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Applications of BMI and BSA - A Retrospective Study.

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Abstract

INTRODUCTION: General examination of any patient routinely includes age, gender, height and weight. The two derived factors of clinical significance from height and weight are body mass index body surface area. Increasing public health awareness and rising trend of childhood obesity with fitness centres, Body mass index as an indicator and Prognosticator became popular. Increased risk of lifestyle illness could be predicted by BMI and metabolically active area was represented by BSA. Both BMI and BSA were derived from height and weight but by the different operations. In this study BMI and BSA were calculated over a wide range of patients and analysed. ***MATERIALS AND METHODS:*** Study: Retrospective observational clinical study. ***Study Population:*** All inpatients admitted across various medical and surgical departments of various age groups and both genders. ***Study Period:*** March 2026 to April 2026. ***Study Sample:*** Convenient sample of Hundred for the short study. ***Study Parameters:*** Age, Gender, Weight, Height, Diagnosis, BMI, BSA. ***Method:*** Case records of hundred inpatients of various departments in the said study period were included in the study. The patient demographic data with diagnosis were noted. BMI was calculated by the formula weight in kilograms divided by height square in meters. BSA was calculated by the formula square root of product of height and weight divided by 3600. All the parameters for the hundred patients were tabulated and analysed. ***RESULTS:*** The numeric summary gives the overall range/spread of age, weight, height, BMI, and BSA across the full cohort. The department counts show which specialty contributed the most patients to this dataset, namely: Ophthalmology, Urology, Obstetrics. BMI had a higher range in females, whereas BSA had a higher range in males. BMI and BSA are both derived from weight and height, but they combined differently. BMI and BSA are correlated but not redundant. BMI captures heaviness, whereas BSA represents absolute body size. The correlation coefficient quantifies how tightly linked they are in this cohort -a moderate but imperfect r($r \approx 0.68$) confirms they carry complementary rather than duplicate information, (relevant for drug dosing decisions, which often use a BSA specifically rather than BMI). BMI Median: 22.7 (Male), 24.1 (Female) Mann–Whitney U $p = 0.15$. ***CONCLUSION:*** Clinical significance of the parameter must be considered in holistic manner and individualised, keeping in mind the situation in which BMI or BSA are taken alone BMI and a BSA could be misleading regarding clinical decision. Drug dosing and graft area calculation could be with BSA whereas morbid obesity and fat distribution could affect outcome with BMI calculation. BMI and BSA are complementary to each other($r=0.68$).

Keywords: BMI-Body Mass Index, BSA - Body Surface Area, W-Weight, H-Height.

INTRODUCTION

Lifestyle disorders and childhood obesity have been on the increasing trend in the last decade. Apart from healthcare professional gymnasia and other health clubs plan workouts elaborating on body mass index (BMI). Both body mass index and body surface area depend on the two parameters namely height and weight. While body mass index gives an idea of appropriate weight for height and suggests probability of illnesses at risk, body surface area suggests the metabolically active parameter of an individual .Body mass index as gain awareness among the public stimulating researches by statisticians, community medical sociologists and even engineering graduates to derive various formula and methodology to calculate BMI with knee height in patients who cannot stand, amputees and facial anthropometry applications which computerisation respectively.

In this study the students have been encouraged to calculate BMI and BSA for around 100 patients across various Inpatient wards, critical care units with various age groups to understand the similarities and differences between the two parameters and enumerate various applications of BMI and BSA.

Aim

1. To evaluate applications of both BMI and BSA.
2. To calculate body mass index and body surface area from case record across various departments.
3. To correlate BMI, BSA and the diagnosis to attach significance of the parameters.

MATERIALS AND METHODS

Study

Retrospective observational clinical study.

Study Population

All inpatients admitted across various medical and surgical departments of various age groups and both genders.

Study Period

March 2026 to April 2026.

Study Sample

Convenient sample of Hundred for the short study.

Study Parameters

Age, Gender, Weight, Height, Diagnosis, BMI, BSA.

Method

Case records of hundred inpatients of various departments in the said study period were included in the study. The patient demographic data with diagnosis were noted. BMI was calculated by the formula weight in kilograms divided by height square in meters. BSA was calculated by the formula square root of product of height and weight divided by 3600. All the parameters for the hundred patients were tabulated and analysed.

