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Short Communication

Prevalence and risk factors of underweight, overweight and obesity among a geriatric population living in a high-altitude region of rural Uttarakhand, India

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Abstract

Objective: To assess the prevalence and risk factors of underweight, overweight and obesity among a geriatric population living in a high-altitude region of India.
Design: Community-based cross-sectional study. Data were collected on socio-demographic profile and anthropometric parameters. Weight and height measurements were utilized for calculation of BMI. Nutrient intake data were collected using 24 h dietary recall.
Setting: High-altitude region of Nainital District, Uttarakhand State, North India.
Subjects: Community-dwelling geriatric subjects (*n* 981) aged 60 years or above.
Results: We found that 26·6 % of the elderly subjects were underweight (BMI < 18·5 kg/m^2). Overweight (BMI 25·0–29·9 kg/m^2) and obesity (BMI ≥ 30·0 kg/m^2) was seen among 18·0 % and 4·6 %, respectively. After controlling for potential cofounders, risk factors such as low level of education and income, chewing problems and lower number of daily meals were found to be associated with underweight. On the other hand, risk factors for overweight/obesity were lower age, high income and unskilled work.
Conclusions: There is a need to develop and implement intervention strategies to prevent underweight, overweight and obesity among the geriatric population of India.

Keywords
Underweight
Overweight
Obesity
Geriatric
High altitude

A high prevalence of malnutrition, as characterized by underweight (UW) and overweight (OW), has been reported among the geriatric population in India[1–13]. The geriatric population has an increased risk of malnutrition due to physiological changes such as reduced metabolic rate, loss of appetite, difficulties in chewing and various co-morbidities[14–16]. UW among the elderly can cause impaired muscle function and immune dysfunction that increases the risk of infection and mortality[17,18]. OW among the elderly, on the other hand, may contribute to the onset of chronic non-communicable diseases such as diabetes, hypertension and CHD, functional decline and disability, and increased mortality[1,2,19–22].

Earlier studies conducted in India suggest that identification of the risk factors associated with malnutrition in the geriatric population plays an important role in prevention of morbidity and mortality among them[1–13]. The majority of these studies have been conducted in plains regions of the country.

Lifestyle factors such as diet and physical activity are different in plains as compared with high-altitude regions of the country. We do not have scientific evidence on the risk factors associated with UW and OW among the geriatric population living in high-altitude regions of India; hence the present study was conducted to fill the gap in the existing knowledge.

Methodology

A community-based cross-sectional study was conducted during 2015–2016 in Nainital District, Uttarakhand State, North India. A total of 981 (35·6 % males and 64·4 % females) geriatric subjects were enrolled for the study. The mean age of males was 69·5 (SD 7·4) years and of

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females, 67·8 (SD 7·2) years. These subjects were selected from thirty clusters (villages) identified by using population proportional to size sampling methodology, as follows: (i) all villages in Nainital District were enlisted using the information obtained from the district census office; (ii) the corresponding total number of households was obtained for each village for calculation of the cumulative population; (iii) the sampling interval was calculated using the following: sampling interval = total cumulative population/number of clusters to be studied (i.e. 30; in Nainital District, total population = 955 128, sampling interval = 955 128/30 = 31 838); (iv) a random number of 5762 was selected between 00001 and 31 838 (four digits); (v) the first village (cluster 1) in which the population was nearly equal to the random number was identified. The cluster with corresponding cumulative population of 5762 was thus selected as cluster 1; (vi) for cluster 2, 5762 + sampling interval = 5762 + 31 838 = 37 600. The cluster with corresponding cumulative population of 37 600 was selected as cluster 2; (vii) for cluster 3, the cluster with corresponding cumulative population of 69 438 (37 600 + 31 838) was selected as cluster 3; and (viii) steps (v) and (vi) were repeated to identify the subsequent clusters.

From the selected village, one lane was selected randomly. From the selected lane, one household was selected randomly. The survey was initiated from the selected first household and contiguously covered all the required number of subjects from the cluster. If the requisite number of subjects could not be covered, then the adjacent village was covered for the remaining sample of subjects. Thirty geriatric subjects in the age group of 60 years or above were selected from each cluster by house-to-house visit. The geriatric subjects were identified with the help of village-level health and nutrition functionaries such as *anganwadi* workers, auxiliary nurse midwives and accredited social health activists.

