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ARTICLE

Relationship between nutritional status, respiratory performance and age: study among Tangkhul Naga females of Northeast India

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ABSTRACT The study aims to examine relationship between nutritional status, respiratory performance and age. Cross-sectional study was carried out among 346 Tangkhul Naga females of Northeast India, ranging in age from 20-70 years. Height, weight, body mass index (BMI), breath holding time, chest expansivity and dynamic lung function tests like forced expiratory volume in one second, force vital capacity, forced expiratory ratio and peak expiratory flow rate were studied. The results showed that both low and high BMI were associated with poor lung functions, and showed inverse relationship. Subjects with normal BMI had better respiratory efficiency as compared to underweight, overweight/obese subjects. Age plays an important role in structural and functional change. BMI and lung functions were also associated with age. BMI increased with advancing age till middle age. Values of $FEV_{1.0}$, FVC, FER, PEFR, BHT and CE declined with advancing age indicating negative association of respiratory performance with age. BMI was also independently associated with lung functions and age. Age and BMI were positively correlated, but both age and BMI has negative associations with respiratory performances. Nutritional disorder had negative impact on lung functions. Evaluating the effect of age and BMI on lung functions showed that ageing had greater impact on respiratory performance.
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KEY WORDS

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The Indian population is passing through a nutritional transition and is expected to witness higher prevalence of adult non-communicable diseases (Rao 2001). Urbanization and globalization are fuelling the nutrition transition. A major factor of the increasing prevalence of cardiovascular disease in developing countries is the on-going nutrition transition with progressive shifts to a westernized diet high in saturated fats and sugar, and a more sedentary lifestyle (Popkin 2002).

Nutritional status is a sensitive indicator of health status. Body mass index (BMI) is considered to be one of the best variables for the anthropometric evaluation in nutritional and the general health screening. On the basis of this index the relative proportion of normal, undernourished and obese people can be assessed (WHO 1995). In Asians, health risk occurs at lower levels of BMI so WHO suggested BMI categories of 23-27·5 kg/m² as increased risk and ≥27·5 kg/m² high risk (WHO Expert Consultation 2004). The health consequences of obesity range from increased risk of premature death, to serious chronic conditions that reduce the overall quality of life (WHO 2005). The burden of cardiovascular disease (CVD) has increased over the last two decades in nearly all developing countries, particularly in urban areas. According to WHO, about 80% of all deaths from CVD worldwide now occur in developing countries, and it is estimated that by the year 2010, CVD will be the leading cause of death in these countries (Boutayeb et al. 2005; CVD 2007).

Obesity has also been found to have negative associations with lung functions (Canoy et al. 2004). Further evidence that obesity may affect $FEV_{1.0}$ comes from assessments of obese patients who lost weight over a short period of time (Aaron et al. 2004). Ubilla et al. (2008) also reported negative association of nutritional disorder with $FEV_{1.0}$ and FVC. Increased lung function impairment has been found in connection with cardiovascular and all-cause mortalities. Decreased forced expiratory volume in 1 second ($FEV_{1.0}$), for example, is an independent predictor for mortalities (Schunemann et al. 2000; Sin et al. 2005). The presence of obstructive or restrictive lung diseases as assessed by spirometry is associated with a higher risk of death (Mannino et al. 2003). Poor lung functions have been found to be related to increased morbidity and mortality in smokers and non-smokers. Impaired pulmonary function, as measured by a low $FEV_{1.0}$ was found to be a predictor of mortality in the general population (Schunemann et al. 2000). Obesity causes various effects on respiratory function in the form of alteration in the respiratory mechanics, decreased

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respiratory muscle strength, decrease in the pulmonary gas exchange, a lower control of breathing and a limitation in the pulmonary function tests (Costa et al. 2008).