RESULTS

Age group of the sample extended from two years to eighty years. Most of the patients occupied the 50 to 65 years age group. The weight of the study population ranged from 10 kg to 100kg, with most patients between 50-75 kg.

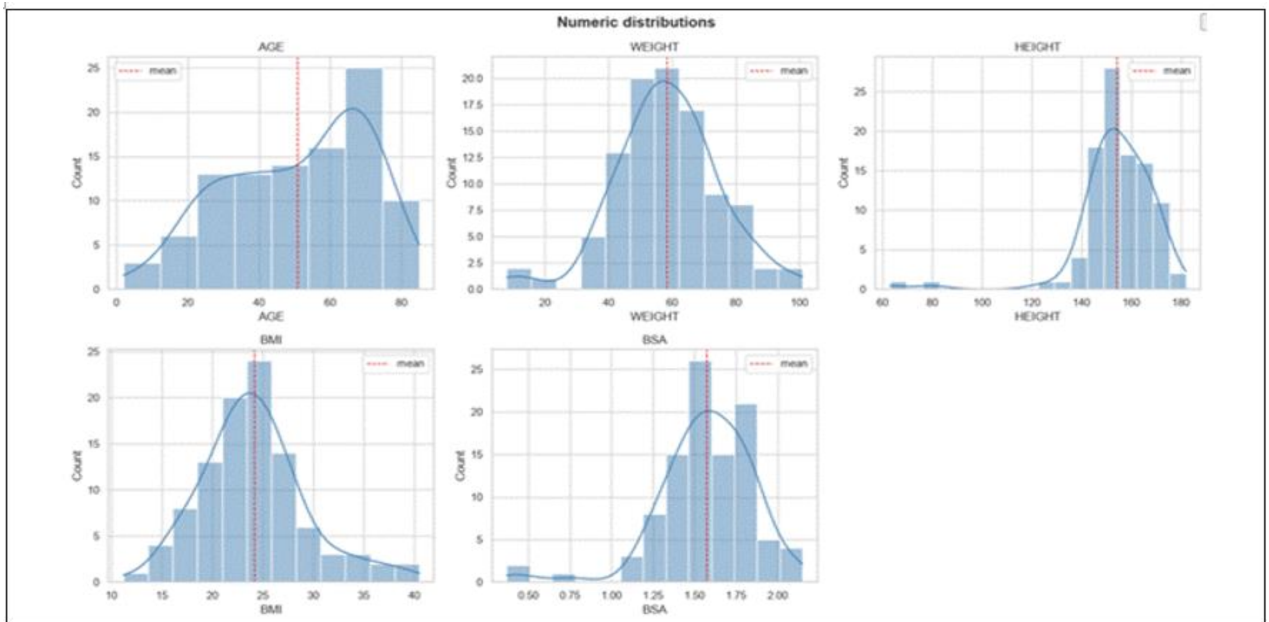

Figure 1: Numeric Distributions

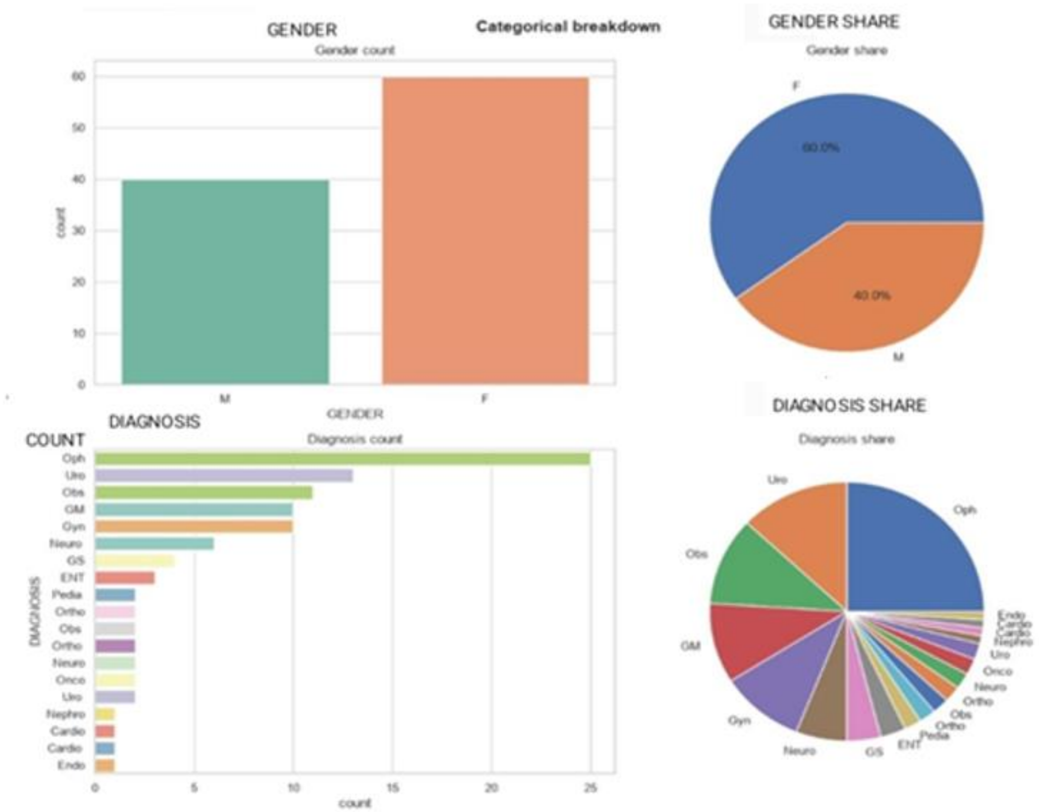

Figure 2: Gender Distribution

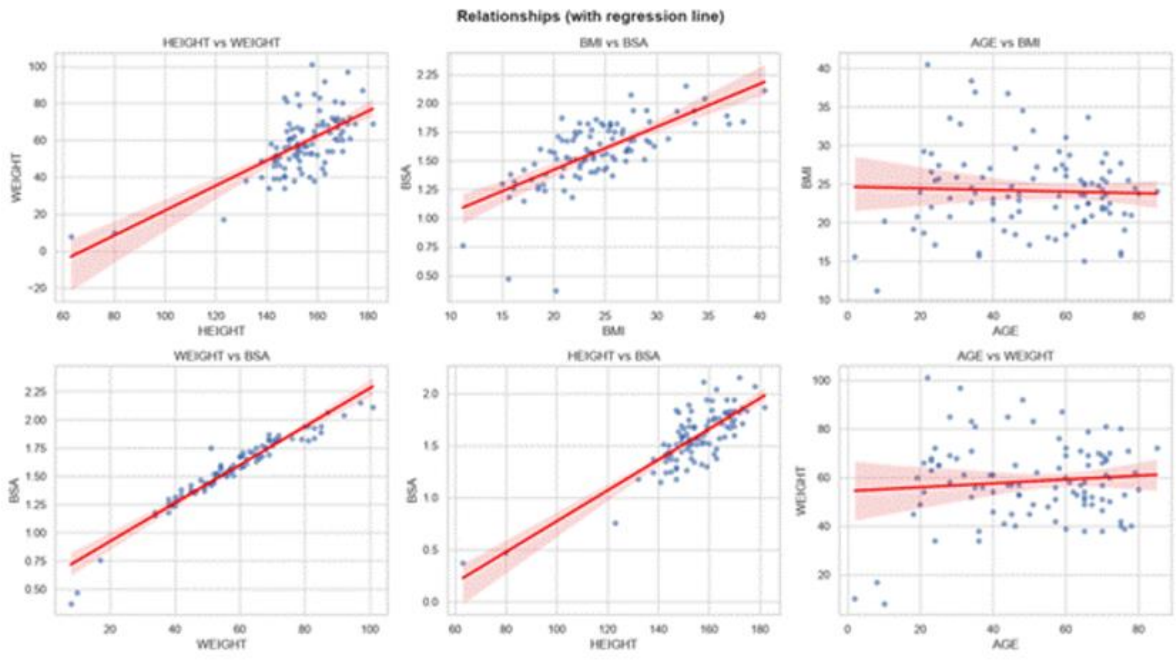

Figure 3: Relationships

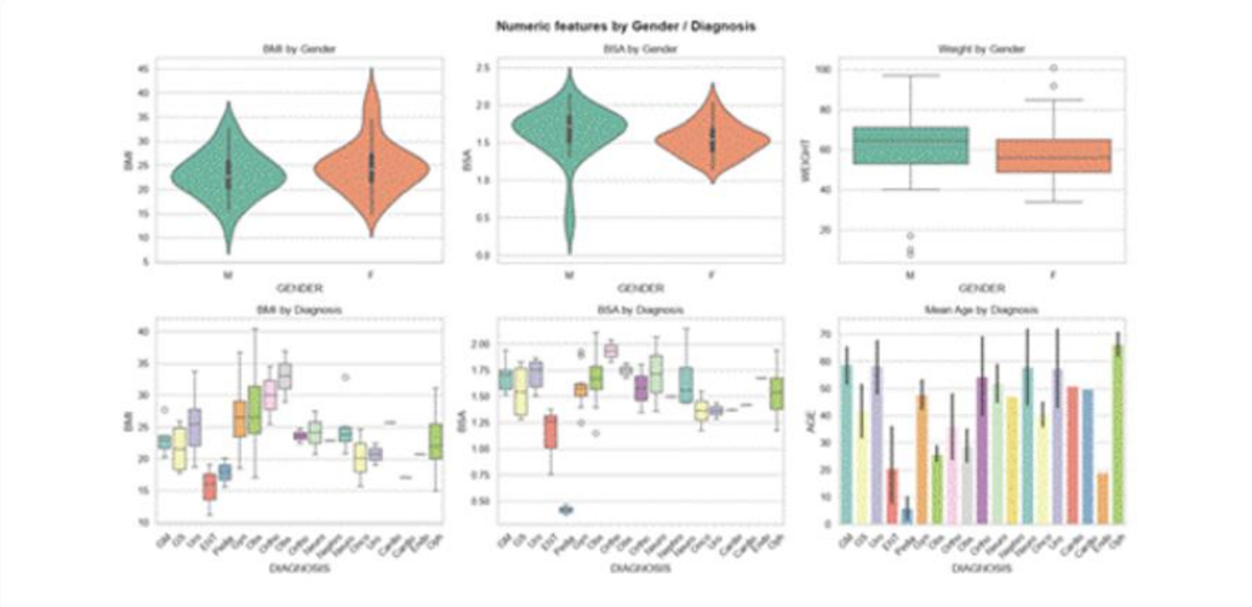

Figure 4: Numeric Features by Gender / Diagnosis

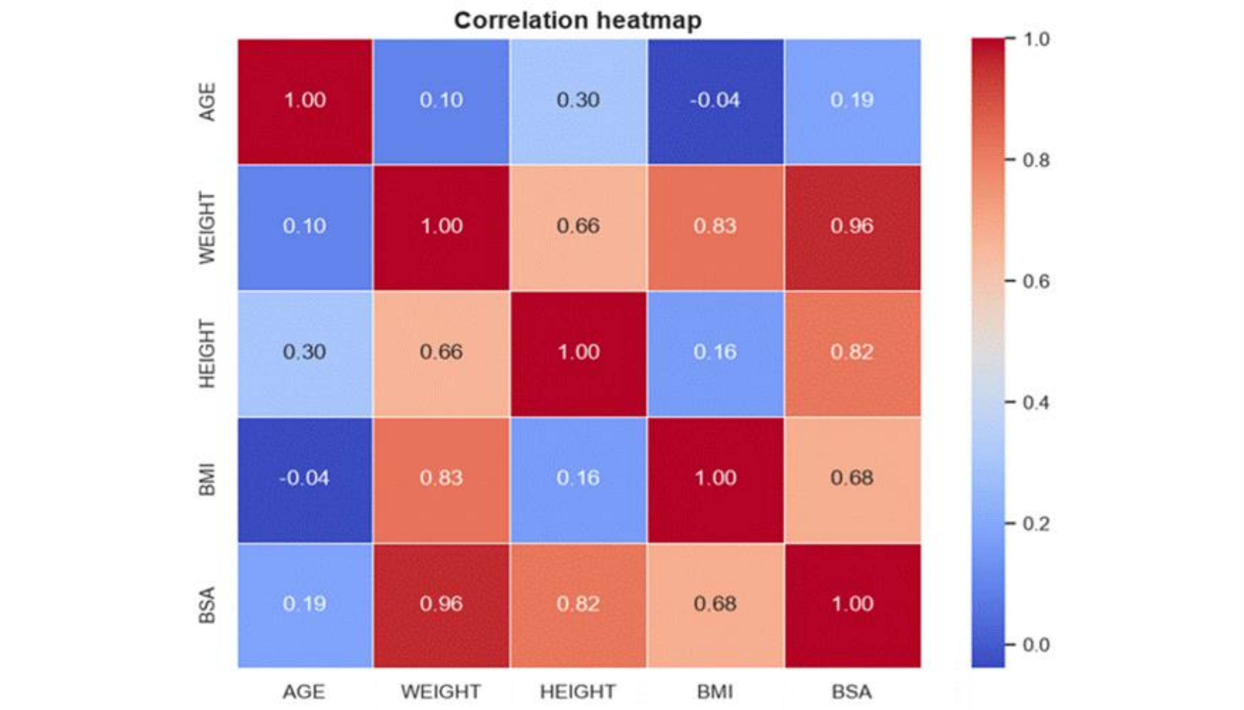

Figure 5: Correlation Heatmap

The height ranged from 120 to 180 cm, peaking at 150 cm. BMI ranged from 10 to 40 and peaked around 24. BSA ranges from 0.5 to 2. Elderly ophthalmic patients for cataract extraction dominated the population. BMI was higher in females and BSA ranged widely in males.

Weight and Height had correlation with r of 0.96 and 0.82 with BSA. With BMI, the r value of weight was 0.83, while height showed r of 0.16. BMI and BSA were highest in obstetric patients in the study population.

DISCUSSION

