International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

An Observational Study on the Association Between Body Mass Index and the Palpability of Selected Anatomical Surface Landmarks in Adults

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Abstract: ***Background**: Anatomical surface landmarks are essential for clinical examination, anatomical education, and various diagnostic and therapeutic procedures. Their palpability may be influenced by increased subcutaneous adipose tissue associated with higher Body Mass Index (BMI).[1–4] **Aim**: To evaluate the association between BMI and the palpability of selected anatomical surface landmarks in overweight and obese adults. **Materials and Methods**: A observational study was conducted on 100 adults aged 18–60 years, including 50 overweight participants (BMI 25.0–29.9 kg/m²) and 50 obese participants (BMI 30.0–33.0 kg/m²) according to World Health Organization criteria.[5–7] The clavicle, acromion process, medial epicondyle of the humerus, styloid process of the radius, facial artery, and brachial artery were assessed by palpation. Palpation pressure (PP) and searching effort (SE) were graded on a three-point ordinal scale (+, ++, +++). Since BMI was a continuous variable and PP/SE were ordinal variables, Spearman's rank correlation was used for statistical analysis. **Results**: A statistically significant positive correlation was observed between BMI and palpation pressure for all anatomical landmarks (Spearman's $\rho = 0.917–0.927$, $p < 0.0001$). BMI also showed a significant positive correlation with searching effort ($\rho = 0.718–0.911$, $p < 0.0001$). The strongest associations were observed for the medial epicondyle, styloid process, facial artery, and brachial artery, whereas the acromion process demonstrated the weakest, though still significant, association with searching effort. **Conclusion**: Increasing BMI was associated with progressively greater palpation pressure and searching effort for identifying anatomical surface landmarks. Arterial landmarks were particularly difficult to identify in individuals with higher BMI. These findings have important implications for clinical examination, anatomy teaching, and procedures that rely on accurate surface landmark identification.[1–4,8]*

Keywords: Anatomical surface landmarks, Body Mass Index, Palpation, Surface anatomy, Clinical anatomy, Obesity, Overweight, Rachana Sharir

1. Introduction

Anatomical surface landmarks are identifiable structures that are visible or palpable on the body surface and serve as essential reference points for locating deeper anatomical structures during clinical examination, anatomical education, diagnostic procedures, and surgical interventions.[1–6] Accurate knowledge of surface anatomy forms the foundation of safe clinical practice, enabling healthcare professionals to identify underlying bones, muscles, joints, blood vessels, nerves, and viscera without relying exclusively on imaging techniques.[2–6]

Surface landmarks are predominantly represented by subcutaneous bony prominences; however, superficial arteries, tendons, muscles, and skin creases also constitute important anatomical guides. These landmarks facilitate physical examination, regional anesthesia, vascular access, orthopedic assessment, emergency procedures, and anatomical dissection.[1–6] Their identification is therefore an indispensable competency for medical students, anatomists, surgeons, anesthesiologists, physicians, and other healthcare professionals.

Although anatomical landmarks occupy relatively constant positions within the human body, their ease of identification varies considerably among individuals. Factors such as age, sex, muscular development, oedema, congenital variations, previous trauma, and particularly the quantity and distribution of subcutaneous adipose tissue influence their visibility and palpability.[3–6] Increased subcutaneous fat may obscure superficial structures, making clinical examination more difficult and potentially reducing the accuracy of anatomical localization.

Body Mass Index (BMI) is the most widely accepted anthropometric index for assessing nutritional status and classifying overweight and obesity in adults.[7–9] Although BMI does not directly measure body fat, it demonstrates a strong correlation with total body adiposity and is widely employed in epidemiological research and clinical practice. The global prevalence of overweight and obesity has increased substantially over recent decades, resulting in a growing number of patients in whom physical examination and surface landmark identification may be technically challenging.[7–9]

Successful identification of anatomical surface landmarks is fundamental to numerous clinical procedures, including venepuncture, arterial cannulation, blood pressure measurement, peripheral pulse examination, fracture assessment, regional nerve blocks, musculoskeletal examination, and emergency interventions.[1–6] Difficulty in locating these landmarks may prolong procedures, increase patient discomfort, and elevate the risk of procedural complications. Consequently, understanding the relationship between BMI and surface landmark palpability has important implications for clinical practice and medical education.

