TPM Vol. 32, No. S1, 2025
ISSN: 1972-6325
https://www.tpmap.org/

Open Access

BODY COMPOSITION PROFILES AND THEIR IMPACT ON RECOMMENDED CALORIC INTAKE IN OUTPATIENT CLINICS AT JAZAN UNIVERSITY HOSPITAL

OHOOD MAHDI HUSSAIN MOBARAKI[1]
DHIKRA ALI MOBARAKI[2]
RANA MANSOUR SALEH BAJONAID[3]
ABEER ESSA MOHAMMED ALMAJAM[4]
AISHA ALI MOJADEL SUWAYDI[5]
MATRAH HASSAN QASSEM GHAWZANI[6]

[1] CLINICAL NUTRITION DEPARTMENT, JAZAN UNIVERSITY, SAUDI ARABIA
EMAIL: ammobarki@jazanu.edu.sa ORCID: 0009-0008-2022-1288
[2] DEPARTMENT OF APPLIED MEDICAL SCIENCES, JAZAN UNIVERSITY, SAUDI ARABIA
EMAIL: Dhikra1m@gmail.com ORCID: 0009-0006-8813-8769
[3] CLINICAL NUTRITION DEPARTMENT, KING FAHAD CENTRAL HOSPITAL, MINISTRY OF HEALTH, SAUDI ARABIA
EMAIL: Rbajonaid@moh.gov.sa ORCID: 0009-0007-4396-380X
[4] CLINICAL NUTRITION DEPARTMENT, PMBNH, SAUDI ARABIA
EMAIL: Abeerm-1414@outlook.sa ORCID: 0009-0003-5751-4037
[5] HOME HEALTH CARE, JEDDAH FIRST HEALTH CLUSTER, SAUDI ARABIA
EMAIL: dietitianaisha@gmail.com ORCID: 0009-0009-1653-5118
[6] CLINICAL NUTRITION DEPARTMENT, JAZAN UNIVERSITY, SAUDI ARABIA
EMAIL: mtghazwani@jazanu.edu.sa ORCID: 0009-0003-2015-6029

Abstract

Background: Clinical decision-making and personalized dietary planning rely on correct assessment of body composition and calorie demands. Bioelectrical impedance analysis (BIA) is becoming a reliable, non-invasive technique to evaluate body composition measures including body fat mass, muscular mass, and fat-free mass. This study looked at body composition measures and advised daily calorie intake among patients at Jazan University Hospital in Saudi Arabia.

Methodology: A cross-sectional study was done with 1784 patients seen in the outpatient department of Jazan University Hospital. Anthropometric measurements and body composition readings were obtained using calibrated BIA devices. The study looked on body mass index (BMI), body fat mass (BFM), fat-free mass (FFM), skeletal muscle mass (SMM), protein levels, and percent body fat (PBF). The main result was the link between the advised daily caloric intake and these body composition variables. Using SPSS, statistical analysis was carried out with significance defined at $p < 0.05$.

Results: Participants' average age was 32.5 years; slightly more men (56.8%) made up the sample. Ninety-nine percent of the participants said they had no history of chronic illness. A surprising prevalence of abnormal adiposity indicators were 66.1% had above-normal BMI, 84.1% had elevated BFM, and 91.1% showed high PBF. In contrast, 57.1% of participants had above-normal FFM; 51.9% had high SMM. With more FFM, SMM, and protein correlating with higher caloric requirements, $p < 0.001$ shows statistically significant links between all measured body composition parameters and the recommended caloric intake.

Conclusion: This study highlights the degree to which body composition influences daily calorie needs. Higher caloric demands were positively linked to lean body mass components like skeletal muscle mass and fat-free mass, therefore stressing the need of tailored dietary evaluations. The findings support BIA's inclusion in daily clinical practice to improve dietary planning's accuracy and hence enhance health outcomes.

