulnar edge of the elbow crease, HT3 was localized at the middle distance between them.

HT2: The acupuncture point was located on the line connecting HT1 and HT3, 3 Cuns above HT3, in the medial bicipital groove medial to biceps brachii.

HT7: The acupuncture point was localized at the ulnar edge of the proximal radiocarpal fold, at the radial edge of the flexor carpi ulnaris tendon, in the space between the pisiform and ulna bones.

HT4, HT5, HT6: Acupuncture points HT6, HT5 and HT4 were located 0.5, 1.0 and 1.5 cun proximal to HT7, respectively, on the radial side of the flexor carpi ulnaris tendon, above the proximal crease of the wrist.

2.4. Determination of De-qi needling depth of acupuncture points

Manipulative procedures were carried out in the procedure room in compliance with aseptic rules. After treating the skin with 70% isopropyl alcohol wipe, an acupuncture needle was inserted vertically until a De-qi sensation or De-qi motor reaction was achieved. Then the acupuncturist removed the needle and measured the length of the inserted needle, which corresponds to the De-qi needling depth (DND) in millimeters. The procedure used acupuncture needles measuring 0.3 x 30 mm and 0.3 x 50 mm, manufactured in Russia by the company “Subal” with registration number FSZ 2012/11663.

2.5. Ultrasound determination of safe needling depth of acupuncture points

The study was performed by a certified ultrasound specialist with more than 12 years of experience. Above the previously localized acupuncture point, the depth of the location of large vessels and nerves was determined in millimeters. To achieve this goal, we determined the distance between the adjacent surface of the transducer and the superior border of each vein, artery, and nerve on transverse views separately in millimeters (ml). The study was conducted on a Mindray DC-70 device with registration number PZN 2017/6113, approved in Russia in 2018.

2.6. Statistical Analysis

Data analysis was processed using SPSS software for Windows (version 20) with calculation of mean (M), standard deviation (SD), and standard error of the data mean (SEM). Shapiro–Wilk test was used to determinate normality, Levene's test for quality of variances testing and multivariate NOVA test for identification significance differences between the three groups. The chances of obtaining false-positive results (type I errors) was reduced by applying the Bonferroni correction test. To compare means of the same variable between two groups was used an independent group t test maximal p value at 0.05. The strength of the linear relationship between two variables was statistically measured using the Pearson correlation coefficient (r). Values of r can range from -1 to 1. The strength of the correlation is usually interpreted as weak if $r < \pm 0.4$, moderate if r is between ±0.4 and ±0.7, and strong if $r > \pm 0.7$.

3. RESULTS

3.1. Demographic data analysis:

Demographic data of the included persons are summarized in Table 1. The age of the participants ranged from 21 to 57 years and averaged 36.8 ± 1.13 years. The male-to-female ratio of the study participants in all groups was 1:1. (p-value > 0.05). Although the range of reported Cun values was similar in the three groups: from 1.6 to 2.4 in UWG, from 1.8 to 2.4 in HWG, and between 1.6 and 2.5 in OWG, the mean values were significantly higher in HWG compared to UWG by 5.2% (t= 3.88, p= 0.0003) and in OWG compared to HWG by 6.5% (t= 4.27, p= 0.0001).

Table 1. Demographic characteristics of the participants

	Underweight group	Normal weight group	Overweight group	**p**
No	30	30	30	
Age (years)	36.7 ± 2.21	38.2 ± 1.98	38.0 ± 2.41	P > 1
Gender (female : male)	15 : 15	16 : 14	15 : 15	p > 1
Cun	19.1 ± 0.21	20.2 ± 0.20	21.4 ± 0.22	p < 0.01
BMI	17.3 ± 0.12	22.3 ± 0.29	30.0 ± 0.60	p < 0.01

Note: BMI - body mass index; p – level of marginal significance, Mean ± SEM.

Correlation analysis between Cun value and age, height, weight and BMI (Figure 4) revealed a weak correlation between Cun value and age ($r = 0.21$, $p < 0.05$) and moderate correlation between Cun value and height value ($r = 0.31$, $p < 0.01$), weight value ($r = 0.61$, $p < 0.001$) and BMI value ($r = 0.60$, $p < 0.001$).

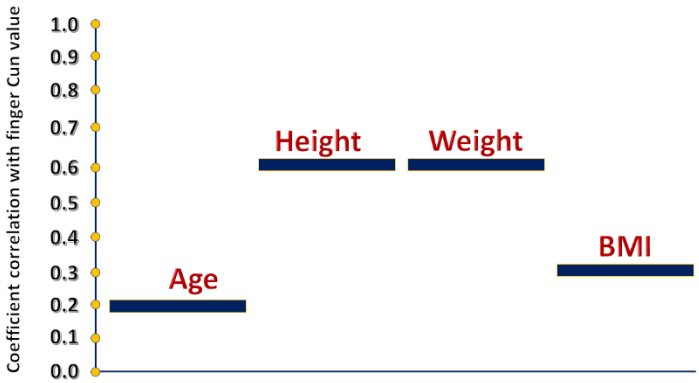


Figure 4. Correlation coefficient between finger Cun value and age, height, weight and BMI of all included participants. Note: BMI – body mass index.