The present study was taken up to explore the relationship between nutritional status, respiratory performance and age among Tangkhul Naga females of Northeast India. Tangkhul Naga tribe is in transitional stage in terms of socioeconomic factors, dietary habit and lifestyle which influenced their biological attributes with increasing prevalence of nutritional disorder and associated health problems. But there has not been any study relating to the effect of nutritional transition among the Tangkhul Naga tribe and such studies among Northeast Indian tribals are scanty in spite of the recent growing urbanization, social and economic change in the region. Nutritional disorder may not affect all segments of the populations equally. Therefore, assessing the associations of nutritional disorder with related health problems would yield valuable information for policy and programmes, especially in their transitional stage as a result of urbanization, socio-economic development and lifestyle change.

Subjects and Methods

Subjects

A cross-sectional study was carried out among 346 Tangkhul Naga females of Ukhrul district of Manipur, Northeast India, ranging in age from 20-70 years. The subjects were divided into five different age groups with ten years interval each to study age trend in height, weight, BMI and lung functions. The purpose of the study and techniques to be used were explained to each subject and only those who volunteered and gave written consent were studied. The research described was compliant with basic ethical standards.

Pilot survey was conducted prior to the main study in order to standardize the techniques used. A door-to-door survey was carried out among Tangkhul Naga females to collect the anthropometric and physiological data along with information regarding their personal information, socioeconomic conditions and their ethnographic profile. The subjects were selected from Tangkhul villages in Ukhrul district. Pregnant women and those who were in lactation period were not included in the study.

Tangkhul Naga is one of the sub-tribe of Naga tribe which constitutes the major bulk of the population of Ukhrul district of Manipur state, the Northeastern most part of India, which is a mountainous region and isolated from the neighboring states by chain of hill ranges. The area of Manipur is 22,327 sq.km and is located between Latitude 23.830N to 25.680N and Longitude 93.030E to 94.780E. In Manipur, Tangkhul Nagas are the second largest tribe which constitutes 19.7% of the state's total tribal population. The Nagas are settled in the Northeastern region of India and also in the Western parts of Myanmar. Northeast India in the context of India occupies a distinctive place due to its geographical, historical, social, cultural, and political features.

Tangkhul Nagas belongs to the Mongoloid stock. The population of Tangkhul Naga is 146,075 and literacy rate is 72.7% (Census of India 2001). Traditionally the Tangkhuls were agriculturalist. The advent of Christianity and western education among them in the later part of the 19th century played a major role in transformation of their belief, traditional practices and also education, which brought about development and socio-economic changes among them. With urbanization and economic development there has been a major shift in their occupation, improvement in socio-economic status and lifestyle, and as a result nutritional transition has been observed over the years among the Tangkhul Nagas. Studies related to their biological attributes are very scanty and to the best of my knowledge the present work is perhaps the pioneering physiological anthropological study among them.

Anthropometric and physiological measurements

Anthropometric measurements were taken using standard protocols as given by Weiner and Lourie (1981). Stature was measured by anthropometer to nearest 0.1 cm and weight was measured using portable weighing machine with least count of 0.5 kg. The value of body mass index was calculated as the weight in kilograms divided by the square of the height in meters (kg/m²) and summarized age group wise, and in order to assess nutritional status, BMI was classified using recommended cut-off points for Asians (WHO 2004).

Dynamic lung functions tests like forced expiratory volume in one second ($FEV_{1.0}$), force vital capacity (FVC), forced expiratory ratio (FER) and peak expiratory flow rate (PEFR) were taken using micro-spirometer. Breath holding time (BHT) and chest expansivity (CE) were assessed using stop watch and steel tape respectively. Lung function tests are also called pulmonary function tests and were used to evaluate how well a person's lungs work. The tests determine how much air lungs can hold, how quickly one can move air in and out of lungs, and how well lungs put oxygen into and remove carbon dioxide from blood. The tests can diagnose lung diseases, measure the severity of lung problems, and check to see how well treatment for a lung disease is working. Spirometry is the most commonly done lung function test.