The following exclusion criteria were adopted: (i) subjects who were unable to comprehend the questions objectively; and (ii) subjects who had auditory problems leading to non-response. We excluded six subjects who had difficulty in comprehension of the questions and ten subjects who had auditory problems leading to non-response. Sixteen subjects with similar sociodemographic profile, educational qualification and economic status were included in the study. An informed written consent was obtained from each subject after explanation of the objectives and data collection parameters for the study. The study was approved by the ethical committee of the All India Institute of Medical Sciences, New Delhi.

Data collection

Sociodemographic profile

A pre-tested structured questionnaire was administered to obtain identification data and sociodemographic profile such as gender, age, educational qualification, present occupation, family monthly income and financial dependency. The socio-economic status was calculated using the Kuppuswamy classification[23].

Anthropometric parameters

Height and weight of the geriatric subjects were measured using standard procedures. BMI was calculated using the formula: BMI (kg/m^2) = [weight (kg)]/[height (m)]^2. BMI was classified as underweight (UW; <18·5 kg/m^2), normal (18·5–24·9 kg/m^2), overweight and pre-obese (OW; 25·0–29·9 kg/m^2) and obese (OB; ≥30·0 kg/m^2) as per the WHO classification[24].

Waist circumference (in centimetres) was assessed to identify abdominal obesity. It was measured at the smallest horizontal girth between the costal margins and the iliac crest at the end of expiration, using a SECA-212 tape, to the nearest 0·1 cm. In accordance with the WHO, waist circumference of >90 cm (35 inches) in men and >80 cm (32 inches) in women was classified as abdominal obesity[25].

Dietary assessment

The dietary intake of nutrients was assessed among one-quarter of the geriatric subjects (*n* 248) using the one-day 24 h dietary recall method. The following steps were undertaken: (i) information regarding the meal pattern and the food items (cooked and uncooked) consumed by the subject was recorded; (ii) for each cooked food item consumed, the raw ingredients used for the preparation were recorded; (iii) equivalent quantities of raw ingredients used for preparation of each food item were weighed using a SECA kitchen scale and recorded; (iv) total volume of each cooked food item was recorded using standard cups; (v) the quantity of each food item consumed by the index subject was assessed using standard cups/spoons/chapatti models. The cups were used to aid the respondent recall the quantities consumed by the index subject; (vi) from steps (iv) and (v), the amount of raw ingredients in grams for each food item consumed by the index subject was calculated; and (vii) nutritive value of the raw foods consumed was determined using food composition tables from the *Nutritive Value of Indian Foods*[26]. The person responsible for cooking the food was interviewed for assessing the dietary intake of the index subject. The dietary intake of macronutrients (energy, protein, fat, carbohydrate), micronutrients (Zn, Fe, Ca, Mg, K, thiamin, riboflavin, niacin, vitamin C, folic acid) and trace elements (Cu, Mn, Mo, Cr) by the geriatric subjects was compared with the RDA for Indians given by the Indian Council of Medical Research[27].

Sample size

Assuming the prevalence of malnutrition to be 50 %[1], the desired sample size (*N*) was calculated with the formula:

$$N = \frac{z_{\text{crit}}^2 p(1-p)}{d^2},$$

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where z_{crit} is the standard normal variate corresponding to 5 % level, relative precision (p) of 5 %, design effect (d) of 2 and non-response rate of 15 %. The total sample size derived was 883 and was rounded to 900. However, we included 981 geriatric subjects in the study.

Statistical analysis

The statistical software package IBM SPSS Statistics for Windows version 20.0 was utilized for conducting the statistical analysis of the data. The χ^2 test was applied with 95 % CI to assess the association of various parameters with UW and OW among the geriatric population. To identify possible risk factors associated with UW and OW/OB, univariate linear regression analysis was performed with each factor. Multivariate logistic regression analysis was conducted on the factors that were found to be associated with UW and OW/OB to identify the independent determinants of UW and OW/OB among the geriatric population. Adjusted OR with 95 % CI were calculated. A P value less than 0·05 was considered as statistically significant.

Results

According to BMI, we found that 26·6 % of the geriatric subjects were UW. The prevalence of OW and OB was 18·0 % and 4·6 % among the geriatric subjects, respectively (Table 1). Abdominal obesity as per waist circumference was prevalent in 27·6 % of geriatric subjects.