BMI History

Adolph Quetelet, a Belgian mathematician, first devised Body Mass Index as a parameter to screen nutritional status in 1830.

This was also called the Quetelet Index and derived as an Individual's weight in kilograms divided by height in meters squared. It was Ancel Keys who renamed Quetelet Index as Body Mass Index (BMI). As Body Mass Index in 1972,[1] BMI is simple to measure in adults and is actually a functional sum of a variety of complex body indicators. Four categories of BMI are in common use to estimate patient's nutritional status or obesity:[2]

Underweight	Less than 18.5 kg/m²
Normal	18.5-25kg/m²
Overweight	25-30kg/m²
Obesity	More than 30kg/m²

By capturing more or less severe BMI variance, obesity could be subcategorised further.[3] BMI is a simple, inexpensive clinical screening tool widely used by medical, paramedical and fitness centres alike. Health care providers and public health agencies recognise obesity as a risk factor for multiple disorders such as diabetes, cardiovascular disorders, chronic orthopedic problems, trauma, collagen vascular diseases, autoimmune disorders, increased risk of colorectal cancer, pulmonary liver malignancy and increased mortality due to malignancy.[4] Increase in risk for pulmonary infections due to poor chest wall compliance and poor respiratory reserve could all be predicted with BMI. The changes in BMI could predict improvement or deterioration of the particular disorder.

Higher BMI is influenced by sedentary lifestyles, structural elements such as sidewalks in the living environment, affordability and availability along with choice of healthy foods.[5] BMI is helpful when used as a screening test with population appropriate cut-offs. BMI provides valuable information at a population and community level to assess trends.

BMI and Pregnancy

Cytokines that result in insulin resistance – leptin, resistin, TNF-α and IL-6 are increased in pregnancy. These may be the primary stimulant of insulin resistance. Secretion of the remaining adipokines are insignificant. Specific patterns have been variously described with gestational diabetes, preeclampsia and fetal growth restriction.[6] In a longitudinal study of 55 pregnant women, Meyer and associates confirmed that higher BMIs are associated with lower adiponectin but higher leptin levels.

BMI as Prognosticator in Malignancy

In a large study conducted in a cohort of 1.6 lakhs health professionals by Michaud et al., high BMI and reduced physical activity increased the risk of pancreatic cancer.[7] Moderate physical activity reduced the risk of malignancy in high BMI individuals. Walking or hiking for 1.5 hours per week reduces the risk of bronchogenic carcinoma by 50% of individuals independent of smoking cessation.[8] Thus, BMI has been an index suggesting increased risk of colonic and other malignancies. Thus, workouts and gymnasia became popular in reducing BMI. Increased awareness among the general mass about childhood obesity and fitness regimes started the marathon, awareness programs, and Pink October and other slow-running programs to alert the public regarding the risk of malignancy in high BMI individuals and the need to maintain fitness of physique to reduce its incidence even in the absence of habitual smoking or drinking.[9]