Forced expiratory volume in one second ($FEV_{1.0}$) is the volume of air which can be exhaled in first second of expiratory effort during a forced expiration after a maximum inspiration. Forced vital capacity (FVC) is the maximum volume of air that can be exhaled as rapidly as possible from a position of full/maximum inspiration. Forced expiratory ratio (FER) is the ratio of forced expiratory volume in one second to forced vital capacity. Peak Expiratory Flow Rate (PEFR) is the maximum rate of exhalation during the expiratory effort. It is the peak expiratory flow rate per minute. Breath holding

Table 1. Basic data and BMI of the Tangkhul Naga females in different age groups.

Age Groups	N	Stature (cm) $\overline{X}$	±SD	't' value	Body Weight (kg) $\overline{X}$	±SD	't' value	Body Mass Index (kg/m²) $\overline{X}$	±SD	't' value
20-29	98	153.2	5.67		48.2	6.57		20.5	2.35	
30-39	88	151.9	4.70	1.78	48.6	7.05	.44	21.1	2.75	1.52
40-49	65	151.9	5.53	0.01	50.9	7.79	1.86	22.0	2.47	2.09*
50-59	53	149.9	4.67	2.07*	50.6	8.06	.21	22.5	3.18	.96
60-70	42	146.6	4.48	3.51***	44.1	7.21	4.03***	20.5	2.97	3.06**
Total	346	151.3	5.50		48.7	7.49		21.2	2.78	

*p<0.05, **p<0.01, ***p<0.001

time is the maximum time for which a person is able to hold his/her breath without running into a situation of discomfort. Chest expansivity measurement is derived by subtracting chest circumference at maximum expiration from chest circumference at maximum inspiration, to give the maximum amount of stretchabilility of the thoracic cage.

Statistically analyses of the data collected were carried out using SPSS which is among the most widely used programs for statistical analysis in social science. The data taken were analyzed for descriptive statistics, Pearson correlation and in order to test the level of significance of the differences between the groups, 't' test and One-way ANOVA were performed.

Results

Basic data and BMI of the subjects are displayed in Table 1. The mean value for height, weight and BMI were found to be 151.3 cm, 48.7 kg and 21.2 kg/m² respectively. Stature was found highest in the youngest and lowest in the oldest age group. The mean value for stature decreased with age where as body weight increased with age till 49 years and decreased thereafter but the differences were statistically significant only between 50-59 years and 60-70 years age groups. BMI increased with age till 59 years and decreased thereafter. 't' test value with level of significance showed the measure of differences between test groups, which are consecutive decadal age groups. In the table, 't' value showed that the differences in mean BMI was statistically significant between 30-39 years and 40-49 years, and also between 50-59 years and 60-70 years age groups.

Table 2 shows distribution of Tangkhul Naga females according to BMI as assessed from Asian cut-off points in different age groups. The result showed that there were significant number of overweight and obese subjects and the prevalence increased with age till 59 years and sharply decline thereafter. The percentage of subjects with normal BMI was found highest among the youngest (20-29 years) age group and lowest among 50-59 years age group. The prevalence of underweight was also found lowest among 40-49 years age group. The prevalence of overweight were found more among the three middle age groups *i.e.* 30-39 years, 40-49 years and 50-59 years, and maximum percentage of obese was found among 50-59 years age group. Among the middle age groups there were more overweight/obese than underweight subjects.

Table 3 displays cross tabulation of age and BMI with respiratory performance. It depicts the effect of age and BMI on lung functions. The mean values of $FEV_{1.0}$, FVC, FER and PEFR were found to be maximum in the youngest age group and declined with advancing age from youngest to the oldest age group. BHT and CE were also found maximum in the youngest age group and declined with advancing age with slight fluctuations. ANOVA F-value showed that the differences between the mean values of all the lung functions in different age groups were highly significant.

Table 3 also shows lung functions in different BMI categories. $FEV_{1.0}$, FVC and PEFR were found to be maximum among subjects with normal BMI, followed by overweight and then by underweight subjects in most cases, though the differences were statistically non significant as shown by F-value. BHT and CE increased with increasing BMI with slight fluctuation. Both low and high BMI were associated with poor lung functions. Obese subjects had the lowest mean values of all the lung functions. Overweight/obesity was related to lung function impairment among the Tangkhul Nagas.