Despite the widespread use of BMI in clinical assessment, relatively few studies have quantitatively evaluated its

influence on the palpability of commonly used anatomical surface landmarks. Most available literature describes the anatomical location and clinical significance of these landmarks but provides limited evidence regarding how increasing adiposity affects their practical identification during physical examination.[1–6,10,11] This represents an important knowledge gap, particularly in populations with increasing rates of overweight and obesity.

From the perspective of **Rachana Sharir**, *pratyaksha pariksha* (direct observation) and *sparshana pariksha* (palpatory examination) constitute essential methods of anatomical assessment.[12,13] The ability to accurately identify external anatomical structures through inspection and palpation is therefore of equal importance in both classical Ayurvedic education and modern clinical anatomy. Evaluating the influence of BMI on surface landmark palpability may provide objective evidence that integrates traditional anatomical concepts with contemporary clinical practice.

Therefore, the present observational study was undertaken to evaluate the association between Body Mass Index and the palpability of selected anatomical surface landmarks, including the clavicle, acromion process, medial epicondyle of the humerus, styloid process of the radius, facial artery, and brachial artery. The findings are expected to contribute to anatomical education, improve clinical examination skills, and facilitate procedures that depend upon accurate identification of surface landmarks in individuals with varying body habitus.

2. Materials and Methods

Aim

To evaluate the association between **Body Mass Index (BMI)** and the palpability of selected anatomical surface landmarks in overweight and obese adults.[7–9]

Objectives

1) To measure the height and body weight of each participant using standard anthropometric techniques.[7–9]
2) To calculate the Body Mass Index (BMI) of each participant using the World Health Organization (WHO) recommended formula.[7–9]
3) To assess the palpability of the following anatomical surface landmarks by standardized palpation:
   - Clavicle
   - Acromion process
   - Medial epicondyle of the humerus
   - Styloid process of the radius
   - Facial artery
   - Brachial artery.[1–6]
4) To grade the palpation pressure and searching effort required for identification of each landmark using a standardized three-point ordinal scale.
5) To determine the association between BMI and the palpability of the selected anatomical surface landmarks using appropriate statistical analysis.

Study Design

A hospital-based observational cross-sectional study was conducted in the Department of Rachana Sharir.

Study Population

The study included **100 adult participants**, comprising **50 overweight** and **50 obese** individuals, selected according to predefined inclusion and exclusion criteria. Participants were recruited after obtaining written informed consent.

Study Duration

January 2026 to June 2026.

Inclusion Criteria

- Adults aged **18–60 years**.
- BMI **≥25 kg/m²** according to WHO classification.[7–9]
- Apparently healthy individuals.
- Individuals willing to provide written informed consent.

Exclusion Criteria

Participants were excluded if they had

- Previous fractures or surgery involving the clavicle, shoulder, upper limb, or face;
- Congenital musculoskeletal deformities;
- Soft tissue swelling, local infection, oedema, or tumours over the examination sites;
- Severe pain or restricted movements interfering with palpation;
- Pregnancy;
- Refusal to participate.

Anthropometric Assessment

Height was measured using a standard stadiometer with participants standing barefoot in the anatomical position. Body weight was measured using a calibrated digital weighing scale with participants wearing light clothing.

Body Mass Index was calculated using the standard WHO formula:

$$BMI = \text{Weight (kg)}/\text{Height (m)}^2$$

Participants were classified according to WHO criteria:

- Overweight: **25.0–29.9 kg/m²**
- Obesity: **≥30.0 kg/m²**[7–9]

Assessment of Anatomical Surface Landmarks

The following anatomical surface landmarks were examined:

- Clavicle
- Acromion process
- Medial epicondyle of the humerus
- Styloid process of the radius
- Facial artery
- Brachial artery.[1–6]

All examinations were performed by the same trained examiner under standardized conditions to minimize observer variability.

