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Comparison of BMI and Skeletal Muscle Mass with Phase Angle in Cancer Patients Receiving Chemotherapy

Research Article

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Abstract

Nutrition is an important factor to assess the quality of life and functionality in patients receiving chemotherapy. Malnutrition has been observed in patients receiving chemotherapy; hence it is an important factor contributing to recovery. The article explores the growing significance of phase angle in comparison withBody mass Index and Skeletal muscle mass in patients receiving chemotherapy.

Introduction

Patient with cancer undergo dynamic and longitudinal changes in nutritional status and body composition. In order to measure the body composition, one of the measures used is the Bioelectrical impedance analysis. BIA is an inexpensive, non-invasive and reproducible technique which uses electric current through body to measure impedance. On the other hand, we have phase angle which is a value derived from the BIA and is an indicator of cell membrane health and integrity.[1] Higher PA values may reflect better cell function, higher muscle mass and lower fat mass. [2] The study aimed to analyse the relationship between phase angle with BMI and skeletal muscle mass in patients receiving chemotherapy in one day at a particular health care institution (S.L Raheja Hospital Fortis, Mumbai).

Material and Methods

A point prevalence study was conducted on patient with various forms of cancer undergoing chemotherapy. The BMI, skeletal muscle mass and phase angles were measured using our machinery in 30 patients who currently received chemotherapy. The measurements were done in one-day and the data was collected as below.

DLTCL- diffuse lymphocytic T- cell Lyphoma;

The above data shows that Body mass index was variable in each individual with a different form of cancer but all receiving chemotherapy. The phase angle has a correlation with the BMI which is illustrated in the graphs below. Skeletal muscle mass is a key component of fat free mass and metabolic health. The lower the Skeletal muscle mass, indicates sarcopenia which increases the risk of poor health outcomes in the form of premature mortality and increased morbidity [3].

The skeletal muscle mass is calculated using height and weight, which has a normal range of 10-20% in males and 18-28% in females. It is important to note that we are measuring the skeletal muscle mass in patients with cancer which may vary.

Statistical Analysis

A multiple linear regression was conducted to assess the predictors of **phase angle** in patients undergoing chemotherapy. The model included **height, weight, skeletal muscle mass (SMM), skeletal muscle index (SMI), and fat percentage** as predictors.

- The overall model was **not statistically significant** ($F(5,24) = 1.74$, $p = 0.165$), explaining **11%** of the variance in phase angle (**Adjusted $R^2 = 0.11$**).

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- **Significant predictors**:
  - **Weight**: A significant **negative relationship** was found between weight and phase angle (β=−2.34, *p*=0.017), indicating that higher weight was associated with lower phase angle.
  - **Skeletal Muscle Mass (SMM)**: A significant **positive relationship** was observed between SMM and phase angle (β=2.22, *p*=0.015), suggesting that greater muscle mass was associated with higher phase angle.
  - **Fat Percentage**: A significant **positive relationship** was found between fat percentage and phase angle (β=1.58, *p*=0.020), indicating that higher fat percentage was associated with a better phase angle.
- **Non-significant predictors**:
  - **Height** (*p*=0.645) and **Skeletal Muscle Index (SMI)** (*p*=0.738) did not show significant relationships with phase angle.

These findings suggest that **SMM** and **fat percentage** play important roles in determining phase angle in chemotherapy patients, while **weight** appears to have an opposing effect. However, the model's overall explanatory power remains modest, indicating that other factors likely influence phase angle.

Implications

- **Skeletal Muscle Mass (SMM)**

The significant positive relationship between SMM and phase angle highlights the importance of maintaining or increasing muscle mass in cancer patients undergoing chemotherapy. SMM is a key determinant of **cellular health**, which phase angle reflects, suggesting that interventions to preserve muscle mass could improve overall health outcomes. It is important to note here that the above is seen in the regression analysis as explained above.

- **Weight**

The negative association between weight and phase angle suggests that simply increasing weight, especially if it involves non-muscle mass (e.g., fat), does not necessarily improve cellular health. This implies that clinicians should focus on muscle preservation rather than just weight gain during chemotherapy.

