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Body Composition and its Determinants among Gond Adult Males Tribes of Sagar, Madhya Pradesh, India

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Abstract

Introduction: Tribal populations in India are undergoing nutritional and lifestyle transitions that may influence body composition and increase the risk of obesity-related health problems. However, evidence on body composition and its determinants among the Gond tribe remains limited. The present study aimed to assess age-related trends in anthropometric and body composition variables among adult Gond tribal males and to examine the association of selected socio-demographic and lifestyle factors with body fat percentage and visceral fat percentage. **Methods:** A community-based cross-sectional study was conducted among 144 adult Gond males (≥18 years) residing in selected tribal villages of the Rehli block, Sagar district, Madhya Pradesh, India, during April 2026. Participants were selected using a multistage sampling technique. Information on socio-demographic characteristics and lifestyle practices was collected through face-to-face interviews using a pre-tested structured research schedule. Anthropometric measurements, including height, weight, body mass index (BMI), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), body fat percentage, subcutaneous fat percentage, visceral fat percentage, and skeletal muscle percentage, were obtained following standardized procedures. Data were analysed using SPSS version 27. Descriptive statistics, one-way analysis of variance (ANOVA), Pearson's correlation, and Chi-square tests were applied, with statistical significance considered at $p < 0.05$. **Results:** Significant age-related differences were observed in body weight, subcutaneous fat percentage, visceral fat percentage, skeletal muscle percentage, and WHR. Advancing age was associated with a progressive increase in visceral fat and a decline in skeletal muscle percentage. Lifestyle behaviors, particularly alcohol consumption, tobacco smoking, and gutkha use, showed significant associations with visceral fat accumulation, whereas body fat percentage was not significantly associated with the selected socio-demographic or lifestyle variables. **Conclusion:** The findings indicate that ageing and unhealthy lifestyle behaviours substantially influence body composition among Gond adult males. Visceral fat emerged as a more sensitive indicator of obesity-related health risk than BMI alone. Periodic body composition assessment and culturally appropriate health promotion strategies focusing on healthy lifestyle practices may help reduce future metabolic health risks in this tribal population.

Keywords: Gond Tribe, Body Composition, Visceral Fat, Anthropometry, Lifestyle Factors.

Resumen

Introducción: Las poblaciones tribales de la India están experimentando transiciones nutricionales y de estilo de vida que pueden influir en la composición corporal y aumentar el riesgo de problemas de salud relacionados con la obesidad. Sin embargo, la evidencia sobre la composición corporal y sus determinantes en la tribu Gond sigue siendo limitada. El presente estudio tuvo como objetivo evaluar las tendencias según la edad en variables antropométricas y de composición corporal entre hombres adultos de la tribu Gond, así como examinar la asociación de factores sociodemográficos y de estilo de vida seleccionados con el porcentaje de grasa corporal y el porcentaje de grasa visceral. **Métodos:** Se realizó un estudio transversal de base comunitaria con 144 hombres adultos Gond (≥18 años) residentes en aldeas tribales seleccionadas del bloque Rehli, distrito de Sagar, Madhya Pradesh (India), durante abril de 2026. Los participantes fueron seleccionados mediante una técnica de muestreo multietápico. La información sobre características sociodemográficas y prácticas de estilo de vida se recopiló a través de entrevistas presenciales utilizando un cuestionario de investigación estructurado y previamente validado. Se obtuvieron mediciones antropométricas incluyendo estatura, peso, índice de masa corporal (IMC), relación cintura-cadera (RCC), relación cintura-estatura (RCE), porcentaje de grasa corporal, porcentaje de grasa subcutánea, porcentaje de grasa visceral y porcentaje de músculo esquelético- siguiendo procedimientos estandarizados. Los datos se analizaron utilizando el software SPSS versión 27. Se aplicaron estadísticas descriptivas, análisis de varianza de una vía (ANOVA), correlación de Pearson y pruebas de chi-cuadrado, considerándose significativa una p < 0,05. **Resultados:** Se observaron diferencias significativas según la edad en el peso corporal, el porcentaje de grasa subcutánea, el porcentaje de grasa visceral, el porcentaje de músculo esquelético y la RCC. El aumento de la edad se asoció con un incremento progresivo de la grasa visceral y una disminución del porcentaje de músculo esquelético. Los hábitos de estilo de vida, particularmente el consumo de alcohol, el tabaquismo y el uso de *gutkha*, mostraron asociaciones significativas con la acumulación de grasa visceral, mientras que el porcentaje de grasa corporal no presentó una asociación significativa con las variables sociodemográficas o de estilo de vida seleccionadas. **Conclusión:** Los hallazgos indican que el envejecimiento y los hábitos de estilo de vida poco saludables influyen sustancialmente en la composición corporal de los hombres adultos Gond. La grasa visceral surgió como un indicador más sensible del riesgo de salud relacionado con la obesidad que el IMC por sí solo. La evaluación periódica de la composición corporal y las estrategias de promoción de la salud culturalmente apropiadas, centradas en prácticas de estilo de vida saludable, podrían ayudar a reducir los riesgos futuros para la salud metabólica en esta población tribal.