Palpation Pressure (PP)

The pressure required to identify each anatomical landmark was graded as follows:

Grade	Interpretation
+	Easily palpable with minimal pressure
++	Palpable with moderate pressure
+++	Palpable only with deep pressure

Grade	Interpretation
+	Easily identified
++	Moderate searching effort
+++	Considerable searching effort

Searching Effort (SE)
The effort required to locate each landmark was graded using a similar three-point scale.

Ethical Considerations
The study was conducted according to the ethical principles of the **Declaration of Helsinki**. Written informed consent was obtained from all participants prior to enrolment.

3. Observations

SN	BMI	Clavicle	Acromion process	Medial epicondyle	Styloid process	Facial artery	Brachial Artery
1	25.2	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +
2	25.2	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +
3	25.2	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +
4	25.3	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +
5	25.5	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +
6	25.5	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +
7	25.5	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +
8	25.6	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
9	25.7	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
10	25.8	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
11	25.8	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
12	25.8	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
13	25.9	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
14	26	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
15	26.1	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
16	26.1	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
17	26.2	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
18	26.2	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
19	26.3	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
20	26.4	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
21	26.4	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
22	26.4	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
23	26.5	PP +, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
24	26.6	PP +, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
25	26.6	PP +, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
26	26.7	PP +, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
27	26.7	PP +, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
28	26.8	PP +, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
29	26.8	PP +, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
30	26.8	PP +, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
31	26.9	PP +, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
32	26.9	PP +, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
33	26.9	PP +, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
34	27	PP ++, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP +, SE ++	PP +, SE ++
35	27	PP ++, SE +	PP +, SE ++	PP +, SE +	PP +, SE +	PP+, SE ++	PP++, SE ++
36	27.1	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
37	27.2	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
38	27.2	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
39	27.3	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
40	27.3	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
41	27.3	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
42	28.1	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
43	28.3	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
44	28.4	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
45	28.4	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
46	29.1	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
47	29.3	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
48	29.4	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
49	29.5	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++
50	29.5	PP ++, SE +	PP +, SE ++	PP++, SE++	PP ++, SE +	PP++, SE ++	PP++, SE ++

BMI in Obese individuals – From 30.0 to 33.0
Palpation pressure –(PP), Searching efforts – (SE)

SN	BMI	Clavicle	Acromion process	Medial epicondyle	Styloid process	Facial artery	Brachial Artery
1	30.0	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
2	30.1	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
3	30.1	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
4	30.2	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
5	30.3	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
6	30.4	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
7	30.4	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
8	30.5	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
9	30.6	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
10	30.6	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
11	30.7	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
12	31.0	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
13	31.0	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
14	31.0	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
15	31.2	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
16	31.3	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
17	31.4	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
18	31.4	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
19	31.4	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
20	31.5	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
21	31.5	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
22	31.5	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
23	31.6	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
24	31.6	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
25	32.0	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
26	32.0	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
27	32.0	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
28	32.0	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
29	32.0	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
30	32.0	PP++, SE++	PP ++, SE ++	PP ++, SE +++	PP ++, SE ++	PP ++, SE +++	PP ++, SE +++
31	32.1	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
32	32.2	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
33	32.2	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
34	32.2	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
35	32.3	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
36	32.3	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
37	32.3	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
38	32.4	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
39	32.4	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
40	32.4	PP+++SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
41	32.5	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
42	32.5	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
43	32.7	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
44	32.7	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
45	32.8	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
46	33.0	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
47	33.0	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
48	33.0	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
49	33.0	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++
50	33.0	PP+++, SE++	PP +++, SE ++	PP +++, SE +++	PP +++, SE ++	PP +++, SE +++	PP +++, SE +++

Statistical Analysis

All collected data were entered into Microsoft Excel and analysed using appropriate statistical software.