Correlations of age, BMI and lung functions are given in Table 4. Pearson correlations among age, BMI and lung

Table 2. Distribution (in percentage) of Tangkhul Naga females according to BMI in different age groups.

Age Groups	Body mass index (BMI) Under-weight	Normal weight	Over-weight	Obese	Total
20-29	18.4	65.3	15.3	1.0	100.0
30-39	19.3	53.4	26.1	1.1	100.0
40-49	4.6	58.5	35.4	1.5	100.0
50-59	9.4	47.2	35.8	7.5	100.0
60-70	31.0	52.4	16.7	-	100.0
Total	16.2	56.6	25.1	2.0	100.0

Table 3. Cross tabulation of age and BMI with respiratory performance.

Age and BMI	N	FEV$_{1.0}$ (lit. BTPS) $\overline{X}$	±SD	FVC (lit. BTPS) $\overline{X}$	±SD	FER (%) $\overline{X}$	±SD	PEFR (lit/min) $\overline{X}$	±SD	BHT (sec) $\overline{X}$	±SD	CE (cm) $\overline{X}$	±SD
Age Group													
20-29 yrs	98	1.95	.47	2.07	.51	93.6	5.84	242.0	76.77	24.7	12.04	6.3	1.51
30-39 yrs	88	1.82	.40	2.01	.43	90.4	7.50	223.9	69.54	20.1	7.21	6.0	1.41
40-49 yrs	65	1.69	.38	1.92	.43	87.7	8.16	212.2	70.17	20.9	9.58	5.5	1.16
50-59 yrs	53	1.46	.29	1.67	.36	87.4	7.72	183.4	53.06	19.3	7.90	5.6	1.39
60-70 yrs	42	1.21	.25	1.46	.28	83.6	7.98	153.0	61.55	20.1	7.15	5.1	1.35
Total	346	1.70	.46	1.89	.48	89.5	7.95	212.0	74.20	21.4	9.53	5.8	1.44
ANOVA		F=33.951, p=.000		F=19.857, p=.000		F=16.989, p=.000		F=15.379, p=.000		F=4.313, p=.002		F=8.547, p=.000	
Body Mass Index													
Underweight	56	1.66	.48	1.83	.48	89.70	8.65	205.41	79.82	20.27	9.29	5.5	1.43
Normal	196	1.74	.46	1.93	.48	89.45	8.09	215.46	71.00	21.54	9.10	5.9	1.40
Overweight	87	1.68	.43	1.85	.46	89.78	7.42	211.61	79.50	21.64	10.04	6.0	1.58
Obese	7	1.40	.22	1.60	.23	87.14	4.41	174.43	36.65	24.14	16.34	5.6	.58
Total	346	1.70	.46	1.89	.48	89.53	7.95	212.03	74.20	21.41	9.53	5.8	1.45
ANOVA		F=1.621, p=.184		F=1.828, p=.142		F=.252, p=860		F=.887, p=.448		F=.487, p=.691		F=1.848, p=.138	

Respiratory Performance: Lung Functions (FEV$_{1.0}$, FVC, FER, PEFR); BHT and CE (BHT, CE).

Table 4. Correlations of Age, BMI and lung functions.

	Age	BMI	FEV$_{1.0}$	FVC	FER	PEFR	BHT	CE
Age	1.000	.114*	-.529**	-.421**	-.399**	-.382**	-.163**	-.289**
BMI	.114*	1.000	-.055	-.036	-.070	-.034	.034	.081
FEV$_{1.0}$	-.529**	-.055	1.000	.936**	.348**	.705**	.189**	.230**
FVC	-.421**	-.036	.936**	1.000	.020	.605**	.183**	.174**
FER	-.399**	-.070	.348**	.020	1.000	.395**	.055	.167**
PEFR	-.382**	-.034	.705**	.605**	.395**	1.000	.178**	.162**
BHT	-.163**	.034	.189**	.183**	.055	.178**	1.000	.155**
CE	-.289**	.081	.230**	.174**	.167**	.162**	.155**	1.000

* p<0.05; ** p<0.01 (2-tailed)

functions showed that age had significant positive correlation with BMI, but had statistically significant negative correlation with all the lung functions FEV$_{1.0}$, FVC, FER, PEFR, CE and BHT. BMI showed significant positive correlation with age but negative correlation with FEV$_{1.0}$, FVC, FER and PEFR. All the lung functions were significantly correlated with each another.