INTRODUCTION:

Body composition analysis has a significant role in providing insights that are important for clinical nutrition and metabolic health evaluation with a greater advantage that conventional indicators as body mass index (BMI) [1,2]. Advanced bioelectrical impedance analysis (BIA) tools have been more popular in the recent years among outpatients environments because of their ability to provide data of the body compositions including skeletal muscle mass (SMM), body fat mass (BFM), proteint levels, and percent body fat (PBF) [3-6], besides evaulating nutritional status of the patients, their metabolic health, and evaluating the disease risk depending on those factors [4,5].
Traitional anthropometric measurements as BMI could be used to determine the recommendations for caloric intake, however, new studie indicates that recommendation of caloric needs should take body composition as a significant factors instead of depending on BMI alone [7-9]. Moreover, differentiation between lean mass and fat mass is significant factors to determine the establishing energy expenditure as resting metabolic rate (RMR) and total caloric needs are associated with skeletal muscle which could not determined with BMI [10,11]. Therefore, having body-derived data and integerating them into the nutritional planning could help in maximizing weight management strategies, dietary intervention, and chronic disease prevention [12,13].
In addition, other factors as age, gender, and lifestyle habits are among the demographic factors that affect the body composition and metabolic health [14,15]. The literature shows that older age is association with loss of muscle mass and increase in the fat mass, so would affect the energy metabolism and nutritional needs [16,17]. Moreover, the differences between male and females considering muscle composition and fat distribution could affect the calorie consumption and recommendations [17]. Therefore, the assessments of these differences using body components analysis would help in more exact and tailored approach for dietary advice.
Understanding body composition profiles is crucial for tailoring dietary treatments given the growing prevalence of obesity, sarcopenia, and metabolic disorders. Among outpatients, this research seeks to analyze InBody-derived body composition statistics and connect it with recommended calorie consumption. This study aims to enhance individualized nutrition strategies and, in clinical settings, patient outcomes by examining how protein levels, body fat percentage, and skeletal muscle mass influence energy needs.

METHODOLOGY:

Using a retrospective cross-sectional design, the researchers looked at the relationship between body composition indicators and recommended daily calorie consumption among outpatients. This study was done at the tertiary care centre in Jazan, Saudi Arabia, Jazan University Hospital, which is famous for giving good outpatient services like dietary evaluation and body composition analysis. The research examined individuals who underwent body composition analysis at the outpatient clinics of the hospital between May 2022 and February 2025.
The research examined every patient record available that met the criteria. To ensure a representative sample, a retrospective random sampling technique was applied utilizing the database of hospital medical records. Eligible participants were adults 18 years of age or older with comprehensive body composition data and demographic information. Patients were turned down if they were pregnant, had missing or not enough body composition data, had implanted medical devices like pacemakers, or had medical conditions like edema that might make it hard for the bioelectrical impedance analysis (BIA) to be accurate.
Obtaining body composition data—including skeletal muscle mass (SMM), body fat mass (BFM), percent body fat (PBF), body mass index (BMI), protein levels, and visceral fat score—involved data gathering. The recommended caloric intake came from the metabolic assessment tool of the system, which estimates daily calorie needs according to individual body composition. Among the demographic and clinical data obtained from the electronic medical records were age and gender. All data were encrypted prior analysis in order to protect patient privacy and in line with ethical research requirements. Since this was a retrospective analysis, there was no need for any participant involvement or genuine recruitment.
For data analysis, descriptive statistics such means, standard deviations, and ranges were used to summarize continuous variables such body composition metrics and caloric intake; categorical variables were presented as frequencies and percentages. Differences in caloric intake and body composition parameters across sex and other demographic variables were assessed using comparative analyses including independent t-tests or Mann-Whitney U tests. ANOVA or Kruskal-Wallis tests were used to explore differences across BMI categories. Pearson or Spearman correlation coefficients were calculated

based on the normality of the data distribution to examine associations between body composition and caloric intake. To ascertain the predictive value of body composition measures for calorie intake, demographic variables were also controlled in multivariate regression analyses. To investigate possible differences, subgroup studies contrasted calorie needs for obesity status and age groups. With statistical significance defined as a p-value below 0.05, SPSS, R, or STATA program was used for all statistical studies. Since no biological samples were taken and no hazardous or unlawful chemicals were used in the study, a disposal plan is not required.

RESULTS:

A total of 1,784 patients were included in the study, with a mean age of 32.5 years (SD = 11.7). The gender distribution showed a slight male predominance, with 56.8% (n = 1,013) being male and 43.2% (n = 771) female. Regarding medical history, the vast majority of the patients (90.9%) reported no history of chronic illnesses. Among those with comorbid conditions, 4.0% had diabetes, 3.0% had hypertension, and 1.2% reported both diabetes and hypertension. Only 1.0% of the participants had dyslipidemia (Table 1).