Risk factors for underweight

High prevalence of UW was found among subjects belonging to the highest age group of >80 years (37·1 %), males (34·1 %), illiterates (30·1 %), unskilled workers (32·1 %), those with lowest monthly family income (i.e. <Rs 1865; 38·3 %), those with chewing problems (39·0 %; all $P < 0·001$) and those who consumed <2 full meals daily (29·7 %; $P = 0·003$; Table 2).

Table 1 BMI and waist circumference, by gender, of community-dwelling geriatric subjects aged 60 years or above (*n* 981) living in a high-altitude region of rural Uttarakhand, India, 2015–2016

	Male (*n* 349)		Female (*n* 632)		Total (*n* 981)	
Grade of nutritional status	*n*	%	*n*	%	*n*	%
BMI						
Underweight (<18·5 kg/m^2)	119	45·6	142	54·4	261	26·6
Normal (18·5–24·9 kg/m^2)	174	35·0	324	65·0	498	50·8
Overweight (25·0–29·9 kg/m^2)	46	26·1	130	73·9	176	18·0
Obese (≥30 kg/m^2)	10	21·7	36	78·3	46	4·6
Waist circumference						
Normal (male, ≤90 cm; female, ≤80 cm)	285	40·1	425	59·9	710	72·4
Abdominal adiposity (male, >90 cm; female, >80 cm)	64	23·6	207	76·4	271	27·6

The multivariate logistic regression analysis identified male gender, level of education and income, chewing problems and lower number of daily meals as the risk factors for UW (Table 3).

The risk for becoming UW was lower among females *v.* males (adjusted OR (AOR) = 0·4; 95 % CI 0·3, 0·6; $P \leq 0·001$), those with high school education or above *v.* illiterates (AOR = 0·4; 95 % CI 0·2, 0·8; $P = 0·009$) and with increasing monthly family income *v.* lowest income (AOR = 0·5, $P = 0·007$ for Rs 5547–9248; AOR = 0·3, $P = 0·007$ for Rs 9249–13 873; AOR = 0·5, $P = 0·034$ for ≥Rs 13 874).

The odds of becoming UW were 2·3 (95 % CI 1·6, 3·1; $P \leq 0·001$) times higher in subjects with chewing problems (*v.* those without) and 1·5 (95 % CI 1·0, 2·1; $P = 0·028$) times higher in subjects consuming <2 full meals daily (*v.* those consuming 3 full meals daily).

Risk factors for overweight

High prevalence of OW/OB was observed among subjects in the age group of 60–70 years (27·9 %), in the general community category (25·8 %), those with high school education or above (37·0 %), the unemployed (26·8 %) and those with monthly family income ≥Rs 13 874 (32·3 %; all $P < 0·001$; Table 2).

After controlling for potential confounders, the risk factors associated with OW were found to be lower age, high level of education, higher income and unskilled work (Table 3). We found that the odds of becoming OW were lower with increasing age *v.* 60–70 years (AOR = 0·4, $P \leq 0·001$ for 70–80 years; AOR = 0·3, $P = 0·013$ for >80 years), unskilled work *v.* unemployed (AOR = 0·3; 95 % CI 0·2, 0·6, $P \leq 0·001$) and those with loss of appetite *v.* without appetite loss (AOR = 0·6; 95 % CI 0·4, 1·0, $P = 0·046$).

The risk for becoming OW was found to be 2·9 (95 % CI 1·6, 5·0; $P \leq 0·001$) times higher in the general community category (*v.* Scheduled Castes/Scheduled Tribes/Other Backward Castes), 1·9 (95 % CI 1·1, 3·5; $P = 0·033$) times higher in subjects with high school education or above (*v.* illiterates) and 2·1 (95 % CI 1·2, 3·8; $P = 0·013$) times higher in those with monthly family income of Rs 5547–9248 (*v.* <Rs 1865).

Dietary assessment

Table 4 presents the mean dietary intake of nutrients by geriatric subjects stratified by BMI. The mean dietary intake of all nutrients was found to be lower among UW and higher among OW/OB geriatric subjects than among those with normal BMI. We found that geriatric subjects did not meet the RDA for energy, protein, Zn, Ca (in females), Fe (in females), folic acid, niacin, riboflavin and Cu across all BMI categories.