Palabras Clave: Tribu Gond, Composición Corporal, Grasa Visceral, Antropometría, Factores De Estilo De Vida.

Introduction

Body composition has rapidly emerged as a main major area of interest in contemporary research world and clinical practice, particularly in the fields of medicine, epidemiology, nutrition, public health, and exercise science (Bennett & Lim, 2025; Holmes & Racette, 2021). Beyond the conventional assessment of body weight, body composition provides detailed information regarding the distribution of fat mass, lean body mass, skeletal muscle, and visceral adiposity in the body, which are important indicators of health and disease risk (Guan et al., 2025; Prado et al., 2025). The assessment of body composition has therefore become an essential and required tool for understanding nutritional status, metabolic health, and physiological well-being across different populations of the world (Minari, 2026).

Nutritional assessment constitutes a fundamental component of body composition evaluation, as it reflects the balance between dietary intake, nutrient utilization, physiological requirements, and losses over time (Thibault et al., 2012). Anthropometric and body composition measurements provide valuable individual health information regarding the nutritional health and populations and are widely used in epidemiological and public health related studies (Yadav et al., 2026; Khadilkar & Khadilkar, 2019). Furthermore, previous study evidence suggests that the effective management of health-related conditions, physical activity patterns, and dietary practices contributes significantly to the maintenance of healthy body composition and the prevention of obesity-related disorders (Holmes & Racette, 2021).

Body composition is influenced by a complex interplay of biological, environmental, socio-economic, and lifestyle-related factors. Age, physical activity, dietary habits, educational attainment, occupational workload, and socio-economic conditions have been identified as important determinants affecting fat distribution and overall body composition among adults (Wells & Shirley, 2016). Variations in these factors often contribute to differences in nutritional status and disease susceptibility across populations.

India is home to a multiple diverse tribal population comprising approximately 8.6% of the country's total population according to the Census of India. They represent unique physic, biological and cultural groups that have adapted to distinct ecological and environmental conditions over generations (Yadav & Kumar, 2024; Office of the Registrar General & Census Commissioner, India, 2011). Owing to their relatively isolated habitats and traditional lifestyles, tribal populations provide valuable opportunities for understanding the relationship between environment, culture, nutrition, and human biology (Gautam, 2019).

In India, the Gond tribe is one of the largest and most widely distributed indigenous communities in India and belongs to the Dravidian ethno-linguistic group (Tribal Welfare Research Institute, Jharkhand, n.d.). The Gond are distributed across several Indian states, including Madhya Pradesh, Chhattisgarh, Maharashtra, Telangana, and Odisha. The Gonds possess a distinct socio-cultural identity characterized by traditional ecological knowledge, subsistence agriculture, forest-based livelihoods, and close interaction with the natural environment (Kumar, 2022; Indira Gandhi National Centre for the Arts [IGNCA], n.d.). Their close relationship with the local environment is also reflected in Gond cultural and livelihood practices (IGNCA, n.d.).

Anthropological and Sociological perspective, the Gond population provides an important framework for studying human biological variation and adaptation (Chaubey et al., 2017). Their traditional lifestyle, combined with varying levels of exposure to modernization and socio-economic transitions, offers valuable insights into the interaction of genetic, environmental, and behavioural factors affecting health outcomes (Bose et al., 2021). These influences are reflected in anthropometric characteristics, body composition patterns, and susceptibility to non-communicable diseases such as obesity, hypertension, and metabolic disorders (International Institute for Population Sciences [IIPS], 2026; Central Bureau of Health Intelligence [CBHI], 2023).

Several studies assess the nutritional and health status of tribal populations in India, information regarding body composition and its determinants among adult Gond males remains limited, particularly in the Sagar district of Madhya Pradesh (Kumar et al., 2024; Ahirwar et al., 2023). Understanding age-related changes in body composition and identifying socio-demographic and lifestyle factors associated with body fat accumulation are important for developing appropriate health interventions and nutritional strategies for tribal populations.