Table 1: Demographic factors of the patients

		Count	Column N %
Age	Mean (SD)	32.5 (11.7)	
Gender	Male	1013	56.8%
	Female	771	43.2%
Medical History	None	1621	90.9%
	Diabetes	71	4.0%
	Hypertension	53	3.0%
	Diabetes/Hypertension	22	1.2%
	Dyslipidemia	17	1.0%

The average body weight among the participants was 73.73 kg (SD = 19.26), with 67.3% classified as above normal, 27.3% as normal, and only 5.4% as subnormal based on age- and gender-specific standards. Body fat mass (BFM) had a mean of 27.89 kg (SD = 13.04), where the majority (84.1%) fell into the above-normal category, while 12.3% had normal and 3.5% had subnormal fat mass. Fat-free mass (FFM) showed a mean of 45.84 kg (SD = 11.10); 60.6% had normal values, 25.8% were subnormal, and 13.6% were above normal. Skeletal muscle mass (SMM) averaged 25.25 kg (SD = 6.75), with over half (56.7%) falling in the normal range, 27.6% below normal, and 15.6% above normal. The mean BMI was 27.70 kg/m² (SD = 6.40), where 66.1% were above normal, 28.2% normal, and only 5.7% subnormal. Percent body fat (PBF) was notably elevated, with an average of 36.55% (SD = 10.83); 91.1% of participants had above-normal PBF, and only 0.2% were classified as subnormal. Protein levels averaged 9.03 g/kg (SD = 2.24), with 60.9% in the normal range, 25.6% below, and 13.5% above normal. Lastly, visceral fat level (VFL) showed a mean of 12.37 (SD = 5.6) (Table 2).

Table 2: Body composition metrics measured using BIA

		Count	Column N %
Weight	Mean (SD)	73.73 (19.26)	
	Subnormal	96	5.4%
	Normal	487	27.3%
	Above normal	1201	67.3%
BFM (Body Fat Mass)	Mean (SD)	27.89 (13.04)	
	Subnormal	63	3.5%
	Normal	220	12.3%
	Above normal	1501	84.1%
FFM (Fat Free Mass)	Mean (SD)	45.84 (11.10)	
	Subnormal	460	25.8%
	Normal	1081	60.6%
	Above normal	243	13.6%

SMM (Skeletal Muscle Mass)	Mean (SD)	25.25 (6.75)	
	Subnormal	493	27.6%
	Normal	1012	56.7%
	Above normal	279	15.6%
BMI (Body Mass Index)	Mean (SD)	27.70 (6.40)	
	Subnormal	101	5.7%
	Normal	503	28.2%
	Above normal	1180	66.1%
PBF (Percent Body Fat)	Mean (SD)	36.55 (10.83)	
	Subnormal	3	0.2%
	Normal	156	8.7%
	Above normal	1625	91.1%
Protein	Mean (SD)	9.03 (2.24)	
	Subnormal	457	25.6%
	Normal	1086	60.9%
	Above normal	241	13.5%
VFL (Visceral fat)	Mean (SD)	12.37 (5.6)	

As illustrated in Figure 1, the majority of participants (77.6%) had an above-normal recommended calorie intake based on age and gender-specific standards, while 20.6% were within the normal range. Only a small proportion (1.8%) were classified as having a subnormal recommended intake. The mean calorie requirement across the sample was 2,112.9 kcal (SD = 463.8), indicating a generally high metabolic demand in the study population (Figure 1).

