# IDENTIFYING LOCATION OF MAXIMUM INTERFACE PRESSURE IN BEDRIDDEN PATIENT –A COMPARATIVE STUDY

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## ABSTRACT

*Bedridden patients are more likely to develop Pressure Ulcers. Major contributing factor includes interface pressure (IP) developed over bony prominences. To alleviate the IP, special purpose mattresses are used and to check the efficacy of these mattresses maximum IP is best evaluation measure. The work is an attempt towards identifying location of maximum IP first by hospital survey. Secondly by reaction board method and CONFORMat® pressure mapping system. The significance between the location of center of mass and location of maximum IP were tested by t-test. Total 40 subjects were considered for study. It is noted that location of center of mass by reaction board and maximum IP on subjects were located approximately at same location. Center of mass and corresponding IP for female subjects were at 53% of subject's height where as for male subject it is at 57 % when subject is lying on board in supine posture.*

***Keywords : Interface Pressure, Pressure Ulcer (Pus), Support Surface, Supine Posture.***

## I INTRODUCTION

Prolonged sleeping posture is one of the most fundamental activities of daily living for the disabled, aged and paraplegic patients. For these people, who have limited mobility and impaired sensation, prolonged sleeping will be highly risky and harmful. This will further create more critical problems like PUs, spasticity.

PUs are one of the most important medical problems in the western world, affecting millions of hospitalized immobile patient, elderly patients in nursing homes and their families, suffering, in addition to increased work load and requiring annual healthcare costs in order of billions dollar [1][2].

PUs occurs due to cell necrosis which is caused by unrelieved pressure and shearing forces on soft tissue overlying bony prominence when patient lying on hospital bed. These two forces can interrupt the blood circulation to underlying tissues. This results in oxygen deficiency in soft tissues and muscles. PU is difficult to cure, treat and is a major cost factor in the health care system. Classical treatment of pressure ulcer prevention involves extended periods of bed rest but which is believed to affect general condition of patient and further deterioration of the patient's life [3]

Since the discomfort of these pressure ulcers for the patients is enormous and the costs for treatment are high, the prevention of PUs is important. Prevention starts with using special materials for mattresses and sheets as well as specially designed bed systems.

The primary cause of pressure ulcers is static IP applied to both the skin and underlying tissue. When this pressure is greater than the blood pressure within the capillaries, blood flow is interrupted. Maintaining IPs below capillary closing pressure (for example 32mmHg) is considered as standard for pressure relief [4].

IP is defined as the pressure distribution on the human tissue when it is compressed between bony prominences and the supporting surface in sleeping posture. It has been extensively adopted to evaluate the occupant's postural behaviors and properties of the supporting surface.

Objective of this paper is to identify the location of maximum IP in bedridden patient and to check significance of location of center of mass with the location of Maximum interface pressure.

## II LITERATURE SURVEY

Prolonged sleeping behavior in bed due to surgery, injury to the spinal cord, or an illness cause's immobility even for less than a day, the pressure of the immobilized body on certain areas can break down the skin [5]. An early study conducted by researcher examined nearly 20,000 residents of 51 nursing homes and found that 11.3 % possessed a stage 2 or deeper pressure ulcer on admission and among those ulcer-free residents remaining in the nursing home for 1 year, 13.2 % developed a new pressure ulcer [6].

PUs develops when patient skin is continuously exposed to a persisting external interface pressure of support surface that is higher than capillary closing blood pressure. If this pressure is continued it can cause tissue necrosis [7].The factors causing PU is complex phenomenon and according to various researchers, they mainly include the pressure under bony prominences, shear forces, temperature, moisture, nutrition, seating position and daily life routine [8-10]. Excessive pressure between human buttock and seating surface is generally recognized as the principal cause of the occurrence of PUs [11]. IP involves mapping using sensors to quantify the pressure between two contacting objects, such as a person and their support surface. It is commonly used by clinician and by researchers investigating the surface, risk factors for ulceration and ulcer prevention protocol [12]. Frederick Shelton [13] compared different surfaces for elderly people (65-70 years) mannequins with Tekscan 5315 system in his test. Inflated beds designed to reduce pressure ulcers requires segmented air bags that alternately inflate and deflate to reduce IP [14]. To locate these air bags we need to know the locations of PU developing areas. The sacrum, hips, spine, elbow, ears, shoulder blades and heels are areas that can breakdown if point is kept in one position for long period of time as shown in Fig.1.