Therefore, the present study was undertaken to examine body composition characteristics, including body fat distribution, among adult Gond males residing in rural areas of Sagar district, Madhya Pradesh. Specifically, the study aims to assess age-related trends in anthropometric and body composition variables among adult males and to investigate the relationship of socio-demographic and lifestyle factors with body fat percentage and visceral fat percentage in the studied population.

Material and Methods

Study Design and Area

The present study was cross-sectional study. It was conducted among adult Gond tribal males residing in tribal villages of Rehli block of Sagar district, Madhya Pradesh, India, carried out during in April 2026. These studies are widely used in nutritional and anthropometric research tools to assess the health and body composition characteristics of populations at a specific point in time (Setia, 2016). Located in the Bundelkhand region of central India, Sagar district is known as the '*Switzerland of Madhya Pradesh*'. A distinctive feature of this region is its large tribal population, which includes the Gond tribe. (District Sagar, n.d.). The study was undertaken to assess body composition characteristics and identify socio-demographic and lifestyle determinants associated with body fat and visceral fat among the study population.

Study Population

The study population consisted of adult Gond tribal males aged 18 years and above. Participants belonging to the Gond tribe and residing permanently in the selected villages were included in the study. The Gond tribe is one of the most populous tribes in India and is recognized as one of the country's most populous Scheduled Tribe communities (Singh, 1997). The term “Gond” is widely believed to have originated from the Telugu word “Konda,” meaning “hill” or “mountain,” reflecting the tribe’s traditional association with hilly regions (Tribal Welfare Research Institute, Jharkhand, n.d.; IGNCA, n.d.). Members of the Gond community commonly identify themselves as “Koi” or “Koitur,” which are considered their indigenous self-designations (IGNCA, n.d.). The historical homeland of the Gonds is known as Gondwana, a region that once comprised large parts of central India (IGNCA, n.d.). In Madhya Pradesh, significant Gond populations are found in districts Sagar as well as Mandla, Balaghat, Betul, Chhindwara, Shahdol, and Damoh (Aadivart Museum, n.d.).

Sample Size and Sampling Procedure

A total of 144 adult Gond males were included in the present study. A multistage sampling technique was employed for the selection of participants. Villages predominantly inhabited by Gond tribal communities were identified in the first stage, followed by household selection through systematic field visits. All participants were selected after obtaining orally and signed informed consent. Individuals with severe physical disabilities, chronic illnesses, or conditions affecting body composition assessment were excluded from the study.

Data Collection

Data collection conducted through household surveys using a pre-tested structured research schedule. It was divided in to main two parts; first is general information regarding socio-demographic characteristics such as age, marital status, educational attainment, occupation, family type, family size, and household income was obtained through face-to-face interviews. Lifestyle-related information including tobacco use, alcohol consumption, dietary habits, and physical activity was also recorded. Second parts of research schedule included anthropometric measurements, i.e. Height (cm), Weight (kg), BMI (kg/m^2), Body Fat (%), Subcutaneous Fat (%), Visceral Fat (%), Skeletal Muscle (%), Waist Hip Ratio (WHR), Waist Height Ratio (WHtR). Standardized research schedule is considered effective tools for collecting socio-demographic and behavioural information in population-based health studies (World Health Organization [WHO], 2010). Anthropometric measurements were strictly followed the guidelines issued by ISAK and ICMR to minimize error measurements for all participants were taken at least three times (Esparza-Ros et al., 2019; Indian Council of Medical Research [ICMR], 2017).

Anthropometric Measurements

Body weight was measured to the nearest 0.1 kg using a calibrated digital weighing scale, with participants wearing light clothing and no footwear. Standing height was recorded to the nearest 0.1 cm using a portable anthropometer rod, with participants standing erect in the Frankfurt plane position. Body Mass Index (BMI) was calculated as weight in kilograms divided by the square of height in meters (kg/m^2) and categorized using BMI cut-points proposed for Asian populations (WHO Expert Consultation, 2004).

Waist circumference and hip circumference were measured using a flexible, non-stretchable measuring tape following standard anatomical landmarks. Waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, whereas hip circumference was measured at the maximum circumference over the buttocks. Waist-to-Hip Ratio (WHR) and Waist-to-Height Ratio (WHtR) were subsequently calculated to assess central adiposity and obesity-related health risks (Ashwell & Hsieh, 2005).

Body Composition Assessment

Body composition parameters were assessed using digital weighing machine, a non-invasive and widely accepted technique for estimating body composition in epidemiological and field-based studies (Kyle et al., 2004a; Kyle et al., 2004b). Measurements were conducted according to the manufacturer's recommended procedures under standardized conditions. Participants were advised to avoid heavy meals, alcohol consumption, and vigorous physical activity prior to assessment to minimize measurement variability. The digital weighing machine was used to obtain estimates of body fat percentage, subcutaneous fat percentage, visceral fat percentage, and skeletal muscle percentage. All measurements were recorded by trained anthropometrist to maintain consistency and reduce observer-related errors.