3.2. Determination of the needling depth of acupuncture points.

A study of De-qi reactions at various acupuncture points of this meridian revealed that the sensorimotor reaction in different patients to the same point has different values: from weak (0-3 points on VAS) to strong (more than 6 points on VAS). In our study, there were no patients who did not show a De-qi reaction during acupuncture of at least one of the points HT1, HT2, HT3, HT4, HT5, HT6, HT7 on both limbs. Since one of the inclusion criteria in our study was the presence of a De-qi reaction during acupuncture of all the indicated points. The results of DND determination in millimeters revealed significant differences between UWG, HWG and OVG groups in all study groups (Figure 5).

- DND of HT1 was found to be significantly more superficial in UWG by 22.5%, averaging 1.98 mm (t=6.20, p=0.001), and deeper in OWG by 58.3%, averaging 5.12 mm (t=11.6, p=0.0001) compared with HWG.
- In HT2, DND was more superficial in UWG by 15.5%, averaging 1.5 mm (t=4.59, p=0.0001) and deeper in OWG by 56.7%, averaging 5.5 mm (t=11.9, p=0.0001) compared with HWG.
- Similar results were obtained in the DND study at HT3 level. We registered a 21.7% reduction, averaging 2 mm (t=5.71, p=0.0001) in UWG and a 44.6% increase in OWG, averaging 4.1 mm (t=8.68, p=0.0001) compared to HWG.
- Less pronounced deviations were found in the DND study at HT4, HT5 and HT6. The deviation was on average 8%, averaging 0.5 mm (t=2.16, p=0.034) in UWG, and 25.8%, averaging 1.5 mm (t=9.96, p=0.0001) in OWG compared to HWG. Almost identical results were obtained in the HT7 study.
- In HT7 DND was found to be located more superficially in UWG by 9%, with an average of 0.5 mm (t = 2.82, p = 0.006), and deeper in OWG by 28%, with an average of 1.6 mm (t = 4.86, p = 0.0001) compared to HWG.

No significant differences were found between the two limbs in terms of DND. No significant differences between genders were observed in DND. It is important to recognize that no complications or side effects were observed with the DND determination procedures.

3.3. Ultrasound determination of the safe needling depth of acupuncture points

In the supine position with the arm raised and abducted and the elbow slightly bent, ultrasound scanning was performed in the anterior-transverse and sagittal planes, holding the transducer on the skin with and without pressure. The resulting transverse and longitudinal views were carefully studied to determine the boundaries of the neurovascular complex localized under the acupuncture point, with a radius of 10 millimeters around the acupuncture point.

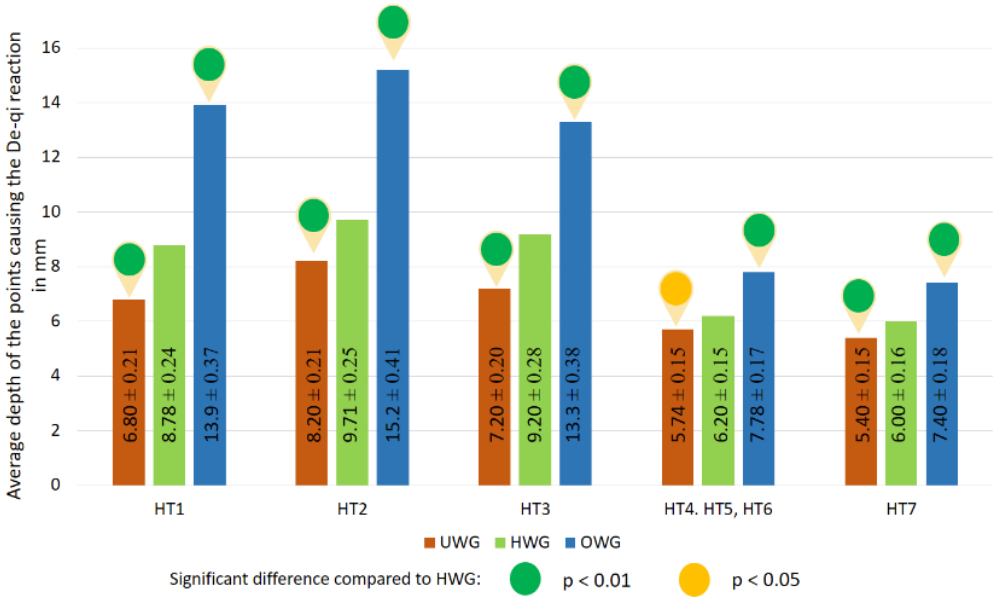


Figure 5. Average depth of points causing De-qi reaction, in mm at acupuncture points of the heart meridian in all study groups.