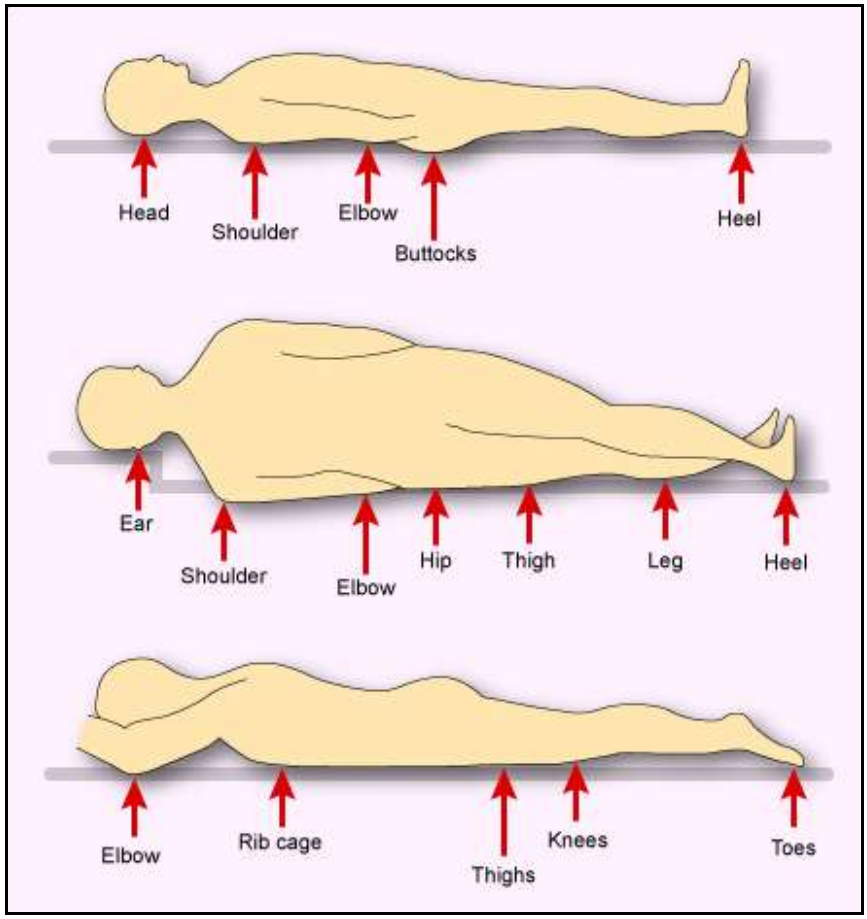


**Fig.1 Common Sites of Pressure Ulcers When Lying Down**

## III METHODOLOGY

### 3.1 Equipment Used

The reaction board used in this trial was wooden platform of 200 X 80 X 3 cm. electronic weighing scale and CONFORMat® pressure mapping system a product by Tekscan Inc. The system includes hardware, software and thin film pressure sensors (mats). The mats thinness enables the user to confidently incorporate the sensors in to the application without altering the characteristics of the support. The combination of these factors enables precise measurement of the location and magnitude of peak pressures and overall pressure distribution pattern.

### 3.2 Subjects

Forty subjects (20- Male and 20- Female) from healthy group were participated in the experiment. Initial data were collected on admission to the trial.

### 3.3 Procedure

For this study static supine posture condition were being considered. Experiment is carried out firstly on the objective questionnaires through hospital survey. 10 doctors and 5 nursing care unit nurses were asked question of

most vulnerable area of PU in bed bound patients. Secondly subjects were instructed to lie on reaction board to find the location of center of mass and then location of maximum IP by using pressure mapping system.

Determination of the center of mass location of a body with respect to a reference axis of rotation involves four steps:

1. A scale reading is taken when the reaction board is unloaded ($R_1$).
2. Subject assumes the desired position on the reaction board.
3. A second scale reading is taken ($R_2$) with the subject maintaining the desired position.
4. The Center of Mass location (x) with respect to the reference axis is calculated using equation 1.

$$x = \frac{(R_2 - R_1)}{W} d \qquad (1)$$

Procedural steps followed while collecting data are as follows

1. Accurate measure of height (h) and weight (W) using the same scale which will be used for the reaction board for each subject.
2. Initial scale reading ($R_1$) and the distance between the knife edges of the reaction board (d) were noted.
3. Participants were instructed to lie supine on the reaction board taking care to align the soles of the participant's feet with axis A (see Fig. 2).
4. Record scale reading, $R_2$, while the participant lies on the board with arms at sides.
5. The distance from axis A to the participant's CG in absolute terms (mm) and then as a percentage of the participant's standing height were calculated using equation