- **Fat Percentage**

The significant positive relationship with phase angle implies that body fat, although often viewed negatively, may play a role in maintaining cellular integrity in cancer patients. This finding requires further investigation to understand how fat distribution and quality impact phase angle.

- **Model Limitations**

The overall model only explains a small portion of the variance in phase angle (**11%**), suggesting that other factors, such as disease severity, inflammation, or hydration status, might also influence phase angle. Future studies with larger sample sizes and more comprehensive data could provide a clearer picture of the factors contributing to phase angle in cancer patients.

- **Suppressor Effects and Multicollinearity**
  - SMM is highly correlated with other body composition parameters, such as weight and skeletal muscle index (SMI). When these variables are included in the regression model, SMM's unique contribution to phase angle becomes more apparent after controlling for shared variance.
  - In simple correlation, SMM's effect on phase angle might be masked by other variables influencing both SMM and phase angle. However, in regression, when those confounding factors are controlled, the independent impact of SMM emerges.
- **Multivariable Contribution**
  - Even if SMM alone does not show a strong correlation with phase angle, its combined effect along with other predictors in the regression model could still be meaningful.
  - Essentially, regression helps isolate the independent role of SMM in predicting phase angle, which may not be evident when looking at simple correlations.
- **Sample Size Considerations**
  - With a small sample size, correlation estimates can be unstable, leading to non-significant results. Regression analysis, by incorporating multiple variables, may still detect an effect that was not apparent in the correlation matrix.

Results

Body composition parameters correlation

Values are r (*p*); BMI: Body mass index; SMM: Skeletal muscle mass; SMI: Skeletal muscle index

Phase angle specific correlation

Phase Angle-Specific Correlation Analysis:

1. Phase Angle and Height:
- Correlation: r=0.04, *p*=0.832
- There is no significant relationship between **height** and **phase angle**.

2. Phase Angle and Weight:
- Correlation: r=−0.017, *p*=0.929
- There is no significant relationship between **weight** and **phase angle**.

3. Phase Angle and BMI:
- Correlation: r=−0.006, *p*=0.974
- There is no significant relationship between **BMI** and **phase angle**.

4. Phase Angle and Skeletal Muscle Mass (SMM):
- Correlation: r=0.039, *p*=0.836

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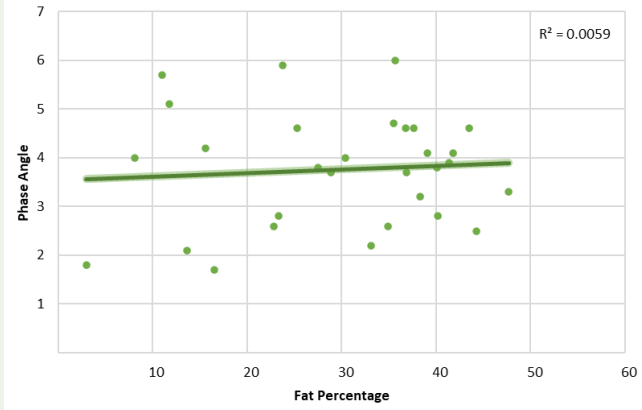

Figure 1: Scatter Plot showing correlation between Phase Angle and Fat Percentage.

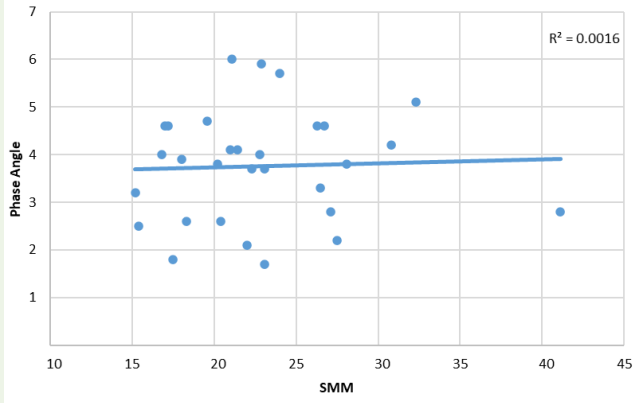

Figure 2: Scatter Plot showing correlation between Phase Angle and SMM.