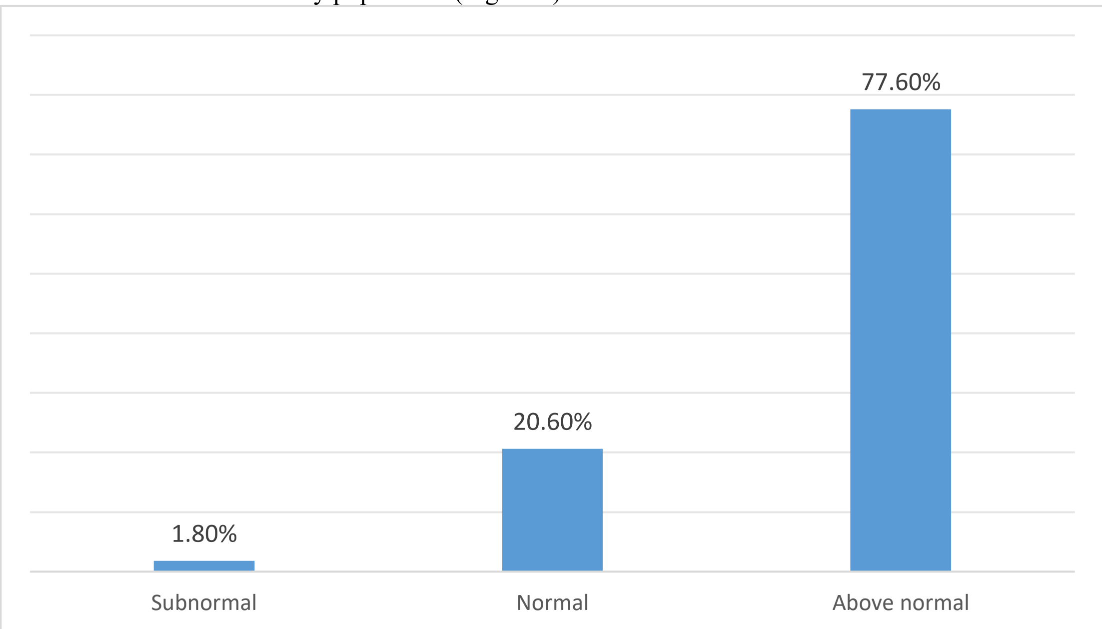

Figure 1: Recommended Calorie Intake among the patients

Table 3 presents the associations between body composition metrics and recommended calorie intake categories. All variables showed statistically significant associations with calorie needs ($p < 0.001$). For instance, individuals with above-normal weight represented the highest proportion among those requiring above-normal calorie intake (58.2%), while all individuals in the subnormal and normal intake categories were from the above-normal weight group. Similarly, elevated body fat mass (BFM) was strongly associated with higher calorie needs; 79.6% of those with above-normal intake had above-normal BFM. Fat-free mass (FFM) also correlated significantly; 58.4% of individuals with above-normal intake had normal FFM, while 30.9% had subnormal levels. Skeletal muscle mass (SMM) and protein levels also showed significant trends; 54.8% and 58.5%, respectively, of those with above-normal intake had normal values. Percent body fat (PBF) was especially telling—88.5% of participants with above-normal intake had above-normal PBF. These findings suggest a robust link between various components of body composition and the calculated caloric requirements in the population.

Table 3: The relation between body composition metrics measured using BIA and recommended calorie intake

		Recommended Calorie Intake						
		Subnormal		Normal		Above normal		
		Count	Column N %	Count	Column N %	Count	Column N %	P-value
Weight	Subnormal	0	0.0%	0	0.0%	96	6.9%	0.000*
	Normal	0	0.0%	5	1.4%	482	34.8%	
	Above normal	32	100.0%	363	98.6%	806	58.2%	
BFM (Body Fat Mass)	Subnormal	0	0.0%	0	0.0%	63	4.6%	0.000*
	Normal	0	0.0%	0	0.0%	220	15.9%	
	Above normal	32	100.0%	368	100.0%	1101	79.6%	
FFM (Fat Free Mass)	Subnormal	1	3.1%	31	8.4%	428	30.9%	0.000*
	Normal	13	40.6%	260	70.7%	808	58.4%	
	Above normal	18	56.3%	77	20.9%	148	10.7%	
SMM (Skeletal Muscle Mass)	Subnormal	1	3.1%	43	11.7%	449	32.4%	0.000*
	Normal	12	37.5%	241	65.5%	759	54.8%	
	Above normal	19	59.4%	84	22.8%	176	12.7%	
BMI (Body Mass Index)	Subnormal	0	0.0%	0	0.0%	101	7.3%	0.000*
	Normal	0	0.0%	13	3.5%	490	35.4%	
	Above normal	32	100.0%	355	96.5%	793	57.3%	
PBF (Percent Body Fat)	Subnormal	0	0.0%	0	0.0%	3	0.2%	0.000*
	Normal	0	0.0%	0	0.0%	156	11.3%	
	Above normal	32	100.0%	368	100.0%	1225	88.5%	
Protein	Subnormal	1	3.1%	38	10.3%	418	30.2%	0.000*
	Normal	13	40.6%	263	71.5%	810	58.5%	
	Above normal	18	56.3%	67	18.2%	156	11.3%	

DISCUSSION

Using bioelectrical impedance analysis (BIA) as the evaluation tool, this study offers valuable insights into the demographic profile, body composition features, and dietary needs of patients visiting Jazan University Hospital. The results highlight a significant correlation between several body composition indices and the suggested daily intake, therefore stressing the need of customized dietary evaluations in clinical practice.