We found that male UW subjects had a significantly lower intakes of energy, Zn, Ca, P, thiamin, niacin, vitamin C, K, Cu (all $P < 0·05$), protein, riboflavin, folic acid, Mg and Mn (all $P < 0·01$) compared with OW/OB geriatric subjects (Table 4).

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Table 2 Sociodemographic characteristics, by nutritional status, of community-dwelling geriatric subjects aged 60 years or above (*n* 981) living in a high-altitude region of rural Uttarakhand, India, 2015–2016

	Normal (*n* 498)		Underweight (*n* 261)		Overweight/ obesity (*n* 222)		
Parameter	*n*	%	*n*	%	*n*	%	*P* value
Age (years)							
60–70 (*n* 591)	283	47·9	143	24·2	165	27·9	0·000
70–80 (*n* 285)	164	57·6	79	27·7	42	14·7	
>80 (*n* 105)	51	48·6	39	37·1	15	14·3	
Gender							
Male (*n* 349)	174	49·9	119	34·1	56	16·0	0·000
Female (*n* 632)	324	51·3	142	22·5	166	26·2	
Community							
SC/ST/OBS (*n* 190)	103	54·2	69	36·3	18	9·5	0·000
Others (*n* 791)	395	49·9	192	24·3	204	25·8	
Type of family							
Nuclear (*n* 279)	152	54·5	73	26·2	54	19·3	0·341
Joint (*n* 657)	320	48·7	179	27·3	158	24·0	
Extended *n* 45)	26	57·8	9	20·0	10	22·2	
Type of house							
Kuccha (*n* 120)	67	55·8	43	35·8	10	8·4	0·000
Semi-*pucca* (*n* 173)	82	47·4	73	42·2	18	10·4	
Pucca (*n* 688)	349	50·7	145	21·1	194	28·2	
Education							
Illiterate (*n* 519)	261	50·3	156	30·1	102	19·6	0·000
Primary school (*n* 236)	121	51·3	69	29·2	46	19·5	
Middle school (*n* 96)	49	51·0	21	21·9	26	27·1	
High school certificate or above (*n* 130)	67	51·5	15	11·5	48	37·0	
Occupation							
Unemployed (*n* 526)	254	48·3	131	24·9	141	26·8	0·000
Unskilled worker (*n* 234)	133	56·8	75	32·1	26	11·1	
Skilled worker (*n* 221)	111	50·2	55	24·9	55	24·9	
Monthly family income (Rs)							
<1865 (*n* 227)	109	48·0	87	38·3	31	13·7	0·000
1866–5546 (*n* 406)	203	50·0	118	29·1	85	20·9	
5547–9248 (*n* 142)	74	52·1	27	19·0	41	28·9	
9249–13 873 (*n* 79)	44	55·7	11	13·9	24	30·4	
≥13 874 (*n* 127)	68	53·5	18	14·2	41	32·3	
Socio-economic class							
Lower (*n* 717)	366	51·0	197	27·5	154	21·5	0·231
Middle (*n* 248)	123	49·6	63	25·4	62	25·0	
Upper (*n* 16)	9	56·2	1	6·3	6	37·5	
Financial dependence							
Yes (*n* 568)	273	48·1	157	27·6	138	24·3	0·126
No (*n* 413)	225	54·5	104	25·2	84	20·3	
Marital status							
Married (*n* 578)	296	51·2	151	26·1	131	22·7	0·915
Single/divorced/separated (*n* 403)	202	50·1	110	27·3	91	22·6	
Living arrangement							
Living with someone (*n* 938)	472	50·3	249	26·6	217	23·1	0·195
Alone (*n* 43)	26	60·5	12	27·9	5	11·6	
Loss of appetite							
Yes (*n* 229)	111	48·5	84	36·7	34	14·8	0·000
No (*n* 752)	387	51·5	177	23·5	188	25·0	
Chewing problems							
Yes (*n* 333)	148	44·4	133	39·0	52	15·6	0·000
No (*n* 648)	350	54·0	128	19·8	170	26·2	
Number of meals in a day							
3 full meals daily (*n* 305)	164	53·8	60	19·7	81	26·5	0·003
<2 full meals daily (*n* 676)	334	49·4	201	29·7	141	20·9	
Physical activity							
Yes (*n* 748)	391	52·3	188	25·1	169	22·6	0·137
No (*n* 233)	107	45·9	73	31·3	53	22·7	

SC/ST/OBS, Scheduled Castes/Scheduled Tribes/Other Backward Castes.