Age Classification

For analytical purposes, participants were classified into five age groups: 18-29 years, 30-39 years, 40-49 years, 50-59 years, and 60 years and above. This categorization facilitated the examination of age-related variations in anthropometric characteristics and body composition indicators, as advancing age is known to influence body fat distribution, muscle mass, and metabolic profile (Wells & Shirley, 2016).

Ethical Considerations

Prior to data collection, Permission to conduct the study was also obtained from relevant local authorities and community leaders. The objectives, procedures, potential benefits, and voluntary nature of participation were clearly explained to all eligible participants. Written and orally informed consent was obtained from each participant before enrolment in the study. Confidentiality and anonymity of the collected information were strictly maintained throughout the research process. The study was conducted in accordance with the ethical principles for biomedical and health research involving human participants as outlined by the Indian Council of Medical Research (ICMR, 2017).

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 27 (IBM Corp., Armonk, NY, USA). Descriptive statistics such as mean, standard deviation, frequency, and percentage were used to summarize the data. Age-related differences in anthropometric and body composition variables were assessed using one-way Analysis of Variance (ANOVA). Pearson's correlation analysis was employed to examine relationships between continuous variables. The association of socio-demographic and lifestyle factors on body fat percentage and visceral fat percentage was assessed using chi-squire test. A p-value of less than 0.05, 0.01, and 0.001 were considered statistically significant (Field, 2018).

Results

This study main objectives are to examine age-related variations in anthropometric measurements and body composition among adult men, and to investigate the relationship between body fat percentages (total body fat and visceral fat) and the socio-demographic and lifestyle factors of the study participants.

Table 1. Socio-demographic and Lifestyle Characteristics of the Study Population (N = 144)

Variables	Characteristics	N	%
Age Group (in year)	Mean ± SD	39.94 ± 10.71	
	18-29	60	41.70
	30-39	26	18.10
	40-49	41	28.50
	50-60	17	11.80
Education	Non educated	36	25.00
	Primary	6	4.20
	Secondary	91	63.20
	Higher Secondary and Above	11	7.60
Marital status	Unmarried	20	13.90
	Married	124	86.10
Occupation	Labour	53	36.80
	Farmer	74	51.40
	Student	17	11.80
House type	Kuccha	112	77.80
	Semi-Pucca	21	14.60
	Pucca	11	7.60
Tobacco Smoking	No	96	66.70
	Yes	48	33.30
Regular Physical Activity	No	98	68.1
	Yes	46	31.9
Alcohol consumption	No	36	25.00
	Yes	108	75.00
Gutkha	No	48	33.30
	Yes	96	66.70

Table 1 presents the socio-demographic and lifestyle characteristics of the study participants. The largest age group was 18-29 years (41.7%), while the smallest was 50-60 years (11.8%). Regarding education, the majority had received secondary education (63.2%), 25.0% were uneducated, and the smallest proportion had only primary education. Among the participants, 86.1% were married. In terms of occupation, farming was the primary activity (51.4%), followed by manual labour (36.8%). Regarding housing, 77.8% lived in kaccha houses, while 7.6% lived in pucca houses. Concerning lifestyle, 66.7% were non-smokers, whereas 33.3% consumed tobacco. A significant portion of the community (68.1%) not engaged in regular physical activity. The prevalence of alcohol consumption was 75.0%, and 66.7% consumed gutkha. The study reveals a population that is predominantly young, married, and engaged in agriculture; while they perform daily physical activity, they also exhibit high consumption of harmful substances.

Table 2 presents age-based differences in anthropometric and body composition characteristics among participants in the 18-29, 30-39, 40-49, and 50-60 age groups. The results indicate no significant difference in height across the different age groups (F = 1.933, p = 0.127). The highest mean height was observed in the 40-49 age group (165.5 ± 5.4 cm), while the lowest mean height was found in the 30-39 age group (162.1 ± 5.8 cm). A significant difference in body weight was observed across the age groups (F = 2.800, p = 0.042). The highest mean weight was recorded in the 40-49 age group (55.4 ± 8.9 kg), and the lowest was observed in the 50-60 age group (49.5 ± 6.6 kg). Although BMI was observed to decrease with age - being lower in the older age group (18.3 ± 2.4 kg/m²) - this difference was not statistically significant (F = 2.577, p = 0.056).