BMI and Fat Mass

BMI is a surrogate measure of body fat, as it measures excess weight rather than excess fat. Despite this fact, BMI is correlated to more direct measures of body fat such as:
Underwater weighing DEXA (Dual-Energy X-ray Absorptiometry). BMI does not distinguish between lean muscle and fat mass. A muscular athlete may have a higher BMI because of extra lean mass and could be categorised as overweight or obese. Lean body mass includes the combined mass of bones, water, ligaments, muscles, tendons, and internal organs.[10] Fat-free mass is calculated as the difference between total body mass and all fat mass, including essential fat. The difference between lean body mass and fat-free mass amounts to approximately 2–3% in men and 5–12% in women. Several formulae have been described to calculate lean body mass in adults by Boer, James, and Hume.

The Boer Formula
For males:
$eLBM = 0.407W + 0.267H - 19.2$
For females:
$eLBM = 0.252W + 0.473H - 48.3$

The James Formula
For males:
$eLBM = 1.1W - 128 (W/H)^2$
For females:
$eLBM = 1.07W - 148 (W/H)^2$

The Hume formula:
For males:
$eLBM = 0.32810W + 0.33929H - 29.5336$
For females:
$eLBM = 0.29569W + 0.41813H - 43.2933$
Where:
W = Weight (kg)
H = Height (cm)

Lean body mass calculation in children is based on estimated extracellular volume (eECV).
$eECV = 0.0215 \times W^{0.6469} \times H^{0.7231}$
$eLBM = 3.8 \times eECV$
Where:
W = weight in kilograms (kg)
H = height in centimeters (cm)

Calculation of Body Fat Percentage
In general terms, fat may be classified as Brown fat Beige fat White fat Visceral fat Subcutaneous fat Body fat can be measured by various tools such as

1. Skinfold calipers
2. Waist, arms, and legs circumference measurements
3. Dual-energy X-ray absorptiometry (DEXA)
4. Hydrostatic weighing
5. Air displacement plethysmography
6. Bioelectrical impedance spectroscopy
7. Bioimpedance
8. Electrical impedance myography
9. 3 -D body scanners

The body fat percentage ranges from 5% to 39% Elliot Upton is a senior personal trainer who has done extensive work on fat percentages in males and females. He is an internationally renowned trainer who offers individualised suggestions and advice on fitness regimes to reduce and recommend appropriate fat percentages.[11,12]

Fat %	Male	Female
5-9%	Essential	Very low
10-14%	Lower abdominal fat	good
15-19%	Less muscle definition	Diet plan needed
20-24%	Higher end of average	Keep physical activity up
25-29%	Obese -Life style changes are needed	Higher average
30-34%	Definite exercise needed	obesity
35-39%	Warning for complications	High risk for diabetic and heart disease

Table 2

Thus BMI could be a valuable clinical tool in population survey and primary death screening Could guide nutritional and exercise counselling.

Limitations of BMI
BMI does not measure functional health and fitness but it is merely an anthropometric measure. It estimates adiposity crudely, given that muscles and bones have a higher density than fat and some and me fat dispositions are worse than others. Ethnic and gender variations exist with BMI and cut off differences could have to be noted seriously. BMI cut-offs may not hold over predictive value for individuals of 65 as they do for ganger adults, as modest overweight status on out carry the same implications for the older population.[13] A higher BMI need not necessarily indicate excessive body weight.

To assess progress using BMI can progress be challenging for adults engaged in fitness programs as they may losing fat. This may result in stable or increased BMI. Thus it is crucial to recognise that relying solemnly on BMI may lead to misleading assessment of progress.[14]

Regarding ethnic considerations South Asian bodily habitus is though to have higher health risks at lower BMI Caucasians due to higher proportional of body fat at the lower BMI than consider obese by WHO cut off is termed sarcopenic obesity. These are at higher risk for type II diabetes. Thus exploring alternative methods such as waist to hip ratio or waist to height ratio (WHER) in addition to BMI could offer more comprehensive assessment of body composition and associated health risks in diverse populations. Standard BMI categories can lead to misclassification bias when considering age, ethnicity, race, sex or metabolic disease risk for certain disorders.[15]