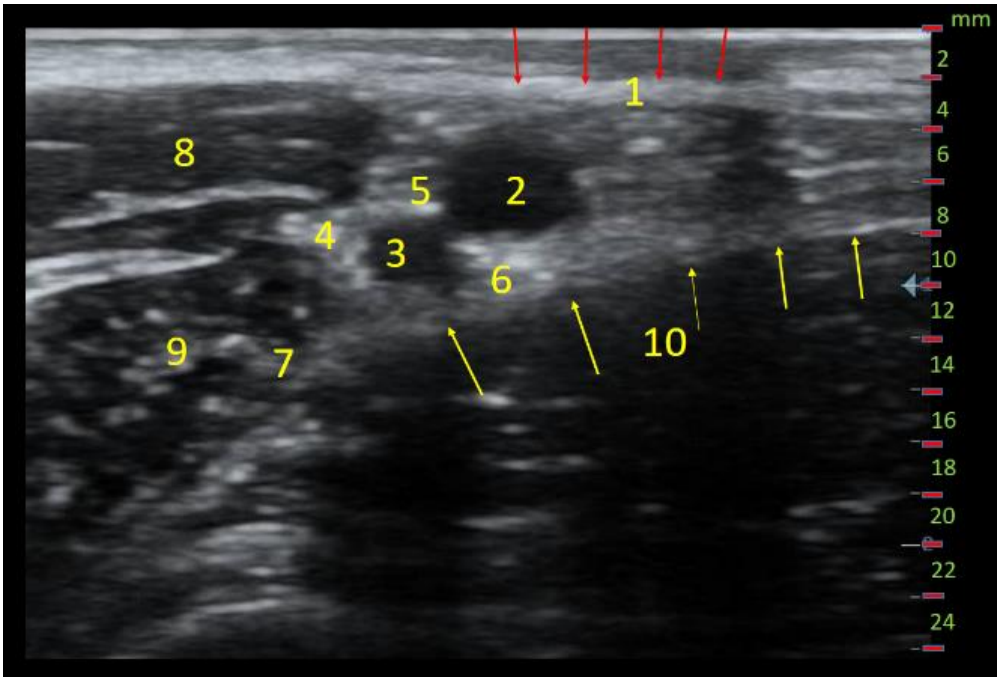


Figure 6. Transverse section view of HT1 acupuncture point examination in axillary fossa.

Note: 1- Brachial deep fascia (indicated by red arrows), 2- Axillary vein, 3- Axillary artery, 4- Median nerve, 5- Ulnar nerve, 6- Radial nerve, 7-Musculocutaneous nerve, 8-Biceps brachialis muscle, 9-Coracobrachialis muscle, 10- Conjoint tendon of teres major and latissimus dorsi muscles (indicated by yellow arrows).

3.3.1 Ultrasound determination of neurovascular structures depth in HT1

In front (more superficially) the brachial deep fascia is clearly visible. From below (the deepest) you can determine the conjoint tendon of teres major and latissimus dorsi muscles. From above, 2 muscles are clearly visible: biceps brachii muscle laterally and Coracobrachialis muscle medially. In the center of the irregular triangle, the axillary vein runs more superficially and the artery runs deeper. Around the artery there are 4 nerves, which are a continuation of the brachial plexus. These nerves are median nerve, ulnar nerve, radial nerve and musculocutaneous nerve. The most superficial nerve is the median nerve, located between the brachial artery and the biceps brachii muscle. Typically, in HT1 acupuncture, the needle is inserted in this direction (Figure 6).

The results showed that the depth of the brachial vein and artery in the UWG was less than in the HWG by 23.4% (t=5.12, p=0.0001) and 15.3% (t=2.60, p=0.011), respectively, while there was no significant difference in the depth of the median nerve between the groups. In the OWG, a pronounced increase in the depth of the brachial artery, median nerve and brachial artery was recorded compared with the HWG by 59.5% (t=10.5, p=0.0001), 67.5% (t=10.5, p=0.0001) and 63.2% (t=10.5, p=0.0001), respectively (Figure 7).