No significant difference in body fat was observed across age groups (F = 0.911, p = 0.438). The highest mean percentage was observed in the 18-29 age group (14.4 ± 5.2%), while the lowest percentage was found in the 30-39 age group (12.0 ± 4.4%). Similarly, no significant difference was found in the waist-to-height ratio (WHtR) across the different age groups (F = 1.803, p = 0.150). A significant difference was observed in subcutaneous fat across the different age groups (F = 2.893, p = 0.038). The highest mean value was found in participants aged 18-29 years (8.3 ± 3.9%), while the lowest value was seen in the oldest age group (5.8 ± 1.9%). A significant difference in visceral fat was observed based on age ($F = 7.840$, $p < 0.001$); mean visceral fat increased from 9.8 ± 4.3% in the 18-29 age group to 14.1 ± 4.3% in the 40-49 age group, before decreasing slightly in the oldest age group (12.0 ± 4.3%).

Table 2. Age-specific variation of anthropometric and body composition variables (Mean ± SD)

Variables	18-29 yrs (I)	30-39 yrs (II)	40-49 yrs (III)	50-60 yrs (IV)	18-60 yrs Total	F-value
Height (cm)	163.6 ± 6.9	162.1 ± 5.8	165.5 ± 5.4	164.6 ± 3.6	164.0 ± 6.0	1.933ns
Weight (kg)	54.6 ± 8.3	51.9 ± 7.0	55.4 ± 8.9	49.5 ± 6.6	53.7 ± 8.2	2.800*
BMI (kg/m²)	20.4 ± 3.0	19.7 ± 2.2	20.2 ± 3.2	18.3 ± 2.4	20.0 ± 2.9	2.577ns
Body Fat (%)	14.4 ± 5.2	12.0 ± 4.4	13.7 ± 4.9	13.1 ± 12.6	13.6 ± 6.3	0.911ns
Subcutaneous Fat (%)	8.3 ± 3.9	6.8 ± 3.1	7.8 ± 3.4	5.8 ± 1.9	7.6 ± 3.5	2.893*
Visceral Fat (%)	9.8 ± 4.3	11.4 ± 4.8	14.1 ± 4.3	12.0 ± 4.3	11.6 ± 4.7	7.840***
Skeletal Muscle (%)	10.5 ± 2.9	10.1 ± 2.5	8.6 ± 2.0	8.9 ± 1.6	9.7 ± 2.6	5.769**
Waist Hip Ratio (WHR)	0.93 ± 0.05	0.95 ± 0.04	0.98 ± 0.07	0.92 ± 0.07	0.95 ± 0.06	6.295***
Waist Height Ratio (WHtR)	0.47 ± 0.05	0.48 ± 0.05	0.48 ± 0.05	0.45 ± 0.05	0.47 ± 0.05	1.803ns

Significant at *p < 0.05 = *; p < 0.01 = **; ns = not significant

Skeletal muscle percentage varied significantly across the different age groups ($F = 5.769$, $p = 0.001$). The highest mean skeletal muscle percentage was found in participants under 30 years of age (10.5 ± 2.9%), while the lowest value was observed in the 40-49 age group (8.6 ± 2.0%), indicating a decline in muscle mass with age.

The waist-hip ratio (WHR) also differed significantly across the age groups ($F = 6.295$, $p < 0.001$). The highest mean WHR was observed in the 40-49 age group (0.98 ± 0.07), whereas the lowest value was found in participants aged 50-60 years (0.92 ± 0.07). Overall, the results indicate that age significantly affects body weight, subcutaneous fat, visceral fat, skeletal muscle percentage, and waist-hip ratio, whereas height, BMI, body fat percentage, and waist-height ratio remain relatively consistent across different age groups. These findings highlight age-related changes in body composition, particularly the increase in visceral fat and the decline in skeletal muscle mass associated with aging.

Table 3 illustrates the association of socio-demographic and lifestyle factors with body fat percentage and visceral fat percentage. The data indicate that the majority of participants belonged to the 18-29 age group (41.70%), followed by the 40-49 age group (28.50%). Chi-square analysis reveals insignificant association between body fat percentage and age group, housing type, physical activity, alcohol consumption, tobacco use, or gutkha consumption ($p > 0.05$). However, statistically significant associations were observed between visceral fat percentage and age group ($\chi^2 = 31.155$, $p < 0.01$), alcohol consumption ($\chi^2 = 8.855$, $p < 0.01$), tobacco use ($\chi^2 = 13.282$, $p < 0.01$), and gutkha consumption ($\chi^2 = 4.564$, $p < 0.05$). No significant associations were found with housing type or physical activity. These results suggest that while the distribution of general body fat does not vary significantly based on these factors, visceral fat is substantially influenced by age and specific lifestyle factors. Statistical significance is indicated as *p < 0.05, **p < 0.01, and ns = not significant.