For the same BMI, females have a higher percent of fat than males and for similar fat free body mass. At population level BMI could assess macronutrition but not micronutrition.[16] Basing an obesity diagnosis solely on BMI can be inaccurate and may increase discriminatory and costly patient consequences. Waist circumferences could indicate body fat distribution but may not distinguish subcutaneous fat from visceral fat. The waist to hip ratio may be a better predictor of cardiovascular disease occurrence than BMI.[17]

Body Surface Area

Body surface area often relates to metabolically active areas of the body. The idea of calculating body surface area has its history from1879 by Meeh.[18] Since then about 25 types of formulae have been evaluated to calculate body surface area with a variability of about 0.5 m^2.[19] The Dubois formula has been the standard until now. The most recent studies have used 3D Laser techniques to determine human BSA, In 1879 Meeh calculated it as 0.1053W^⅔.

In 1916, Dubois formula 0.007184 W^42.5 *H^0.725 was used and in vogue until today in 2010 schlich et and derived the formula for men: 0.000579479. W^0.38*H^1.24 and for women 0.00097482 x W^0.46*H^1.08. W is weight in kilograms and H is height in centimeters.

Mostelle Formulae of square root of product of weight and height divided by 3600. The total lives volume index is determined[14] by BSA has vast applications in surgery and critical care and therapeutics.

a) BSA supports the process of transplantation of both solid organs and skin such as liver and kidney where there may be discrepancy in the size of the organ between donor and recipient.
b) To measure treating dosage of lamivudine in chronic hepatitis B.
c) BSA is a high predictive value in burns to determine area burnt, skin needed for grafting, prognosis and outcome,
d) BSA is used to calculate glomerular filtration rate[15] to assess renal function except in obesity and children.
e) BSA is a major variable in treatment of nephrotic syndrome.[16] weight based dosing, may be less than body surface Area based dosing in smaller children.
f) Calculation of cancer chemotherapy drugs based on BSA has been proved beneficial. Selection of doses for cytotoxic chemotherapy USES bsa calculation.[17]
g) Drugs which accumulate in ECF should be dosed on the basis of BSA as if it reflects the volume of extracellular fluid and total body water more precisely than body weight itself.[18] Hence antiviral, antifungal, and antimicrobials require dosing regimen on the basis of BSA.
h) The U.S. FDA has recommended BSA as a method for using data from animal model species to establish safe starting doses for initial human clinical trial.[19]
(i) Veterinary medicine confirms wide scope of applications with meeh’s formula.

All BSA formulae were established on the basis of an isolated standard physique adult group of people. Hence they may be one our dwarfism on gigantic proportions incorrect BSA estimation may lead to failure of treatment and poor outcome. At the low height values extreme differences in BSA may cause alarm especially in short obese adults and children. Further research on development of a more comprehensive BSA estimation formula may be needed.

Summary of Results

Table 3: Exploratory Data Analysis – Summary Statistics

	Count	Mean	Std	Min	25%	50%	75%	Max
Age	100	50.7	19.8	2	34.8	56	67	85
Weight	100	58.4	16.3	3	49	57.5	68.2	101
Height	100	154	15.9	63	148	154	164	182
BMI	100	24.1	5.22	11.2	20.9	23.7	26.8	40.5
BSA	100	1.57	0.287	0.37	1.43	1.58	1.76	2.15

The numeric summary gives the overall range / spread of age, weight, height, BMI and BSA across the full cohost. The department, counts show which speciality contributed the most patients to this data set, namely ophthalmology, urology and Obstetrics. BMI had a higher range in females and BSA had higher Range in males. BMI and BSA are both derived from weight and height but they combine differently. BMI and BSA are correlated but not recommendment. BMI captures heaviness and BSA absolute body size. The correlation co-efficient quantifies how tightly linked they are in this cohort; a moderate but imperfect r (r=0.68) confirms they carry complementary rather than duplicate information (relevant for drug dosing decisions which often use BSA specifically rather than BMI). BMI Median 22.7 (Male) 24.1(female) MAN whitey up=0.15.

CONCLUSION

Body mass index and body surface area are two common parameters routinely used in medical practice. This Study WAS conducted to encourage understanding and applications of BMI and BSA, BMI focuses on predicting increased risk to systemic illness as well as prognosticate them, BSA speaks on metabolically active area and its important in drug dosing and burns management apart from other indication, BMI and BSA complement each other but not duplicate each other.

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