Intakes of energy, protein, carbohydrate, P, niacin, K (all $P < 0·05$), Fe and Mn (all $P < 0·01$) were found to be significantly higher among male OW/OB subjects than among subjects with normal BMI (Table 4).

Discussion

The present study reported a high prevalence of both UW and OW (as assessed by BMI), indicating a double burden of malnutrition, among geriatric subjects living in a high-altitude area of Uttarakhand, India. An earlier study conducted in a similar region of Uttarakhand also documented high UW and OW/OB prevalence among geriatric subjects: 35·5 and 15·9 %, respectively[13]. Studies conducted in plains regions of India have similarly shown a high prevalence of UW (range of 21–55 %)[1–7] and a higher prevalence of OW/OB (range of 26–46 %)[8–12]. We observed a lower prevalence of OW/OB, possibly because

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Table 3 Univariate and multivariate logistic regression analysis of various risk factors of underweight and overweight/obesity *v.* normal weight among community-dwelling geriatric subjects aged 60 years or above (*n* 981) living in a high-altitude region of rural Uttarakhand, India, 2015–2016

	Normal weight *v.* underweight						Normal weight *v.* overweight/obesity					
	Unadjusted			Adjusted			Unadjusted			Adjusted		
Parameter	OR	95 % CI	*P* value	OR	95 % CI	*P* value	OR	95 % CI	*P* value	OR	95 % CI	*P* value
Age (years)												
60–70	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
71–80	0·95	0·7, 1·3	0·78	0·80	0·6, 1·5	0·238	0·44	0·3, 0·6	0·78	0·39	0·2, 0·6	0·000
>80	1·51	0·9, 2·4	0·079	1·11	0·7, 1·8	0·678	0·50	0·3, 0·9	0·08	0·44	0·2, 0·8	0·013
Gender												
Male	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Female	0·64	0·4, 0·8	0·004	0·40	0·3, 0·6	0·000	1·59	1·1, 2·3	0·01	1·69	0·9, 2·9	0·063
Community												
SC/ST/OBC	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Others	0·72	0·5, 1·0	0·073	0·79	0·5, 1·1	0·214	2·95	1·7, 5·0	0·000	2·90	1·6, 5·0	0·000
Type of family												
Nuclear	1·00	Ref.	–				1·00	Ref.	–			
Joint	1·16	0·8, 1·6	0·37				1·39	0·9, 2·0	0·077			
Extended	0·72	0·3, 1·6	0·427				1·08	0·5, 2·4	0·844			
Education												
Illiterate	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Primary school	0·95	0·7, 1·4	0·796	0·79	0·5, 1·2	0·297	0·97	0·6, 1·5	0·895	0·98	0·6, 1·5	0·94
Middle school	0·72	0·4, 1·2	0·234	0·59	0·3, 1·1	0·113	1·35	0·8, 2·3	0·256	1·39	0·8, 2·6	0·285
High school certificate or above	0·37	0·2, 0·7	0·001	0·38	0·2, 0·8	0·009	1·83	1·2, 2·8	0·006	1·92	1·1, 3·5	0·033
Occupation												
Unemployed	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Unskilled worker	1·09	0·8, 1·5	0·62	0·88	0·5, 1·3	0·572	0·35	0·2, 0·6	0·000	0·34	0·2, 0·6	0·000
Skilled worker	0·96	0·6, 1·4	0·839	0·79	0·4, 1·3	0·352	0·89	0·6, 1·3	0·561	0·94	0·5, 1·6	0·817
Monthly family income (Rs)												
<1865	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
1866–5546	0·73	0·5, 1·0	0·086	0·82	0·6, 1·2	0·323	1·47	0·9, 2·4	0·109	1·37	0·8, 2·3	0·211
5547–9248	0·46	0·3, 0·8	0·003	0·47	0·3, 0·8	0·007	1·94	1·1, 3·4	0·018	2·10	1·2, 3·8	0·013
9249–13 873	0·31	0·2, 0·6	0·002	0·35	0·2, 0·8	0·007	1·91	1·0, 3·6	0·045	1·43	0·7, 2·8	0·298
≥13 874	0·34	0·2, 0·6	0·000	0·49	0·3, 0·9	0·034	2·12	1·2, 3·7	0·008	1·56	0·8, 2·9	0·158
Socio-economic class												
Upper	1·00	Ref.	–				1·00	Ref.	–			
Middle	0·95	0·7, 1·3	0·781				1·19	0·8, 1·7	0·324			
Lower	0·21	0·0, 1·6	0·136				1·58	0·6, 4·5	0·390			
Financial dependence												
Yes	1·00	Ref.	–				1·00	Ref.	–			
No	0·80	0·6, 1·1	0·159				0·74	0·5, 1·0	0·66			
Marital status												
Married	1·00	Ref.	–				1·00	Ref.	–			
Single/divorced/separated	1·06	0·8, 1·4	0·674				1·01	0·7, 1·4	0·914			
Living arrangement												
Living with someone	1·00	Ref.	–				1·00	Ref.	–			
Alone	0·90	0·4, 1·8	0·709				0·40	0·2, 1·1	0·078			
Loss of appetite												
No	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Yes	1·65	1·2, 2·3	0·003	1·33	0·9, 1·9	0·12	0·63	0·4, 0·9	0·032	0·63	0·4, 1·0	0·046
Chewing problems												
No	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
Yes	2·45	1·8, 3·3	0·000	2·26	1·6, 3·1	0·000	0·72	0·5, 1·0	0·082	0·86	0·6, 1·3	0·443
Number of meals in a day												
3 full meals daily	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–	1·00	Ref.	–
<2 full meals daily	1·64	1·2, 2·3	0·005	1·50	1·0, 2·1	0·028	0·85	0·6, 1·2	0·353	0·95	0·7, 1·3	0·777
Physical activity												
Yes	1·00	Ref.	–				1·00	Ref.	–			
No	1·41	1·0, 2·0	0·047				1·14	0·8, 1·7	0·477			