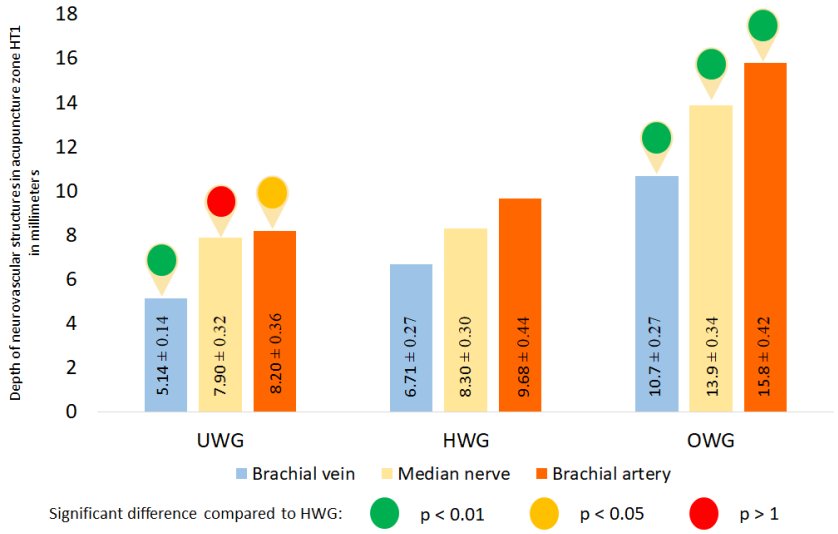
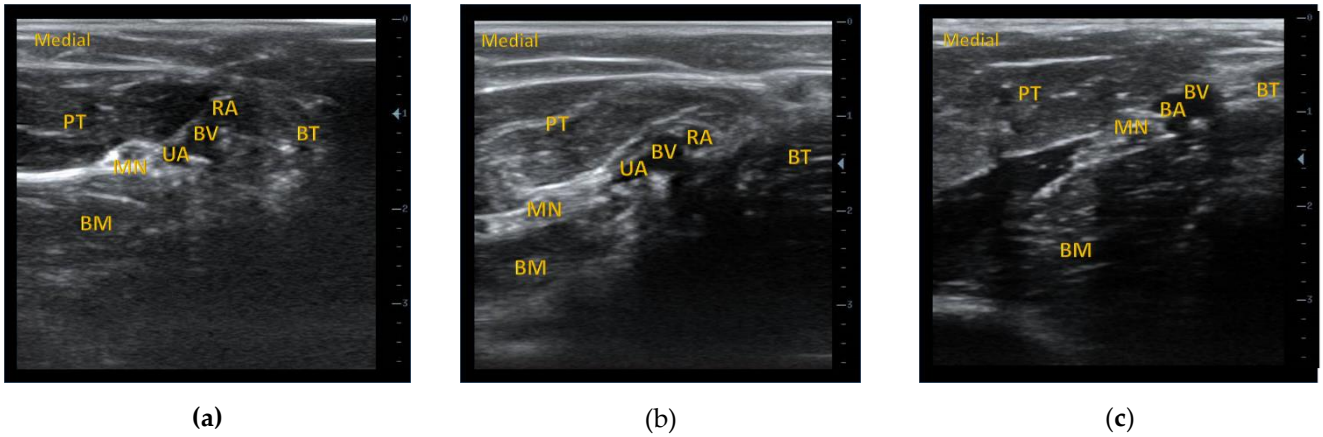


Figure 7. Depth of neurovascular structures in acupuncture zone HT1 in millimeters. Note: UWG – underweight group; HWG – health weight group; OWG – overweight group.

3.3.2. Ultrasound determination of neurovascular structures depth in HT3

Ultrasound examination in different patients reveals different variants of displacement of the median nerve from the accompanying brachial artery. Furthermore, the most common change recorded on HT3 ultrasound in the cubital fossa was high bifurcation of the brachial artery into the ulnar and radial arteries. It is important to note that the depth of the neurovascular structures largely depends on the size of the pronator teres in the cubital fossa (Figure 8).



(a) (b) (c)

Figure 8. Transverse section view of HT3 acupuncture point examination in cubital fossa. a - woma Note: PT - pronator teres; BM – brachial muscle; BT – biceps tendon; MN – median nerve; BA – brachial artery; BV – brachial vein; UA – ulnar artery; RA - radial artery.

The depth of the brachial vein, median nerve and brachial artery was significantly more superficial in UWG compared to HWG by 37.2% (t = 4.86, p= 0.001), 34.4% (t = 5.78, p= 0.001) and 29.4% (t = 3.93, p= 0.0001), respectively. A different picture was revealed in OWG, where the location of the vein, nerve and artery had a deeper value compared to HWG by 26.7% (t = 2.35, p= 0.021), 24.1% (t = 2.49, p= 0.015) and 24,1% (t = 2.36, p= 0.021), respectively (Figure 9).