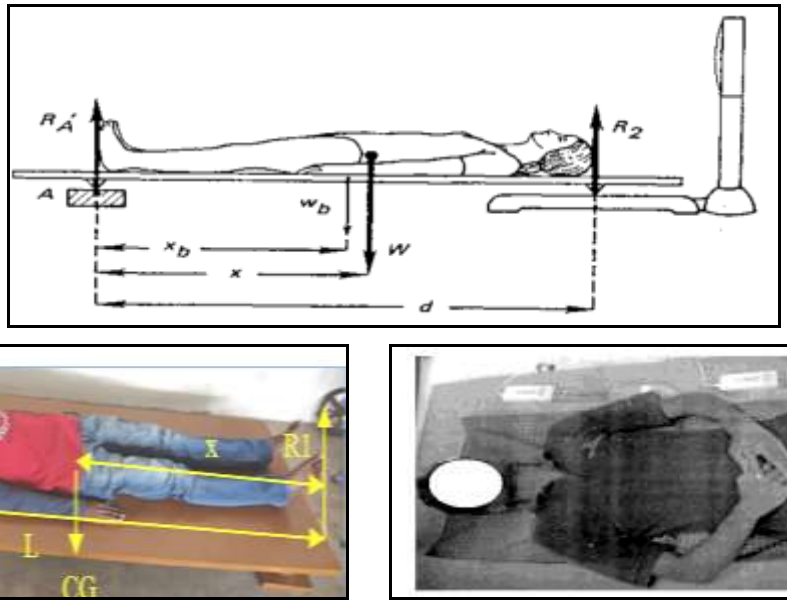


**Fig. 2: Experimental Setup**

Anthropometric data like Height, weight age and reactions on reaction boards for calculating center of mass were measured and collected through computer interface by using Ms Access form as shown in Fig. 3. Data collected were tabulated as shown in TABLE NO.1 and TABLE NO.2