The demographic data showed that, with an average age of 32.5 years, most participants were fairly young, and somewhat more males (56.8%). Interestingly, most subjects (90.9%) had no major medical history, hence lowering the possibility of confounding metabolic effects linked to chronic disease in the study. Independent of significant comorbidities, this demographic uniformity enables a more exact investigation of the link between body composition and daily needs.

Analysis of body composition revealed that, for important adiposity markers, a sizable fraction of patients had above-normal levels. Particularly, 84.1% had above-normal body fat mass (BFM), 66.1% had above-normal body mass index (BMI), and 91.1% had high percent body fat (PBF). Consistent with growing rates of overweight and obesity in Saudi Arabia and the wider Middle East region, these results point to a high frequency of excess adiposity. In this region, lifestyle changes including decreased physical activity and higher calorie intake have greatly contributed [18-20].

Metabolically worrying is excess adiposity because it is linked to insulin resistance, dyslipidemia, and a pro-inflammatory state that raises the risk for cardiometabolic diseases [21]. Furthermore, the changed hormonal environment in those with high body fat particularly increased leptin and decreased adiponectin levels can throw off energy balance and appetite control [22].

Lean body components—fat-free mass (FFM) and skeletal muscle mass (SMM)—showed strong positive relationships with suggested calorie intake, unlike adiposity. Higher FFM and SMM participants had appropriately higher daily calorie needs, which is in line with the metabolic literature [23,24]. Lean tissues, especially skeletal muscle, are quite metabolically active and are very important for resting energy expenditure (REE). Studies have shown that FFM explains between 6080% of the variance in REE, therefore highlighting its relevance for daily calorie needs [11,25].

Furthermore, skeletal muscle not only helps with basal energy expenditure but also improves insulin sensitivity and glucose metabolism, therefore impacting body energy dynamics even further [26]. Therefore, those with more muscle mass probably need more calories, which backs up the fact that in this study people with higher than normal SMM also had higher recommended calorie intake [27].

Normal or above-normal protein levels in patients showed a significant link with calorie needs. This likely reflects the role of dietary protein in promoting lean tissue maintenance and repair as well as its thermogenic effect on metabolism; therefore, insufficient protein intake reinforces the need of enough protein for keeping both muscular mass and energy balance [28]. Low protein intake can cause muscle catabolism and decreased metabolic rate, therefore emphasizing the need of sufficient protein for maintaining both muscle mass and energy balance [28].

The fact that there were statistically significant relationships between all the parameters of body composition that were measured and the recommended calorie intake ($p < 0.001$) makes BIA even more useful as a way to figure out how many calories patients in a clinical population need [1, 29]. These results back up the move from using models that estimate calories based on the population to more tailored approaches that take into account each patient's unique physical makeup, including their lean and fat mass.

These findings have real-world clinical significance. Standard indicators such as BMI sometimes fail to distinguish between fat and lean mass, therefore potentially misclassifying muscular people as overweight or underestimating metabolic needs in those with low muscle mass but high adiposity [2]. Including body composition analysis into regular clinical nutrition evaluation could thus improve the accuracy of dietary recommendations, enhance patient outcomes, and aid long-term weight and disease management.

CONCLUSION

Ultimately, this research confirms that a key predictor of calorie needs is body composition, especially the ratio between fat mass and lean mass. Including BIA-derived data into clinical treatment offers a more precise, customized foundation for dietary planning. To better grasp the dynamics of metabolism and improve nutritional treatment, future studies should investigate longitudinal changes in body composition and energy requirements across various patient groups—including those with chronic diseases.

REFERENCES:

1. Holmes CJ, Racette SB. The Utility of body composition assessment in nutrition and Clinical Practice: An Overview of Current Methodology. Nutrients [Internet]. 2021 Jul 22;13(8):2493. Available from: https://doi.org/10.3390/nu13082493
2. Wu Y, Li D, Vermund SH. Advantages and limitations of the body mass Index (BMI) to assess adult obesity. International Journal of Environmental Research and Public Health [Internet]. 2024 Jun 10;21(6):757. Available from: https://doi.org/10.3390/ijerph21060757
3. Branco MG, Mateus C, Capelas ML, Pimenta N, Santos T, Mäkitie A, et al. Bioelectrical Impedance Analysis (BIA) for the Assessment of Body Composition in Oncology: A scoping review. Nutrients [Internet]. 2023 Nov 15;15(22):4792. Available from: https://doi.org/10.3390/nu15224792
4. Sheptulina AF, Lyusina EO, Mamutova EM, Yafarova AA, Kiselev AR, Drapkina OM. Bioelectrical Impedance Analysis Demonstrates Reliable Agreement with Dual-Energy X-ray Absorptiometry in Identifying Reduced Skeletal Muscle Mass in Patients with Metabolic Dysfunction-Associated Steatotic Liver Disease and Hypertension. Diagnostics [Internet]. 2024 Oct 16;14(20):2301. Available from: https://doi.org/10.3390/diagnostics14202301
5. Sui Y, Huang Z, Dong S, Zheng Y. Comparison of the two algorithms of skeletal muscle mass index: an observational study in a large cohort of Chinese adults. Health [Internet]. 2022 Jan 1;14(08):895–909. Available from: https://doi.org/10.4236/health.2022.148063
6. Herzallah S, Alkhalaileh N, Sundookah A, Dabbour I, Abu-Samak M, Olaimat A, et al. Bioelectrical impedance analysis (BIA) of body segment composition as an obesity assessment tool

among Jordanians. African Journal of Food Agriculture Nutrition and Development [Internet]. 2024 May 31;24(5):26277–92. Available from: https://doi.org/10.18697/ajfand.130.24590
7. Rotella CM. Measurement of body composition as a surrogate evaluation of energy balance in obese patients. World Journal of Methodology [Internet]. 2015 Jan 1;5(1):1. Available from: https://doi.org/10.5662/wjm.v5.i1.1
8. Pescari D, Mihuta MS, Bena A, Stoian D. Quantitative analysis of the caloric restriction versus isocaloric diets models based on macronutrients composition: impacts on body weight regulation, anthropometric, and bioimpedance parameters in women with obesity. Frontiers in Nutrition [Internet]. 2024 Dec 12;11. Available from: https://doi.org/10.3389/fnut.2024.1493954
9. Riaz M, Lodhi S. Beyond BMI: Exploring obesity trends in the south Asian region. Obesity Pillars [Internet]. 2024 Dec 11;13:100156. Available from: https://doi.org/10.1016/j.obpill.2024.100156
10. Zampino M, Semba RD, Adelnia F, Spencer RG, Fishbein KW, Schrack JA, et al. Greater skeletal muscle oxidative capacity is associated with higher resting metabolic rate: results from the Baltimore Longitudinal Study of Aging. The Journals of Gerontology Series A [Internet]. 2020 Mar 23;75(12):2262–8. Available from: https://doi.org/10.1093/gerona/glaa071
11. Gitsi E, Kokkinos A, Konstantinidou SK, Livadas S, Argyrakopoulou G. The Relationship between Resting Metabolic Rate and Body Composition in People Living with Overweight and Obesity. Journal of Clinical Medicine [Internet]. 2024 Oct 1;13(19):5862. Available from: https://doi.org/10.3390/jcm13195862
12. Mehta NH, Huey SL, Kuriyan R, Peña-Rosas JP, Finkelstein JL, Kashyap S, et al. Potential mechanisms of precision nutrition-based interventions for managing obesity. Advances in Nutrition [Internet]. 2024 Feb 3;15(3):100186. Available from: https://doi.org/10.1016/j.advnut.2024.100186
13. Singar S, Nagpal R, Arjmandi BH, Akhavan NS. Personalized Nutrition: Tailoring Dietary Recommendations through Genetic Insights. Nutrients [Internet]. 2024 Aug 13;16(16):2673. Available from: https://doi.org/10.3390/nu16162673
14. Zeinali F, Habibi N, Samadi M, Azam K, Djafarian K. Relation between Lifestyle and Socio-Demographic Factors and Body Composition among the Elderly. Global Journal of Health Science [Internet]. 2015 Dec 18;8(8):172. Available from: https://doi.org/10.5539/gjhs.v8n8p172
15. Mohamoud HM, Kamruzzaman Md, Islam MM, Klamrak A, Rahman SS. Body Composition, Nutritional Status, and Socio-Demographic Factors among university students and teachers in Bangladesh: a pilot study. Food and Humanity [Internet]. 2024 Sep 1;100417. Available from: https://doi.org/10.1016/j.foohum.2024.100417
16. Harper EJ. Changing perspectives on aging and energy requirements: aging, body weight and body composition in humans, dogs and cats. Journal of Nutrition [Internet]. 1998 Dec 1;128(12):S2627–31. Available from: https://doi.org/10.1093/jn/128.12.2627s
17. St-Onge MP, Gallagher D. Body composition changes with aging: The cause or the result of alterations in metabolic rate and macronutrient oxidation? Nutrition [Internet]. 2009 Dec 9;26(2):152–5. Available from: https://doi.org/10.1016/j.nut.2009.07.004
18. Alsulami S, Baig M, Ahmad T, Althagafi N, Hazzazi E, Alsayed R, et al. Obesity prevalence, physical activity, and dietary practices among adults in Saudi Arabia. Frontiers in Public Health [Internet]. 2023 Mar 28;11. Available from: https://doi.org/10.3389/fpubh.2023.1124051
19. Kutbi HA, Mumena WA. Overweight and obesity among adolescents in Saudi Arabia: a multi-school cross-sectional study. BMC Pediatrics [Internet]. 2025 May 2;25(1). Available from: https://doi.org/10.1186/s12887-025-05633-5
20. Alqarni SSM. A review of prevalence of obesity in Saudi Arabia. Journal of Obesity & Eating Disorders [Internet]. 2016 Jan 1;02(02). Available from: https://doi.org/10.21767/2471-8203.100025
21. Shah A, Mehta N, Reilly MP. Adipose inflammation, insulin resistance, and cardiovascular disease. Journal of Parenteral and Enteral Nutrition [Internet]. 2008 Oct 30;32(6):638–44. Available from: https://doi.org/10.1177/0148607108325251
22. Laursen TL, Zak RB, Shute RJ, Heesch MWS, Dinan NE, Bubak MP, et al. Leptin, adiponectin, and ghrelin responses to endurance exercise in different ambient conditions. Temperature [Internet]. 2017 Feb 13;4(2):166–75. Available from: https://doi.org/10.1080/23328940.2017.1294235
23. Izuegbuna OO, Sodiq T, Olawumi HO, Olatoke SA, Agodirin O. Body composition, energy expenditure and caloric intake among breast cancer patients at a teaching hospital in Nigeria—a cross sectional study. Ecancermedicalscience [Internet]. 2023 Sep 4;17. Available from: https://doi.org/10.3332/ecancer.2023.1600
24. Lombardo M, Magarotto R, Marinelli F, Padua E, Caprio M, Annino G, et al. IDEAL REDUCTION OF CALORIES FOR GREATEST REDUCTION OF BODY FAT AND MAINTENANCE OF LEAN BODY MASS. Journal of Aging Research and Lifestyle [Internet]. 2017 Jan 1;1–6. Available from: https://doi.org/10.14283/jarcp.2017.1