Body Mass Index (BMI) was considered a **continuous variable**, whereas palpation pressure (PP) and searching effort (SE) were **ordinal variables** (+ = 1, ++ = 2, +++ = 3). Consequently, **Spearman's rank correlation coefficient (ρ)** was used to determine the relationship between BMI and both palpation pressure and searching effort.[14]

Correlation coefficients were interpreted as follows:

Spearman's ρ	Interpretation
0.00–0.19	Very weak
0.20–0.39	Weak
0.40–0.59	Moderate
0.60–0.79	Strong
0.80–1.00	Very strong

A **p-value <0.05** was considered statistically significant.

4. Results

A total of **100 participants** were enrolled in the present study, including **50 overweight** (BMI 25.0–29.9 kg/m²) and **50 obese** (BMI 30.0–33.0 kg/m²) individuals.

The palpability of six anatomical surface landmarks was evaluated using standardized grading for palpation pressure (PP) and searching effort (SE).[1–6]

Overall Findings
With increasing BMI, progressively greater palpation pressure and searching effort were required for identification of all anatomical surface landmarks.

Bony landmarks, particularly the clavicle and styloid process of the radius, remained relatively easier to identify than arterial landmarks throughout the study. Conversely, the facial artery and brachial artery became increasingly difficult to locate with increasing BMI.

Participants belonging to the obese group consistently required greater palpation pressure and greater searching effort than overweight participants.

Correlation between BMI and Palpation Pressure
Spearman's rank correlation analysis demonstrated a **very strong positive correlation** between BMI and palpation pressure for every anatomical landmark examined.

The correlation coefficients ranged from **ρ = 0.917 to 0.927**, and all correlations were highly statistically significant (**p <0.0001**).

The strongest association was observed for
- Medial epicondyle
- Styloid process
- Facial artery
- Brachial artery

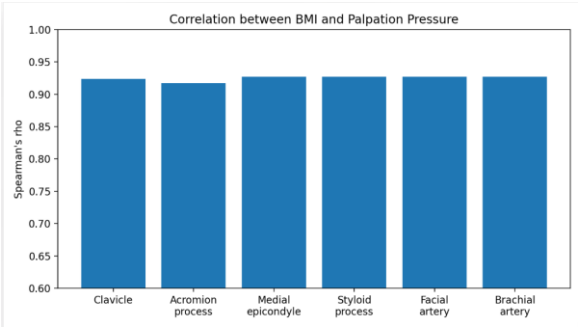
indicating that increasing BMI markedly increased the pressure required for successful palpation.

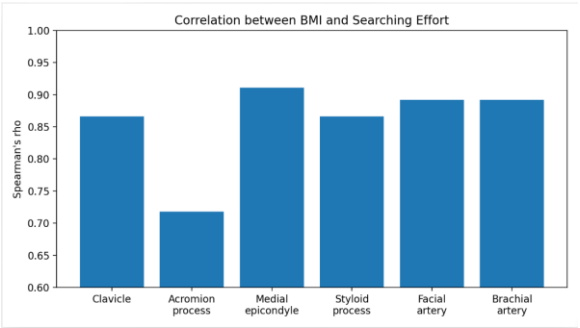
Correlation between BMI and Searching Effort
BMI also demonstrated a statistically significant positive correlation with searching effort for all anatomical landmarks. Correlation coefficients ranged from **ρ = 0.718 to 0.911 (p <0.0001)**.

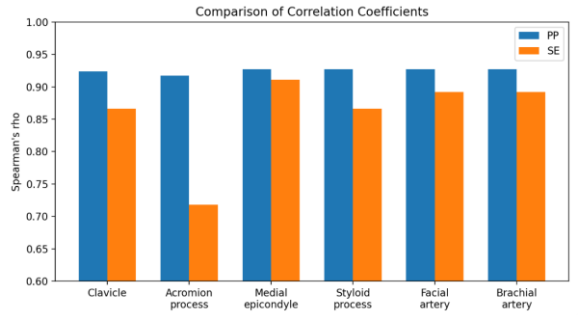
Among all landmarks, the **acromion process** exhibited the lowest correlation (ρ = 0.718), although the association remained statistically significant.