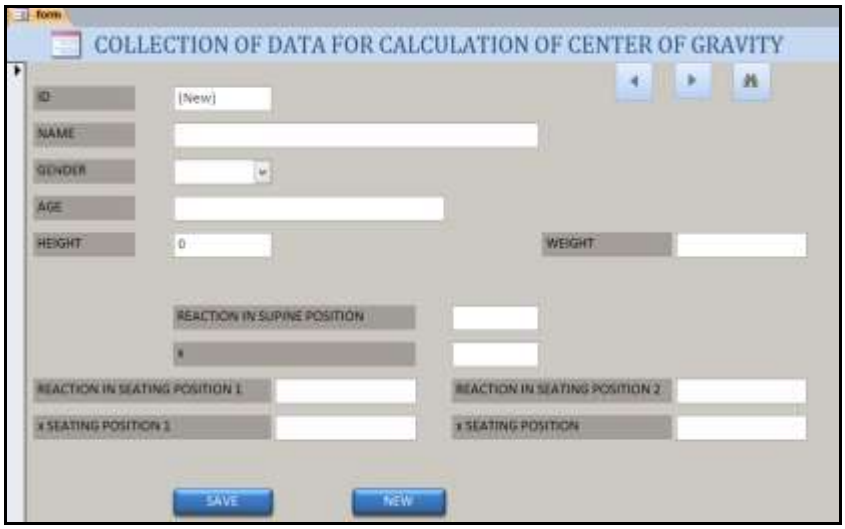


**Fig.3: Data Collection Input Window.**

**Table1. Location of center of mass by using reaction board method**

| Male Subjects | Height in (cm) | Weight in (Kg. | Location of Center of Mass (mm) | Female Subjects | Height in(cm) | Weight in (Kg.) | Location of Center of Mass (mm) |
|---|---|---|---|---|---|---|---|
| 1 | 173 | 64.88 | 100.04 | 21 | 163 | 54.66 | 90.63 |
| 2 | 174 | 65.74 | 98.86 | 22 | 161 | 56.00 | 82.61 |
| 3 | 168 | 64.52 | 94.19 | 23 | 157 | 44.25 | 87.66 |
| 4 | 171 | 67.16 | 94.56 | 24 | 152 | 49.08 | 86.31 |
| 5 | 180 | 66.87 | 102.71 | 25 | 159 | 61.52 | 88.86 |
| 6 | 175 | 58.77 | 98.62 | 26 | 159 | 63.02 | 89.88 |
| 7 | 171 | 78.12 | 95.61 | 27 | 159 | 57.07 | 84.59 |
| 8 | 172 | 85.70 | 100.55 | 28 | 159 | 47.88 | 84.85 |
| 9 | 171 | 57.06 | 97.64 | 29 | 157 | 47.20 | 83.96 |
| 10 | 178 | 75.04 | 99.88 | 30 | 152 | 49.53 | 81.07 |
| 11 | 171 | 76.66 | 98.71 | 31 | 149 | 38.28 | 81.26 |
| 12 | 167 | 65.74 | 94.58 | 32 | 151 | 53.60 | 79.88 |
| 13 | 173 | 49.75 | 99.25 | 33 | 164 | 64.42 | 92.00 |
| 14 | 170 | 73.63 | 97.45 | 34 | 159 | 41.85 | 90.97 |
| 15 | 170 | 68.00 | 99.88 | 35 | 163 | 69.10 | 85.95 |
| 16 | 178 | 75.00 | 103.51 | 36 | 159 | 40.60 | 89.37 |
| 17 | 181 | 66.27 | 104.89 | 37 | 152 | 49.50 | 86.14 |
| 18 | 166 | 52.16 | 93.29 | 38 | 149 | 41.70 | 83.32 |
| 19 | 171 | 85.26 | 97.85 | 39 | 147 | 41.52 | 80.65 |
| 20 | 175 | 59.45 | 99.19 | 40 | 164 | 58.66 | 87.1 |

**Table2. Location of maximum interface pressure by using pressure mapping system**

| Male Subjects | Height in (cm) | Location of Max. IP (mm) | Max. IP (mm of Hg) | Female Subjects | Height in (cm) | Location of Max. IP (mm) | Max. IP (mm of Hg) |
|---|---|---|---|---|---|---|---|
| 1 | 173 | 98.17 | 171 | 21 | 163 | 84.73 | 154 |
| 2 | 174 | 98.34 | 87 | 22 | 161 | 82.94 | 144 |
| 3 | 168 | 91.21 | 113 | 23 | 157 | 90.15 | 100 |
| 4 | 171 | 94.32 | 184 | 24 | 152 | 83.97 | 121 |
| 5 | 180 | 93.06 | 114 | 25 | 159 | 86.34 | 129 |
| 6 | 175 | 97.68 | 176 | 26 | 159 | 78.70 | 180 |
| 7 | 171 | 94.91 | 95 | 27 | 159 | 86.91 | 111 |
| 8 | 172 | 98.88 | 111 | 28 | 159 | 87.05 | 106 |
| 9 | 171 | 90.04 | 120 | 29 | 157 | 89.55 | 104 |
| 10 | 178 | 105.28 | 92 | 30 | 152 | 87.12 | 96 |
| 11 | 171 | 95.39 | 97 | 31 | 149 | 88.98 | 109 |
| 12 | 167 | 93.69 | 117 | 32 | 151 | 91.51 | 135 |
| 13 | 173 | 93.84 | 95 | 33 | 164 | 91.71 | 96 |
| 14 | 170 | 92.38 | 131 | 34 | 159 | 85.34 | 139 |
| 15 | 170 | 97.10 | 112 | 35 | 163 | 82.78 | 136 |
| 16 | 178 | 98.91 | 89 | 36 | 159 | 86.86 | 113 |
| 17 | 181 | 94.04 | 93 | 37 | 152 | 86.28 | 99 |
| 18 | 166 | 98.18 | 81 | 38 | 149 | 91.26 | 107 |
| 19 | 171 | 96.94 | 136 | 39 | 147 | 85.57 | 146 |
| 20 | 175 | 99.20 | 83 | 40 | 164 | 86.82 | 89 |

### 3.4 Statistical Analysis

After collecting the data for testing the significant relation between location of center of mass and location of maximum IP hypothesis were formulated and significance were tested by using two tailed t-test with 0.05 significance level by using equation 2.

Null hypothesis Ho: $\mu P = \mu R$

Alternative hypothesis Ha: $\mu P \neq \mu R$

$$t = \frac{\mu R - \mu P}{\sqrt{\frac{SR^2}{n-1} + \frac{SP^2}{n-1}}} \qquad (2)$$

Where μR = Average location of center of mass

- μP = Average location of Maximum IP
- SR = S.D. of locations of center of mass
- SP = S.D. of locations of maximum IP

Results of t-test are shown in TABLE 3.