25. Henkel S, Frings-Meuthen P, Diekmann C, Coenen M, Stoffel-Wagner B, Németh R, et al. Influence of ambient temperature on resting energy expenditure in metabolically healthy men and women. Journal of Nutrition [Internet]. 2025 Jan 1; Available from: https://doi.org/10.1016/j.tjnut.2025.01.013
26. Merz KE, Thurmond DC. Role of skeletal muscle in insulin resistance and glucose uptake. Comprehensive Physiology [Internet]. 2020 Jul 8;785–809. Available from: https://doi.org/10.1002/cphy.c190029
27. Ribeiro AS, Nunes JP, Schoenfeld BJ, Aguiar AF, Cyrino ES. Effects of different dietary energy intake following resistance training on muscle mass and body fat in bodybuilders: a pilot study. Journal of Human Kinetics [Internet]. 2019 Nov 30;70(1):125–34. Available from: https://doi.org/10.2478/hukin-2019-0038
28. Stokes T, Hector A, Morton R, McGlory C, Phillips S. Recent Perspectives Regarding the Role of Dietary Protein for the Promotion of Muscle Hypertrophy with Resistance Exercise Training. Nutrients [Internet]. 2018 Feb 7;10(2):180. Available from: https://doi.org/10.3390/nu10020180
29. Hu Q, Long Q, Wang W, Ma M. Bioelectrical impedance analysis for measuring body composition and predicting low muscle mass in apparently healthy pediatric outpatients: a retrospective observational study. BMC Pediatrics [Internet]. 2025 Apr 16;25(1). Available from: https://doi.org/10.1186/s12887-025-05579-8