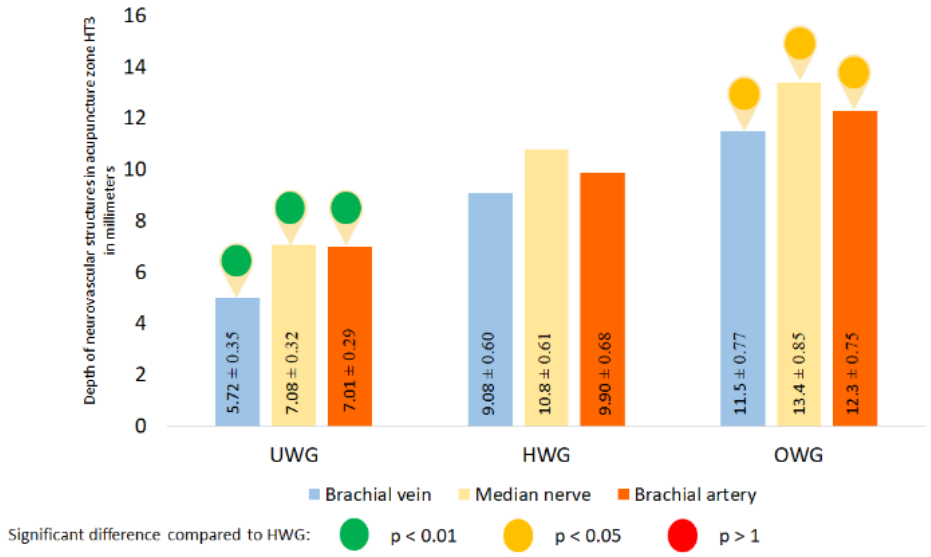


Figure 9. Depth of neurovascular structures in acupuncture zone HT3 in millimeters. Note: UWG – underweight group; HWG – health weight group; OWG – overweight group.

3.3.3. Ultrasound determination of neurovascular structures depth in HT2

Following structures can be identified in ultrasound examination: laterally - biceps brachii and brachialis muscle, medially - triceps brachii, and deeper, the contours of the humerus. In the center, the medial intermuscular septum of the arm between the triceps brachii and brachialis muscles is clearly visible. Between the triceps and biceps brachii muscles, the brachial artery, vein, and median nerve pass together, so that the median nerve passes more superficially (Figure 10).

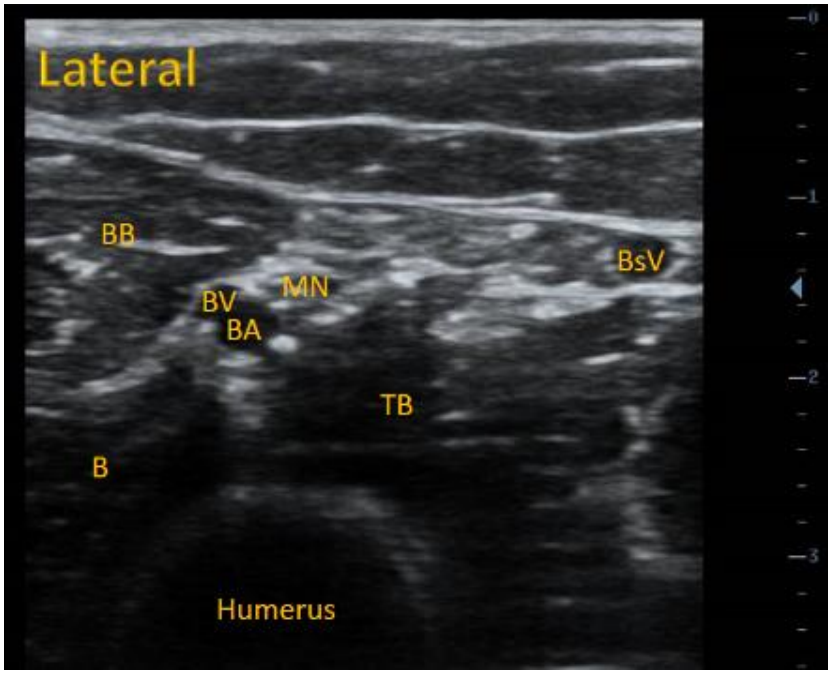


Figure 10. Transverse section view of HT2 acupuncture point examination in the medial bicipital groove. Note: BB -biceps brachii; B – brachial muscle; TB – triceps brachii; MN – median nerve; BA – brachial artery; BV – brachial vein; BsV – basilic vein.

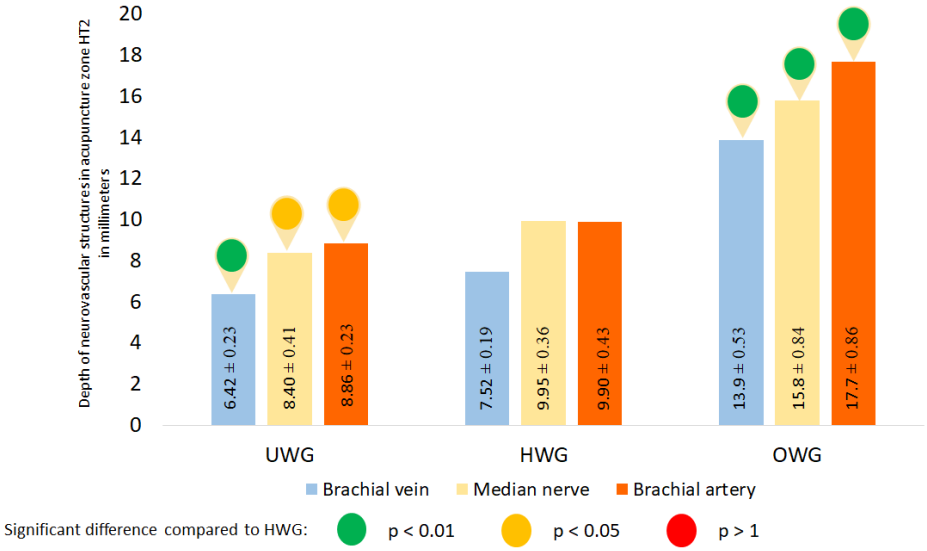


Figure 11. Depth of neurovascular structures in acupuncture zone HT3 in millimeters. Note: UWG – underweight group; HWG – health weight group; OWG – overweight group.