SC/ST/OBS, Scheduled Castes/Scheduled Tribes/Other Backward Castes; Ref., reference category.

of higher physical activity and active lifestyle of our geriatric subjects due to the inadequate transportation facilities and difficult terrains of hilly regions of Uttarakhand. However, abdominal obesity as indicated by waist circumference was found to be high (27·6 %), suggesting increased risk of myocardial infarction, stroke, metabolic syndrome and premature death among the geriatric subjects[25].

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Table 4 Mean dietary intake of nutrients, by gender and nutritional status, of community-dwelling geriatric subjects aged 60 years or above (*n* 248) living in a high-altitude region of rural Uttarakhand, India, 2015–2016

	Male												Female											
	Normal (*n* 55)			Underweight (*n* 33)			Overweight/obese (*n* 17)						Normal (*n* 73)			Underweight (*n* 33)			Overweight/obese (*n* 37)					
	(1)			(2)			(3)						(4)			(5)			(6)					
Nutrient	Mean	SD	% RDA	Mean	SD	% RDA	Mean	SD	% RDA	*P* value (2 *v.* 3)	*P* value (1 *v.* 2)	*P* value (1 *v.* 3)	Mean	SD	% RDA	Mean	SD	% RDA	Mean	SD	% RDA	*P* value (5 *v.* 6)	*P* value (4 *v.* 5)	*P* value (4 *v.* 6)
Energy (kJ)	6303·6	1616·7	64·9	6122·0	1501·6	63·1	7440·4	2172·8	76·6	0·015**	0·603	0·023**	5688·6	1351·0	71·5	5332·5	1528·0	67·1	5694·8	1581·1	71·6	0·334	0·24	0·982
Energy (kcal)	1506·6	386·4	64·9	1463·2	358·9	63·1	1778·3	519·3	76·6	0·015**	0·603	0·023**	1359·6	332·9	71·5	1274·5	365·2	67·1	1361·1	377·9	71·6	0·334	0·24	0·982
Protein (g)	51·2	17·5	85·3	47·2	12·6	78·7	61·4	18·1	102·3	0·002*	0·263	0·041**	44·6	13·3	81·1	42·1	14·4	76·6	44·9	12·6	81·7	0·396	0·396	0·905
Fat (g)	46·5	15·9	186·1	44·6	16·2	178·2	52·4	13·8	209·5	0·097	0·581	0·177	45·3	14·0	226·5	41·6	13·5	207·8	41·9	13·5	209·7	0·908	0·201	0·232
Carbohydrate (g)	227·6	58·7	–	229·9	55·8	–	272·3	98·3	–	0·057	0·855	0·024**	204·3	54·9	–	193·1	59·4	–	213·6	65·9	–	0·179	0·347	0·435
Zn (mg)	5·9	2·1	49·6	5·5	1·7	46·0	7·0	2·7	58·4	0·022**	0·33	0·096	5·0	1·6	50·1	4·8	2·1	48·4	5·2	1·9	52·3	0·416	0·656	0·521