- There is no significant relationship between **SMM** and **phase angle**.

5. Phase Angle and Skeletal Muscle Index (SMI):

- Correlation: r=−0.049, *p*=0.798
- There is no significant relationship between **SMI** and **phase angle**.

6. Phase Angle and Fat Percentage:

- Correlation: r=0.077, *p*=0.686
- There is no significant relationship between **fat percentage** and **phase angle**.

Discussion

No significant correlations were observed between **phase angle** and any of the anthropometric or body composition variables, including height, weight, BMI, SMM, SMI, and fat percentage.

- Correlation measures only the direct pairwise relationship between two variables without accounting for other factors.

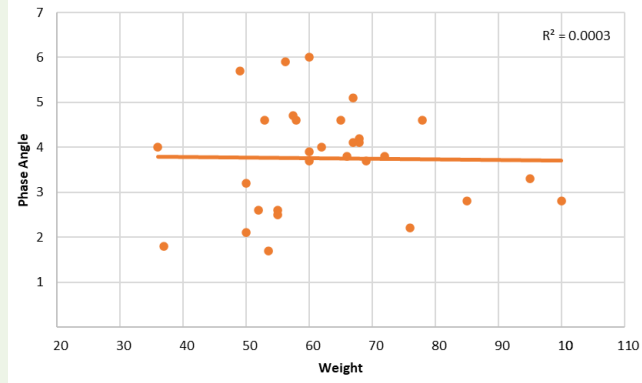

Figure 3: Scatter Plot showing correlation between Phase Angle and Weight

Table 1: Correlation of anthropometric and body composition parameters

	Weight	BMI	SMM	SMI	Fat percentage	Phase angle
Height	**0.654** (<0.001)	0.156 (0.410)	**0.812** (<0.001)	**0.697** (<0.001)	-0.159 (0.401)	0.04 (0.832)
	Weight	**0.844** (<0.001)	**0.75** (<0.001)	**0.665** (<0.001)	**0.436** (0.016)	-0.017 (0.929)
		BMI	**0.394** (0.031)	**0.371** (0.043)	**0.71** (<0.001)	-0.006 (0.974)
			SMM	**0.936** (<0.001)	-0.233 (0.214)	0.039 (0.836)
				SMI	-0.305 (0.101)	-0.049 (0.798)
					Fat percentage	0.077 (0.686)

Values are r (*p*); BMI: Body mass index; SMM: Skeletal muscle mass; SMI: Skeletal muscle index

- Regression, on the other hand, evaluates the relationship between the dependent variable (phase angle) and multiple predictors simultaneously, adjusting for the influence of other variables.

Although simple correlation analysis did not indicate a significant relationship between SMM and phase angle, multiple regression analysis identified SMM as a significant predictor. This discrepancy can be attributed to the fact that correlation measures only the direct relationship between two variables, while regression accounts for multiple predictors simultaneously, adjusting for shared variance. In this study, the high correlation of SMM with other anthropometric variables, particularly weight and skeletal muscle index, may have masked its direct effect on phase angle in the correlation analysis. However, when included in the regression model, SMM's independent contribution became evident. These findings underscore the importance of multivariable approaches in evaluating body composition predictors of phase angle.

Summary

A total of 30 patients were analysed, of which 33% were females. Skeletal Muscle Mass (SMM) is the strongest predictor of phase angle, highlighting its role in maintaining cellular health and integrity. BMI and Weight show weak relationships with phase angle, suggesting that weight alone is not a good indicator of phase angle, and the