Table 1: Correlation between BMI and Palpability of Anatomical Surface Landmarks

Anatomical landmark	Spearman's ρ (PP vs BMI)	p-value	Spearman's ρ (SE vs BMI)	p-value
Clavicle	0.924	<0.0001	0.866	<0.0001
Acromion process	0.917	<0.0001	0.718	<0.0001
Medial epicondyle	0.927	<0.0001	0.911	<0.0001
Styloid process	0.927	<0.0001	0.866	<0.0001
Facial artery	0.927	<0.0001	0.892	<0.0001
Brachial artery	0.927	<0.0001	0.892	<0.0001







Interpretation
The findings indicate that increasing BMI significantly reduces the ease of palpation of both bony and arterial anatomical surface landmarks. The observed very strong positive correlations suggest that greater subcutaneous adiposity substantially increases both the palpation pressure and the searching effort required for anatomical landmark identification. These observations are consistent with established anatomical principles that increased soft tissue thickness obscures superficial structures and complicates clinical examination.[1–6,10,11]

5. Discussion

The present observational study was undertaken to evaluate the association between **Body Mass Index (BMI)** and the palpability of selected anatomical surface landmarks in overweight and obese adults. The findings demonstrated a statistically significant positive correlation between BMI and both palpation pressure and searching effort for all anatomical landmarks examined. As BMI increased, progressively greater palpation pressure and searching effort were required for successful identification of the clavicle, acromion process, medial epicondyle of the humerus, styloid process of the radius, facial artery, and brachial artery. These observations indicate that increasing adiposity adversely affects the ease of identifying clinically important surface landmarks.[1–6]

The very strong positive correlations observed between BMI and palpation pressure (Spearman's ρ = 0.917–0.927) suggest that increased subcutaneous adipose tissue substantially reduces the prominence of superficial anatomical structures. Surface anatomy is fundamentally based on the ability to identify bony prominences and superficial neurovascular structures through inspection and palpation. Standard anatomical texts describe these landmarks as readily palpable under normal circumstances; however, excessive adipose tissue increases the depth between the skin surface and the underlying structure, thereby reducing tactile perception during clinical examination.[1–6]

Among the bony landmarks evaluated, the clavicle and styloid process of the radius remained comparatively easier to identify across the BMI range, although they also demonstrated a progressive increase in palpation pressure with increasing BMI. This observation may be explained by their superficial anatomical location and minimal muscular coverage. The clavicle is almost entirely subcutaneous throughout its length, while the radial styloid process projects prominently beneath the skin at the lateral aspect of the wrist, making both structures relatively resistant to obscuration by moderate increases in adipose tissue.[1–6]

The medial epicondyle demonstrated one of the strongest correlations with BMI for both palpation pressure and searching effort. Although it is a prominent bony projection, its palpability is influenced by surrounding soft tissues, particularly in individuals with increased adiposity. Increased deposition of subcutaneous fat around the elbow may reduce the examiner's ability to distinguish the medial epicondyle from adjacent muscular structures, thereby increasing both the pressure and time required for localization.[2–6]

The facial artery and brachial artery were the most difficult anatomical landmarks to identify, particularly among obese participants. Unlike bony prominences, arteries are identified primarily by palpation of pulsations rather than direct contact with a rigid structure. Increased thickness of subcutaneous tissue attenuates arterial pulsations and increases the distance between the artery and the examining fingers, thereby making arterial localization more challenging. This finding has important clinical implications because accurate identification of these arteries is essential for peripheral pulse examination, blood pressure measurement, arterial cannulation, emergency vascular access, and reconstructive surgical procedures.[1,2,5,6,11]