Ca (mg)	768·1	419·0	128·0	734·3	290·9	122·4	957·9	476·3	159·6	0·045**	0·684	0·119	744·7	416·6	93·1	681·6	329·8	85·2	768·1	349·1	96·0	0·292	0·445	0·769
P (mg)	1248·3	382·8	208·1	1178·3	324·7	196·4	1500·2	549·0	250·0	0·012**	0·383	0·037**	1092·6	357·4	182·1	1041·7	337·9	173·6	1163·1	367·8	193·8	0·157	0·492	0·335
Thiamin (mg)	1·4	0·5	116·1	1·3	0·4	110·5	1·6	0·7	137·3	0·032**	0·472	0·076	1·2	0·3	117·1	1·1	0·4	110·7	1·2	0·4	123·0	0·191	0·405	0·417
Riboflavin (mg)	1·2	0·5	85·1	1·0	0·4	74·0	1·5	0·6	104·5	0·003*	0·123	0·061	1·0	0·4	93·0	1·0	0·5	89·5	1·1	0·4	97·7	0·413	0·674	0·534
Niacin (mg)	10·7	3·4	67·0	10·2	2·9	63·6	13·2	5·9	82·5	0·018**	0·439	0·034**	9·1	2·8	76·1	8·9	3·1	74·0	9·8	3·3	81·7	0·232	0·672	0·268
Vitamin C (mg)																								
Median	56·7		191·3	40·1		148·6	87·9		250·1	0·016**	0·26	0·254	46·5		161·0	52·5		129·3	42·3		138·2	0·702	0·24	0·41
IQR	24·8–95·8		–	29·8–81·5		–	47·0–155·0		–	–	–	–	23·2–80·8		–	30·1–70·9		–	28·4–67·0		–	–	–	–
Fe (mg)	19·2	12·2	112·7	17·4	13·2	102·2	30·6	20·8	179·8	0·009*	0·524	0·006*	17·3	14·4	82·5	15·7	10·6	74·7	16·3	9·2	77·8	0·784	0·564	0·709
Folic acid (μg)	190·3	108·4	95·1	168·6	87·8	84·3	272·6	136·3	136·3	0·002*	0·334	0·012**	160·7	83·5	80·3	138·7	77·1	69·3	166·4	86·9	83·2	0·164	0·201	0·739
Mg (mg)	370·2	152·9	108·9	330·9	116·3	97·3	455·3	174·7	133·9	0·004*	0·208	0·056	303·8	109·5	98·0	281·7	116·1	90·9	341·6	216·1	110·2	0·16	0·348	0·224
K (mg)	1581·4	539·7	–	1567·1	409·7	–	1983·7	734·3	–	0·013**	0·896	0·016**	1399·1	442·6	–	1372·1	484·7	–	1507·1	571·7	–	0·293	0·778	0·277
Cu (mg)	1·7	0·6	83·6	1·6	0·5	80·3	2·0	0·7	97·6	0·038**	0·601	0·112	1·5	0·8	73·5	1·4	0·6	68·6	1·4	0·5	71·5	0·657	0·508	0·77
Mn (mg)	4·9	1·9	246·9	4·4	1·4	220·9	6·8	2·9	338·5	0·005*	0·17	0·003*	4·1	1·3	202·5	3·8	1·5	188·3	4·4	1·5	220·3	0·076	0·336	0·205
Mo (mg)	0·3	0·2	–	0·3	0·2	–	0·3	0·2	–	0·698	0·813	0·555	0·2	0·2	–	0·2	0·1	–	0·2	0·2	–	0·384	0·135	0·778
Cr (mg)	0·03	0·02	66·3	0·03	0·01	57·2	0·03	0·01	68·6	0·177	0·245	0·827	0·03	0·01	50·5	0·03	0·02	59·3	0·03	0·02	65·9	0·531	0·181	0·023**

IQR, interquartile range.
**P* value significant at 0·01, ***P* value significant at 0·05.