Table 4 present a significant associations between age, anthropometric variables, and body composition indicators. Age showed a positive correlation with visceral fat ($r = 0.333$, $p < 0.001$) and waist-to-hip ratio (WHR) ($r = 0.189$, $p < 0.05$), while exhibiting a negative correlation with skeletal muscle mass ($r = -0.283$, $p < 0.01$) and subcutaneous fat ($r = -0.170$, $p < 0.05$). Weight and BMI demonstrated strong positive correlations with body fat percentage, subcutaneous fat, visceral fat, and WHtR ($p < 0.001$), highlighting their close association with adiposity. Similarly, body fat percentage showed a strong correlation with subcutaneous fat ($r = 0.781$, $p < 0.001$) and WHtR ($r = 0.544$, $p < 0.001$). Visceral fat showed a strong positive association with WHR ($r = 0.693$, $p < 0.001$) and WHtR ($r = 0.857$, $p < 0.001$), but a negative correlation with skeletal muscle mass ($r = -0.278$, $p < 0.01$). Overall, fat-related variables were strongly interlinked, whereas skeletal muscle mass showed an inverse relationship with most indicators of adiposity.

Table 5 presents the distribution of BMI categories by age group, incorporating body fat percentage and visceral fat classification. A significant association between BMI categories and body fat percentage was observed in the younger age groups - specifically those under 30 years ($\chi^2 = 21.364$, $p < 0.01$) and those aged 30-39 years ($\chi^2 = 12.699$, $p < 0.05$). This indicates that higher BMI categories in these groups are linked to elevated body fat levels. However, this association was not significant in the older age groups (40-50 and 50-60 years), suggesting that the relationship weakens with advancing age. Regarding visceral fat classification, a significant association with BMI categories was found only in the group under 30 years of age ($\chi^2 = 21.843$, $p < 0.01$), whereas no significant association was observed in the other age groups. Overall, the results indicate that BMI is a strong predictor of both body fat percentage and visceral fat in younger individuals, while this association diminishes in older age groups.

Table 3. Association of selected socio-demographic and lifestyle variables with Body Fat Percentage and Visceral Fat Percentage among the study population (N = 144)

Variables	Body Fat %				χ^2	Visceral Fat %				Total		χ^2
	Normal		High			Normal		High				
	N	%	N	%		N	%	N	%	N	%	
Age Group												
18-29	48	39.00	12	57.10	3.438 ns	34	72.30	26	26.80	60	41.70	31.155**
30-39	24	19.50	2	9.50		7	14.90	19	19.60	26	18.10	
40-49	35	28.50	6	28.60		2	4.30	39	40.20	41	28.50	
50-60	16	13.00	1	4.80		4	8.50	13	13.40	17	11.80	
House type												
Kaccha	97	78.90	15	71.40	1.551ns	37	78.70	75	77.30	112	77.80	0.235 ns
Semi-Pucca	18	14.60	3	14.30		6	12.80	15	15.50	21	14.60	
Pucca	8	6.50	3	14.30		4	8.50	7	7.20	11	7.60	
Physical Activity												
No	84	68.3	14	66.7	2.732 ns	32	68.1	66	68	98	68.1	1.548 ns
Yes	39	31.7	7	33.3		15	31.9	31	32	46	31.9	
Alcohol Consumption												
No	31	25.20	5	23.80	0.019 ns	19	40.40	17	17.50	36	25.00	8.855**
Yes	92	74.80	16	76.20		28	59.60	80	82.50	108	75.00	
Tobacco Smoking												
No	82	66.70	14	66.70	0.000 ns	41	87.20	55	56.70	96	66.70	13.282**
Yes	41	33.30	7	33.30		6	12.80	42	43.30	48	33.30	
Gutkha												
No	41	33.30	7	33.30	0.000 ns	10	21.30	38	39.20	48	33.30	4.564*
Yes	82	66.70	14	66.70		37	78.70	59	60.80	96	66.70	

Significant at *p < 0.05 = *; p < 0.01 = **; ns = not significant

Table 4. Correlation between Age, Anthropometric Variables and Body Composition Variables (n=144)