Although the acromion process demonstrated the lowest correlation with searching effort (ρ = 0.718), the association remained statistically significant. The acromion is a broad, flat projection forming the highest point of the shoulder and usually remains identifiable even in overweight individuals because of its prominent anatomical position and limited overlying soft tissue. Nevertheless, increasing BMI still resulted in greater palpation pressure, indicating that obesity influences even the most accessible surface landmarks.[1–6]

The present findings are consistent with established anatomical principles regarding the influence of soft tissue thickness on palpation. Field's *Anatomy, Palpation and Surface Markings* emphasizes that successful surface anatomy depends not only on anatomical knowledge but also on the examiner's ability to appreciate tactile differences between superficial and deep structures.[4] Similarly, Gray's Anatomy and Clinically Oriented Anatomy describe how variations in body habitus influence the visibility and palpability of anatomical landmarks, particularly in individuals with increased adiposity.[1,3]

The increasing global prevalence of overweight and obesity further enhances the clinical relevance of the present study. According to the **World Health Organization**, obesity has become one of the most important public health challenges worldwide, with a continuous rise in prevalence across both developed and developing countries.[7,9] Consequently, clinicians are increasingly required to examine patients in whom conventional surface landmarks are less easily identified. The present study provides objective quantitative evidence supporting this practical clinical observation.

From the perspective of **Rachana Sharir**, the findings also reinforce the importance of **Pratyaksha Pariksha** (direct observation) and **Sparshana Pariksha** (palpatory examination), which are fundamental methods of anatomical assessment described in the classical Ayurvedic texts.[12,13] Accurate knowledge of external anatomical structures remains essential for understanding the relationships of deeper organs and tissues. The present study provides contemporary scientific evidence supporting the relevance of these traditional examination methods in individuals with varying body habitus.

The findings of this study have several important educational implications. Undergraduate and postgraduate students of anatomy, surgery, orthopaedics, anaesthesiology, emergency medicine, and Ayurveda should be trained to recognize that increased BMI may alter the palpability of clinically important anatomical landmarks. Teaching programs should therefore incorporate examination of individuals with different body compositions to improve clinical competency and procedural confidence.

The present study possesses several strengths. It included equal numbers of overweight and obese participants, employed standardized palpation grading systems, and used **Spearman's rank correlation**, an appropriate statistical method for analysing the relationship between a continuous variable and ordinal data. The uniformly high correlation coefficients and highly significant p-values indicate the robustness and consistency of the observed associations.

However, certain limitations should be acknowledged. The study was conducted at a single institution with a relatively modest sample size of 100 participants. Only overweight and obese individuals were included; therefore, comparisons with individuals having normal or underweight BMI were not possible. In addition, palpation assessments were performed by a single examiner, and inter-observer variability was not evaluated. Future multicentre studies involving larger and more diverse populations, objective measurements of subcutaneous fat thickness using ultrasonography, and assessment of examiner reliability would provide stronger evidence regarding the influence of BMI on anatomical landmark palpability.

Overall, the present study demonstrates that increasing BMI significantly influences the clinical identification of anatomical surface landmarks. The observed strong positive correlations between BMI and both palpation pressure and searching effort provide quantitative evidence that increased adiposity reduces the ease of surface landmark identification. These findings are highly relevant to clinical examination, anatomical education, procedural training, and evidence-based teaching in both modern anatomy and **Rachana Sharir**.

Clinical Significance

The findings of the present study have important implications for clinical practice, anatomical education, and procedural medicine.

Increasing BMI significantly influences the palpability of both bony and arterial anatomical landmarks. Recognition of this relationship enables clinicians to anticipate greater difficulty during physical examination and procedures requiring accurate anatomical localization.

The results are particularly relevant for:

- Physical examination
- Orthopaedic assessment
- Vascular examination
- Blood pressure measurement
- Peripheral arterial cannulation
- Regional anaesthesia
- Emergency medicine
- Plastic and reconstructive surgery
- Anatomy teaching

Knowledge of the effect of BMI on surface landmark identification may improve procedural success, reduce complications, minimize patient discomfort, and enhance clinical confidence among undergraduate and postgraduate students.