It is noteworthy that the deviation of the neurovascular complex in depth in UWG compared to HWG was proportionately moderate, which turned out to be 13.5% ($t = 2.10$, $p = 0.031$) more superficial, in contrast to the indicators of OWG, which turned out to be significantly deeper compared to HWG by 74.3% ($t = 7.95$, $p=0.001$) (Figure 11).

3.3.4. Ultrasound determination of neurovascular structures depth in HT7

Ultrasound examination of the wrist line above the pisiform bone can reveal three important structures: the pisiform and ulnar arteries, and the ulnar nerve, which passes between them before entering Guyon's canal (Figure 12).

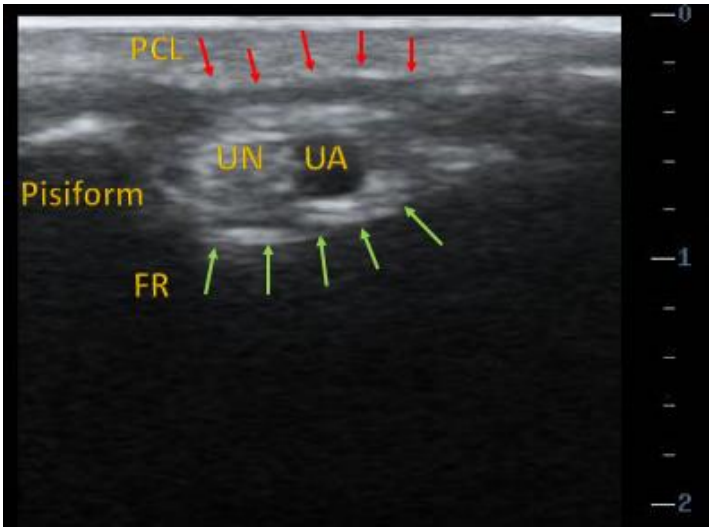


Figure 12. Transverse section view of HT7 acupuncture point examination at the ulnar end of the transverse crease of the wrist. Note: UN – ulnar nerve; UA – ulnar artery; PCL – palmar carpal ligament (indicated by red arrows); FR – flexor retinaculum (indicated by green arrows).

Interestingly, the depth of the ulnar artery and ulnar nerve in UWG had values close to HWG (Figure 13). However, in OWG, the ulnar artery and ulnar nerve were located deeper than in HWG by 19,6% (t = 4.76, p= 0.001).

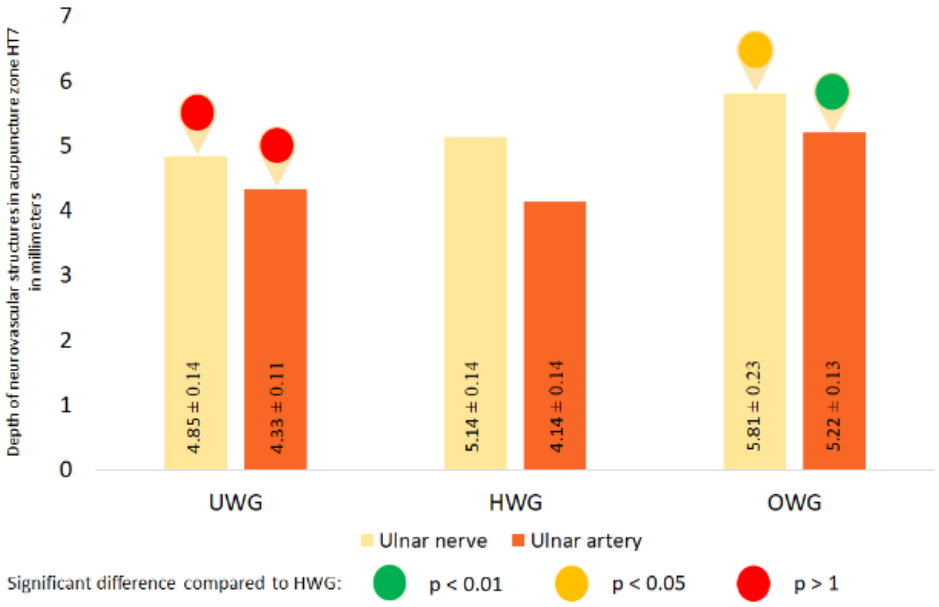


Figure 13. Depth of neurovascular structures in acupuncture zone HT7 in millimeters. Note: UWG – underweight group; HWG – health weight group; OWG – overweight group.