We found that the male geriatric subjects ($P < 0{\cdot}001$) had a significantly higher risk of developing UW. Earlier studies conducted in Puducherry and Haryana showed that males had 2·5 times and 0·3 times higher risk of becoming UW than females, respectively[4,12]. Menopause-related weight gain, accumulation of visceral fat and adiposity in females may have accounted for lower risk of UW but higher risk of OW/OB as compared with male geriatric subjects[28].

Studies have suggested that physiological changes related to ageing lead to decrease in both fat mass and fat-free mass after 70 years of age and decrease in height[29,30]. This may have possibly resulted in higher prevalence of UW with increasing age ($P < 0{\cdot}01$) of the subjects.

In the present study, we found low educational status to be a significant risk factor for UW among the geriatric population (Tables 2 and 3). An earlier study conducted in Birmingham, Alabama, USA also reported lower educational status as the strongest predictor for UW[31]. Conversely, a recent study conducted by Ratnaprabha *et al.* in Bangalore, India documented that literate subjects had 5·3 times higher risk of becoming OW/OB possibly due to better social conditions and better access to food[12]. Several studies conducted in Brazil, Iran and Spain have reported increasing income as an important risk factor for OW/OB among geriatric subjects, as observed in the present study[32–35], whereas geriatric subjects having less than Rs 1000/month per capita income has been associated with 2·5 times higher chances of becoming UW in an earlier study conducted by Kalaiselvi *et al.* in Puducherry[7]. This suggests that educational status and economic status may have an important effect on the weight status of geriatric subjects.

In the present study, other factors such as chewing difficulties ($P < 0{\cdot}001$) and lower number of daily meals ($P = 0{\cdot}028$) consumed by geriatric subjects were identified to significantly increase their chances of developing UW. A recent systematic review documented chewing problems and loss of appetite as significant risk factors for protein–energy malnutrition and UW among geriatric subjects[36]. Previous studies conducted in West Bengal[2] and Tamil Nadu[3] also reported that subjects who had decline in food intake had 2·3 and 0·4 times higher risk of developing undernutrition, respectively.

BMI has been utilized as an indicator of chronic energy deficiency and malnutrition among geriatric subjects as it reflects the percentage of body fat and fat-free mass[37]. In the present study, we observed that geriatric subjects with low BMI had lower dietary intakes of nutrients than those with normal BMI. Earlier studies conducted in other countries have also reported similar associations[38–40]. Further weight loss due to inadequate dietary intake among these UW geriatric subjects may increase their risk of developing disability, compromised immune function, increased susceptibility to acute illnesses and reduce survival rate[41–43].

Conversely, the percentage adequacy and nutrient intakes were documented to be significantly higher among OW/OB than UW and normal-weight geriatric subjects, possibly due to overall higher quantity of food consumed by the former. The diets of the geriatric subjects were found to be high in fat density (double the RDA) and low on nutrient density. Hence, they may be at an increased risk of developing CVD and other chronic non-communicable diseases.

The strengths of the present study are as follows: (i) it is possibly the first study which has investigated the possible risk factors associated with OW/OB and UW among geriatric subjects residing in a high-altitude region of India; and (ii) it is a community-based study in which data were collected through house-to-house visit to ensure appropriate sampling. The limitation of the study is that we had to exclude subjects who were unable to comprehend the questions objectively and who had auditory problems leading to non-response.

Conclusion

In conclusion, the present study documented high prevalence of UW, OW and OB among geriatric subjects residing in a hilly region of Uttarakhand, India. Thus, there is a need to develop targeted, multifactorial interventions that aim to prevent the development of UW, as well as OW/OB, among this geriatric population. This will aid in maintenance of nutritional status among this geriatric population and delay the onset of health-related problems.

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