From the perspective of Rachana Sharir, the study also provides scientific evidence supporting the continued importance of Pratyaksha Pariksha and Sparshana Pariksha in anatomical assessment.[12],[13]

6. Conclusion

The present observational study demonstrated a significant positive association between Body Mass Index (BMI) and the palpability of selected anatomical surface landmarks.

As BMI increased, progressively greater palpation pressure and searching effort were required for successful identification of the clavicle, acromion process, medial epicondyle of the humerus, styloid process of the radius, facial artery, and brachial artery. Spearman's rank correlation analysis revealed very strong positive correlations between BMI and palpation pressure ($\rho = 0.917–0.927$) and strong positive correlations between BMI and searching effort ($\rho = 0.718–0.911$), with all associations being highly statistically significant ($p < 0.0001$).

Among the anatomical landmarks examined, the facial artery, brachial artery, and medial epicondyle were most affected by increasing BMI, whereas the acromion process remained comparatively easier to identify despite increasing adiposity.

The study highlights the importance of considering BMI during clinical examination, anatomical teaching, and procedures dependent upon accurate surface landmark identification. These findings provide objective evidence supporting the integration of anatomical knowledge with clinical practice and reinforce the relevance of surface anatomy in both modern medicine and Rachana Sharir.

References

[1] Standring S, editor. *Gray's Anatomy: The Anatomical Basis of Clinical Practice*. 42nd ed. London: Elsevier; 2021.
[2] Snell RS. *Clinical Anatomy by Regions*. 10th ed. Philadelphia: Wolters Kluwer; 2019.
[3] Moore KL, Dalley AF, Agur AMR. *Clinically Oriented Anatomy*. 9th ed. Philadelphia: Wolters Kluwer; 2023.
[4] Field D, Owen Hutchinson J. *Field's Anatomy, Palpation and Surface Markings*. 5th ed. Edinburgh: Elsevier; 2012.
[5] Ellis H. *Clinical Anatomy: Applied Anatomy for Students and Junior Doctors*. 14th ed. Oxford: Wiley-Blackwell; 2018.
[6] Drake RL, Vogl AW, Mitchell AWM. *Gray's Anatomy for Students*. 5th ed. Philadelphia: Elsevier; 2023.
[7] World Health Organization. *Obesity: Preventing and Managing the Global Epidemic*. WHO Technical Report Series No. 894. Geneva: WHO; 2000.
[8] StatPearls. Treasure Island (FL): StatPearls Publishing; 2023.
[9] World Health Organization Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*. 2004;363(9403):157–163.
[10] Van Sint Jan S, Della Croce U. Identifying the location of human skeletal landmarks: Why standardized definitions are necessary. *Clin Biomech*. 2005;20:659–660.
[11] Walker HK, Hall WD, Hurst JW, editors. *Clinical Methods*. 3rd ed. Boston: Butterworths; 1990.
[12] Chaurasia BD. *Human Anatomy*. Vol. 1. 9th ed. New Delhi: CBS Publishers; 2019.
[13] Datta AK. *Essentials of Human Anatomy*. Part I. 11th ed. Kolkata: Current Books International; 2022.
[14] Rosner B. *Fundamentals of Biostatistics*. 8th ed. Boston: Cengage Learning; 2016.
[15] Practical Statistics for Medical Research. London: Chapman & Hall; 1991.
[16] Bates' Guide to Physical Examination and History Taking.
[17] Hoppenfeld's Physical Examination of the Spine and Extremities.
[18] DeGowin's Diagnostic Examination.
[19] *Sushruta Samhita*. Sharira Sthana. English translation by K.R. Srikantha Murthy. Varanasi: Chaukhambha Orientalia.
[20] *Charaka Samhita*. Sharira Sthana. English translation by R.K. Sharma, Bhagwan Dash. Varanasi: Chaukhambha Sanskrit Series Office.