3.3.5. Ultrasound determination of neurovascular structures depth in HT4, HT5 and HT6

It is important to note that the 3 indicated acupuncture points (HT6, HT5, HT4) are located on a line no longer than 1.0 Cun, which corresponds to an average of 20 mm. The line on which the acupuncture points are located is limited on the medial side by the tendon of the flexor carpi ulnaris and laterally by the ulnar atery. This space is occupied by the ulnar nerve (Figure 14).

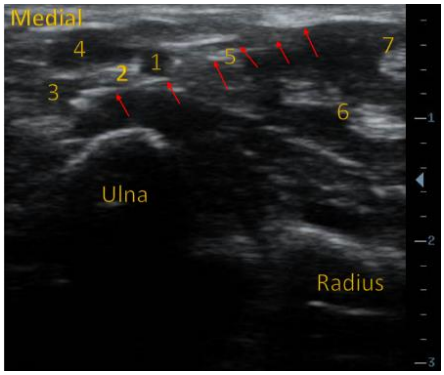


Figure 14. Transverse section view of HT5 acupuncture point examination at a distance of 20 mm proximal to the ulnar end of the transverse wrist crease. Note: 1 – ulnar artery; 2 – ulnar nerve; 3 – tendon of flexor carpi ulnaris; 4 – basilic vein; 5 - flexor retinaculum (indicated by red arrows); 6 - tendons of flexor digitorum profundus; 7 – tendons of flexor digitorum superficialis.

The ultrasound results showed that there was no significant difference between the depth values of the ulnar nerve and ulnar artery at all acupuncture points. Comparison of UWG and HWG showed that the depth of the ulnar artery and ulnar nerve were similar in the two groups. On the contrary, the ulnar nerve and ulnar artery depth in OWG was 16.2% (t = 2.10, p = 0,04) deeper than in HWG (Figure 15).

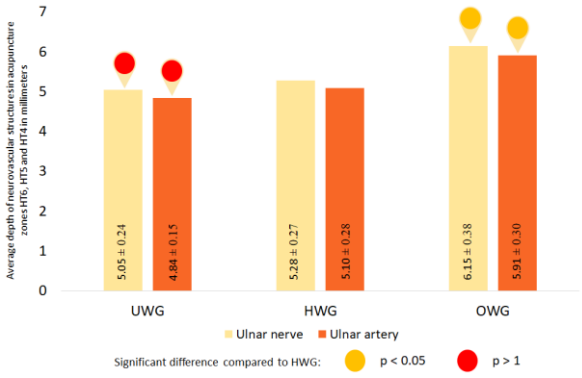


Figure 15. Average depth of neurovascular structures in acupuncture zones HT6, HT5, HT4 in millimeters. Note: UWG – underweight group; HWG – health weight group; OWG – overweight group.

3.4. Relationship between DND and SND

Taking into account the deep neuroarterial structures, it can be established that the relationship between the level of DND and SND at all acupuncture points was as follows:

- HT1: DND was slightly higher than SND in UWG by 1.1 mm (t = 2.8739, p = 0.0057), and no significant difference was observed between DND and SND in HWG and OWG (t = 1.2494, p = 0.216).
- HT2: No significant differences were found between DND and SND values in the groups (t = 0.4342 p= 0.661).
- HT3: At this point, closer to the direction of needle insertion, is the median nerve. If we take the upper border of the nerve as the lower border of SND, we can note that DND in UWG and HWG was at the level of SND (t = 0.3180, p = 0.75) and (t = 0.1074, p = 0.91), respectively, but in HWG DND was slightly higher than SND by 1.6 mm (t = 2.3838, p = 0.02).
- HT4, HT5, HT6: At these points, SND is determined by the border of the ulnar nerve when palpating the ulnar artery. However, in all groups, DND was deeper

SND by 0,65 mm in UWG (t = 2.2101, p=0.03), by 0.92 mm in HWG (t = 3.1281, 0.0028) and by 1,63 mm in OWG (t = 4.2880, 0.0001)

- HT7: At this point, SND is determined by the border of the ulnar nerve when palpating the ulnar artery. However, in all groups, DND was below SND by 0,55 mm in UWG (t = 2.7293, p=0.008), by 0.86 mm in HWG (t = 4.1914, 0.0001) and by 1,59 mm in OWG (t = 5.4783, 0.0001).

In all the studied acupuncture points, Pearson correlation analysis revealed a moderate positive correlation between DND and SND and a very weak correlation between DND and Cun value in mm. Notably, the correlation between DND and BMI was moderately positive in HT1, HT2, HT3, but weakly positive in HT4, HTF, HT6, HT7.