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PatientNo.	OPD/IPD	CANCER	HEIGHT	WEIGHT	BMI	S.M.M	S.M.I	FAT %	PHASE ANGLE
1	DAY CARE	CA PANCREASE	157	57.5	23.3	19.6	5.4	35.5	4.7
2	DAY CARE	MULTIPLE MYELOMA	154	60	25.3	18	6	41.4	3.9
3	DAY CARE	RECURRENT NHL, DLTCL	175	68	22.2	30.8	8	15.6	4.2
4	IPD-ICU	CA PROSTATE	167	85	30.5	27.1	6.9	40.2	2.8
5	IPD-ICU	CA EPIGLOTIS	162	55	21	18.3	4.7	34.9	2.6
6	IPD-WARD	AML	157	58	23.5	17	5.2	43.5	4.6
7	IPD-WARD	CA COLON	165	37	13.6	17.5	6.2	3	1.8
8	IPD-WARD	GERM CELL TUMOR	154	60	25.3	21.1	6	35.7	6
9	IPD-WARD	PSEUDOMYXOMA PERITONEI	152	36	15.6	16.8	4.7	8.1	4
10	IPD-WARD	CNS LYMPHOMA	157	55	22.3	15.4	4.2	44.3	2.5
11	IPD-WARD	NHL DLBCL	172	68	23	21	5.6	41.8	4.1
12	IPD-WARD	CA STOMACH	160	67	26.2	21.4	6.4	39.1	4.1
13	IPD-WARD	CA STOMACH	180	56.3	17.4	22.9	5.9	23.8	5.9
14	IPD-ICU	AML MONOCYTIC PREDOMINENCE	160	52	20.3	20.4	5.6	22.8	2.6
15	IPD-ICU	CA LUNG WITH BONE METS	167	50	17.9	22	6.3	13.6	2.1
16	IPD-WARD	ACUTE AML	175	67	21.9	32.3	8.2	11.8	5.1
17	IPD-WARD	MONOCYTIC AML	187	100	28.6	41.1	9.6	23.3	2.8
18	IPD-WARD	MULTIPLE MYELOMA	171	69	23.6	23.1	6.3	36.9	3.7
19	IPD-WARD	CA LUNG ADVANCED	173	72	24.1	28.1	7.2	27.5	3.8
20	IPD-ICU	AFI NEGATIVE NHL WITH HYDATID CYST OF LIVER	170	60	20.8	22.3	6.3	28.9	3.7
21	IPD-WARD	SQUAMOUS CELL CARCINOMA OF LEFT AUDITORY CANAL	167	49	17.6	24	6.4	11	5.7
22	IPD-ICU	CA LUNG	165	62	22.8	22.8	6.3	30.4	4
23	IPD-ICU	MATASTATIC BREAST CA UROTHELIAL CA	152	50	21.6	15.2	4.7	38.3	3.2
24	IPD-ICU	RENAL CA	178	76	24	27.5	7.1	33.1	2.2
25	IPD-WARD	CA BREAST	152	53	22.9	17.2	5.3	37.6	4.6
26	IPD-WARD	CA TONGUE RECURRENT	172	65	22	26.3	6.5	25.3	4.6
27	IPD-WARD	ISAOLATED PLASMACYTOMA	180	78	24.1	26.7	6.8	36.8	4.6
28	IPD-WARD	CA GALL BLADDER	157	66	26.8	20.2	6.1	40.1	3.8
29	IPD-WARD	CHOLANGIOCARCINOMA	176	95	30.7	26.5	7.1	47.7	3.3
30	IPD-ICU	CA TONGUE	155	53.6	22.3	23.1	7.4	16.5	1.7

muscle mass component (SMM) likely plays a more significant role. Fat Percentage and SMI do not show significant correlations with phase angle, suggesting that these variables may not be as important in determining phase angle in this specific sample.

This study can aid in providing us with an insight in increasing nutrition in order to increase theskeletal muscle mass in cancer patients. With this insight, the phase angle measurements would be higher which would correlate with the cell membrane health, hydration and nutrition status in order to guide us towards their recovery and reduce morbidity [4]. Moreover, it is reported there is a statistically weakly positive correlation was found between body mass index and phase angle values ($p<0.05$) seen in study [5]. Statistically moderate positive correlation was found between body muscle and phase angle values ($p<0.05$). In addition, as mentioned in many sources, the phase angle can be an indicator of the integrity and functional adequacy of the cells, especially in diseases with catabolism effect. In order to increase phase angle, one can include a balanced diet which includes mediterranean diet benefiting in preventing cardiovascular diseases, promoting longevity and supporting health aging.[6] The nutrition must target a protein rich and high protein intake in forms of enteral and parenteral nutrition.[7-9]

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