**Table3. Two tailed t- Test Results**

$t_{statistic} = 0.478$

$\mu R = 92.20$ $SR = 7.26$

$\mu P = 91.49$ $SP = 5.74$

$t_{critical}$ = –t 0.025, 39 is -2.0227 and *t* 0.025, 39 is 2.0227

d.f. = n-1 = 39

α = significance level = 0.05

For two tailed test from statistical table –t 0.025, 39 is -2.0227 and the critical value *t*0.025, 39 is 2.0227. Since t-statistical is fall between these values we have accepted the null hypothesis *H*0: $\mu$P = $\mu$R in favor of the alternative hypothesis *H*A: $\mu P \neq \mu R$

Thus Average location of center of mass is equal to average location of maximum IP.

After determining the location of each person's center of mass, the ratio of the center of mass to the height of each person was calculated using formula x/h, and shown in Fig. 4 and Fig. 5. Where x is the location of the person's center of mass and h is the person's height.

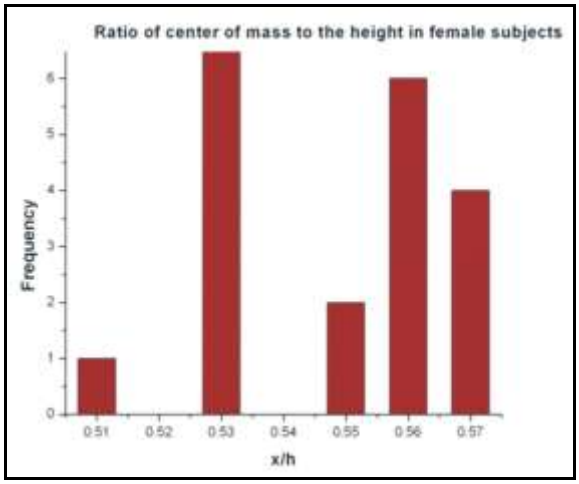


**Fig. 4: Frequency of ratio of center of mass to height values obtained from the female subjects**

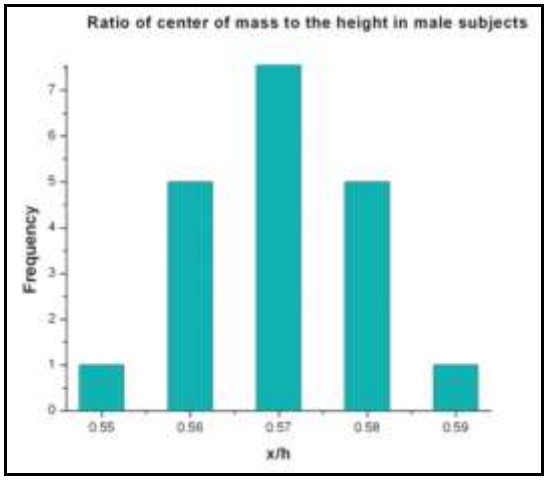


**Fig. 5: Frequency of ratio of center of mass to height values obtained from the male subjects**

## IV RESULTS AND DISCUSSION

### 4.1 Location of center of mass

1. Figure 2 and Table 1gives the actual location of center of mass measured by reaction board method. Average location of center of mass calculated was (x = 92.31cm)

2. Figure 4 and 5 gives that ratio of center of mass to height values for female and male subjects. It was noted that Males and females have different centers of mass females' centers of mass are lower than those of males. The average ratio of center of mass to height in females is approximately 0.53 and the average ratio of center of mass to height in males is approximately 0.57

### 4.2 Location of maximum IP

From Table 2 it was calculated that average location of maximum IP was (x = 91.49cm)

And from t –test it is tested that average location of maximum IP will locate at same location as that of average location of center of mass i.e test is significant.

## V CONCLUSION

From this study it is clear that maximum interface pressure due to person's center of mass is slightly below his/her belly button i.e. at sacrum. Maximum Interface pressures noted at sacrum in male subjects were in the range of 83 - 184 mmHg and in female subjects were in the range of 89- 180 mmHg.

It was also noted that Males and females have different centers of mass females' centers of mass are lower than those of males. The average ratio of center of mass to height in females is approximately 0.53 and the average ratio of center of mass to height in males is approximately 0.57.

Also it is understood that Pressure redistributing support surfaces, designed to prevent and treat pressure ulceration are generally based on location and magnitude of IP. The outcomes of this study will help the researchers as well as designers for designing personalized support surface and checking the efficacy of support surfaces to reduce PUs.

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