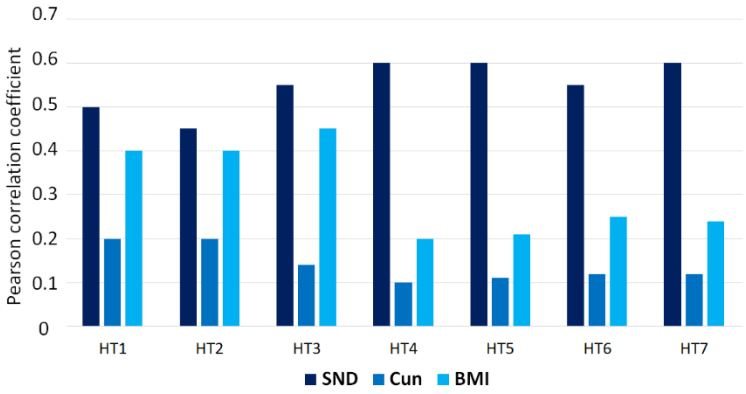


Figure 16. Pearson correlation coefficient between the value of De-qi needling depth and values of safe needling depth, Cun in millimeters and body mass index in all studied acupuncture points. Note SND – safe needling depth; BMI – Body mass index.

4. DISCUSSION

To our knowledge, this may be the first study to investigate the DND and SND range of needle insertion depth in heart meridian points acupuncture in healthy people taking into account the BMI. The depth of needle insertion is determined by the acupuncturist during the procedure based on the patient's sensory responses and motor responses that may occur at the tip of the inserted needle (De-qi reaction). Despite the existing specific recommendations and standards for the selection of acupuncture depth for almost all acupuncture points, the difficulty of performing acupuncture in patients with significant deviations in body weight from the norm remains. Many studies have shown that the depth of acupuncture points has a deeper meaning in overweight people and a more superficial meaning in thin people [38, 43, 44].This task becomes more complicated if large nerves and vessels pass under or near these points. Actually, such complexity is encountered when performing acupuncture on HT1, HT2, HT3, HT4, HT5, HT6 and HT7 of people with a strong deviation of body weight from normal standards

In this study, after determination of DND by needling and SND by ultrasound we compared obtained results between UWG, HWG and OWG. The DND study showed that DND of HT1, HT2, and HT3 were more superficial in UWG compared to HWG at 1.83 mm and deeper in OWG compared to HWG at 4.9 mm. In contrast, the DND deviation of HT4, HT5, HT6, HT7 was significant but mild in both groups, with a slight decrease in UWG compared to HWG of only 0.54 mm and a slight increase in OWG compared to HWG not exceeding 1.5 mm. Thus, it is necessary to take these deviations into account when choosing the depth of acupuncture points HT1, HT2, HT3 depending on BMI. Similar results were obtained in a study of SND in these individuals. Changes in SND were obtained only in the study of HT1, HT2, HT3 and amounted to deviations on average in UWG compared to HWG by 1.9 mm and in OWG compared to HWG by 4.7

mm. At points HT4, HT5, HT6, HT7, the changes in UWG and OWG compared to HWG did not exceed 1 mm and were not significant. Furthermore, a moderate to strong correlation was noted between DND and SND at HT1, HT2, HT3. These findings mirror that the active acupuncture points of the heart meridian are located near the underlying neuroarterial structures and depend on their depth.

The Cun value was determined in millimeters for each participant. Despite the fact that the range of Cun values in millimeters did not differ significantly between the groups, the average values showed a reliable dependence of these indicators on BMI. Furthermore, correlation analysis revealed a strong relationship between the Cun value in millimeters and the participant's height and weight, but a weak association with age and BMI. The data obtained leave no doubt that the use of the personal unit of measurement "Cun" makes the depth range and localization of acupuncture points more individual. However, there are still some discrepancies. Our results indicate that Cun measurements across groups do not reflect corresponding changes in neurovascular depth or DND in patients with underweight to overweight BMI and cannot be used to accurately determine DND in these groups. In line with our results, many authors have pointed this fact in their studies [45, 46, 47].

Overall, serious complications associated with acupuncture, such as peripheral nervous system damage and internal organ injury, are extremely rare, occurring at a rate of approximately 0.04–0.08 per 10,000 procedures [48]. Although there is little information in the literature about the presence of nerve or vascular damage in acupuncture of heart meridian points [49], in our study, no complications or side effects were recorded as a result of acupuncture of HT1, HT2, HT3, HT4, HT5, HT6, HT7 points on 180 arms in people of different body types.

5. CONCLUSION

The depth of the acupuncture points of the heart meridian HT1, HT, HT3 strongly depends on the degree of obesity in overweight people and is less responsive to body weight in underweight people. At the same time, changes in the points HT4, HT5, HT6 and HT7 have slight deviations in underweight and overweight people compared to people with healthy weight. Moreover, the depth of the heart meridian points is directly related to the depth of the underlying neuroarterial structures and weakly correlates with the Cun value in millimeters.

Declaration of Patient Consent. The authors confirm that they have obtained all necessary patient consent forms. In the form, the patients gave their consent for the publication of their images and other clinical information in the journal. The patients understand that their names and initials will not be published and appropriate steps will be taken to conceal their identity, but anonymity cannot be guaranteed.

Author Contributions: Conceptualization, M.A-Z.; formal analysis, M.A-Z.; writing—original draft preparation, M.A-Z.; supervision, M.A-Z.; project administration, M.A-Z. All authors have read and agreed to the published version of the manuscript.

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