Variables	Age	Height (cm)	Weight (kg)	BMI	% Fat	Sub cutaneous Fat	Visceral Fat	Skeletal Muscle (%)	WHR	WHtR
Age	1	0.093ns	-0.103ns	-0.156ns	-0.080ns	-0.170*	0.333***	-0.283**	0.189*	-0.003ns
Height (cm)	0.093ns	1	0.356***	-0.148ns	0.068ns	0.082ns	0.185*	-0.139ns	0.023ns	-0.180*
Weight (kg)	-0.103ns	0.356***	1	0.868***	0.605***	0.756***	0.564***	-0.009ns	0.327***	0.593***
BMI	-0.156ns	-0.148ns	0.868***	1	0.603***	0.757***	0.496***	0.060ns	0.319***	0.718***
% Fat	-0.080ns	0.068ns	0.605***	0.603***	1	0.781***	0.466***	-0.037ns	0.351***	0.544***
Subcutaneous Fat	-0.170*	0.082ns	0.756***	0.757***	0.781***	1	0.612***	0.068ns	0.400***	0.731***
Visceral Fat	0.333***	0.185*	0.564***	0.496***	0.466***	0.612***	1	-0.278**	0.693***	0.857***
Skeletal Muscle (%)	-0.283**	-0.139ns	-0.009ns	0.060ns	-0.037ns	0.068ns	-0.278**	1	-0.240**	-0.133ns
WHR	0.189*	0.023ns	0.327***	0.319***	0.351***	0.400***	0.693***	-0.240**	1	0.638***
WHtR	-.003ns	-.180*	.593***	.718***	.544***	.731***	.857***	-.133ns	.638***	1

Significant at *p < 0.05 = *; p < 0.01 = **; p < 0.001 = ***; ns = not significant

Table 5. Age-wise Association of BMI Categories with Body Fat % and Visceral Fat %

Age Group	BMI	Body Fat %				Total	χ^2	Visceral Fat %				Total	χ^2
		Normal		High				Normal		High			
		N	%	N	%	N		N	%	N	%	N	
18-29	Underweight	15	31.30	0	0.00	15	21.364**	13	38.20	2	7.70	15	21.843**
	Normal	29	60.40	4	33.30	33		21	61.80	12	46.20	33	
	Overweight/ Obese	4	8.30	8	66.70	12		0	0.00	12	46.20	12	
30-39	Underweight	7	29.20	0	0.00	7	12.699*	2	28.60	5	26.30	7	0.385ns
	Normal	17	70.80	1	50.00	18		5	71.40	13	68.40	18	
	Overweight/ Obese	0	0.00	1	50.00	1		0	0.00	1	5.30	1	
40-49	Underweight	13	37.10	0	0.00	13	4.130ns	2	100.00	11	28.20	13	4.529ns
	Normal	18	51.40	4	66.70	22		0	0.00	22	56.40	22	
	Overweight/ Obese	4	11.40	2	33.30	6		0	0.00	6	15.40	6	
50-60	Underweight	10	62.50	0	0.00	10	1.948ns	3	75.00	7	53.80	10	0.697ns
	Normal	5	31.30	1	100.00	6		1	25.00	5	38.50	6	
	Overweight/ Obese	1	6.30	0	0.00	1		0	0.00	1	7.70	1	

Discussion

The current study objective was to assess age-related variations in anthropometric and body composition among Gond adult males of Sagar district, Madhya Pradesh, and to examine the relationship of socio-demographic and lifestyle factors with body fat percentage and visceral fat percentage. The findings reveal important patterns of body composition among this tribal population and provide insights into the potential determinants of nutritional health status.

The socio-demographic profile depicted that the majority of participants were young adults, married, engaged in farming and labor activities, and living in kaccha houses. Despite the physically demanding occupations of most participants, a high prevalence of alcohol consumption, gutkha use, and tobacco smoking was found, that adversely influence long-term health problems.

Age-specific variations observed significant differences in body weight, subcutaneous fat, visceral fat, skeletal muscle percentage, and waist-hip ratio. Body weight reached its highest level among individuals aged 40-49 years and declined thereafter. Such age-related reductions in body weight have been reported among rural and tribal populations and are often attributed to physiological ageing, declining nutritional intake, and gradual loss of lean body tissue. Similar age-associated changes in anthropometric characteristics have been observed among Kheria Sabar males of West Bengal and elderly rural Indian populations (Das et al., 2020; Ghosh & Bala, 2011). Although BMI showed a declining trend with age, the variation was insignificant. Finding indicate that BMI alone may not adequately capture age-related changes in body composition. The BMI limitation in distinguishing fat mass from lean mass has been widely recognized, particularly among ageing populations where muscle loss and fat redistribution occur simultaneously. Consequently, body composition indicators provide a more comprehensive assessment of nutritional status than BMI alone (Wu et al., 2024).

One of the most important findings was the significant increase in visceral fat with increasing age. Visceral fat increased from early adulthood with its highest level among participants 40-49 years of the age groups. Correlation analysis found a positive relationship between age and visceral fat. Increased visceral adiposity is considered a major risk factor for cardiovascular disease, insulin resistance, metabolic syndrome, and type 2 diabetes (Lv & Huo, 2024). Studies conducted among Indian tribal populations have similarly reported that higher visceral fat contributes substantially to cardiometabolic risk (Kshatriya & Acharya, 2016; Kuper et al., 2014).

In contrast, skeletal muscle percentage declined significantly with age and showed a negative correlation with both age and visceral fat. Age-related decline in skeletal muscle has been documented across diverse populations and is associated with reduced physical strength, lower work capacity, and increased vulnerability to metabolic disorders (Pabla et al., 2024; Wilkinson et al., 2018). The simultaneous increase in visceral fat and decline in skeletal muscle observed in the present study suggests an unfavorable shift in body composition among middle-aged and older Gond males. Similar findings have been reported among peri-menopausal women of central India and among ageing tribal populations of India, where lower muscle mass was accompanied by higher adiposity indicators (Chandel et al., 2019).

Subcutaneous fat also showed significant age-related variation and exhibited a negative correlation with age. While visceral fat increased with advancing age, subcutaneous fat tended to decrease. This pattern suggests that ageing in the study population is characterized more by redistribution of fat than by an increase in total body fat. Such findings support previous evidence indicating that body fat distribution undergoes substantial changes during adulthood, with greater accumulation of metabolically active abdominal fat (Kuk et al., 2009).

The association analysis shows that body fat percentage was insignificant with socio-demographic and lifestyle behaviours. However, visceral fat percentage showed significant associations with age group, alcohol consumption, tobacco smoking, and gutkha uses. Alcohol consumption has been linked with increased abdominal fat deposition and altered lipid metabolism, while tobacco use has been associated with central fat accumulation despite lower overall body weight (Dorn et al., 2003). These findings propound that visceral adiposity is more sensitive to behavioral and lifestyle influences than total body fat percentage. The significant association between gutkha use and visceral fat should be interpreted cautiously, as the cross-sectional design cannot establish causality and the study did not quantify dose or duration of gutkha exposure.

Correlation analysis further highlighted strong positive relationships among body weight, BMI, body fat percentage, subcutaneous fat, visceral fat, waist-hip ratio, and waist-height ratio. Particularly noteworthy was the strong correlation between visceral fat and waist-height ratio ($r = 0.857$, $p < 0.001$), indicating that waist-height ratio may serve as a useful field-based indicator of central obesity among tribal populations. Similar observations have been reported in studies examining body composition and cardiometabolic risk among Indian populations, where waist-related measures were found to be more predictive of metabolic risk than BMI alone (Sarna et al., 2021).

Age-wise analysis of BMI in relation to body fat and visceral fat revealed that BMI was a stronger predictor of adiposity among younger adults than among older individuals. Significant associations were observed between BMI and body fat percentage among participants below 40 years of age, whereas these relationships became weaker and statistically insignificant in older age groups. This finding indicates that age-related alterations in body composition may reduce the predictive value of BMI among older adults (Sruthi et al., 2023). Therefore, reliance on BMI alone may underestimate health risks among ageing tribal populations.

Thus, the present study demonstrates that age is an important determinant of body composition among Gond adult males. Advancing age is associated with increased visceral adiposity, elevated waist–hip ratio, and declining skeletal muscle mass. Lifestyle factors such as alcohol consumption, tobacco smoking, and gutkha use appear to contribute significantly to visceral fat accumulation. The findings highlight the importance of incorporating body composition assessment into tribal health programmes, as conventional anthropometric measures may fail to identify individuals at increased metabolic risk.

Conclusion

The present study findings highlight the impact of age and lifestyle factors on body composition among Gond adult males of Sagar district, Madhya Pradesh. Significant age-related differences were observed in body weight, subcutaneous fat, visceral fat, skeletal muscle percentage, and waist-hip ratio. With increasing age, visceral fat increased while skeletal muscle mass declined, pointing changes in body composition that may elevate future health risks.

Findings further revealed that alcohol consumption, tobacco smoking, and gutkha use were significantly associated with visceral fat accumulation, whereas body fat percentage showed no significant association with the selected socio-demographic and lifestyle variables. Overall, the study suggests that visceral fat is a more sensitive indicator of age and lifestyle-related health risks than BMI alone. Regular monitoring of body composition and promotion of healthy lifestyle practices are important for improving the health status of the Gond tribal population.

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Informed Consent Statement

All the athletes included in the study provided written informed consent.

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