Discussion

Body mass index and body weight increased till middle age depicting the accumulation of fat with age, and slightly declined among older subjects as was also reported by Kapoor and Tyagi (2002). It can be due to more energy intake, fat rich diet and relatively less energy expenditure among the younger subjects. The reason for decline in stature in advanced age could also be due to thinning of intervertebral discs as well as flabbiness of muscles, changing the posture which is an impact of ageing on height among the old subjects. Aiken (1995) reported that a loss of collagen between spinal vertebrae causes the spine to bow and the height to shrink.

Age had an impact on both BMI and lung functions among Tangkhul Naga females. All the lung functions, FEV$_{1.0}$, FVC, FER, PEFR, BHT and CE were found more efficient among the younger subjects and declined steadily with advancing age till the oldest age group. It showed that respiratory performance has negative association with advancing age. Earlier study also reported significant associations of age with physiological functions including lung functions (Mungreiphy et al. 2007). Reduced flow rates are due to a combination of airway narrowing and decreased lung recoil (Brusasco and Pellegrino, 2002). Reduced elasticity of the lungs results in increased functional residual capacity and closing volume, reduced vital capacity and forced expiratory volume (Bell et al. 1980). Lung function impairment increased with age in the present study which was consistent with other studies (Hankison et al. 1999; Canoy et al. 2004).

The present study showed that nutritional status as assessed from BMI had impact on lung functions. Subjects with normal BMI had better respiratory efficiency than underweight and overweight subjects. Respiratory efficiency was found lowest among obese subjects. Negative association between overweight/obesity and lung functions was observed among the Tangkhul Nagas. Ubilla et al. (2008) also found consistent evidence in males and females that a BMI of less than 20 and 30 or over are negatively associated with $FEV_{1.0}$ and FVC in comparison to a BMI of 20–24.9, although the differences were not always statistically significant stratified by sex. BMI as a composite measure of lean and fat tissues may not provide a single explanation for its relation with $FEV_{1.0}$ and FVC. At lower BMI, where fatness may be moderate, an increase in BMI may represent in part an increase in muscle and this would explain a positive relation between BMI and lung function, but beyond a BMI level in which the increment is due to more adipose tissue, say 30 or more, $FEV_{1.0}$ and FVC start to decrease. Similar finding had also been reported by Canoy et al. (2004). Naimark and Cherniack (1960) showed that reduced compliance of the total respiratory system in obese individuals was almost entirely related to reduced chest wall compliance.

In the present study, lung functions, $FEV_{1.0}$, FVC, PEFR, BHT and CE were found to increase with increasing BMI from underweight till normal weight but deceased beyond BMI of 23 kg/m². This finding confirmed previous reports by Schoenberg and colleagues which stated that weight adjusted for height increased lung function, but beyond a certain point, decreased lung function (Schoenberg et al. 1978). Overweight/obesity has been shown to be inversely related to lung functions among the Tangkhul Nagas.

Pearson correlations showed that both BMI and age had negative associations with respiratory performances among the Tangkhul Naga females but age and BMI were positively correlated with one another. Evaluating the effect of age and BMI on lung functions and performance as assessed from ANOVA F-value and correlations showed that ageing had the greater impact on respiratory performance though BMI also had significant influence on lung functions.

Conclusions

This study showed that nutritional status based on BMI, lung functions and age were interrelated. There is negative association between nutritional disorder especially overweight/obesity and respiratory performances. BMI and lung functions were also independently associated with age. Lung function impairment increased with age. The Tangkhul Nagas were traditionally agriculturalist so many of the older subjects were still continuing the occupation which require more physical activity but still had lower respiratory efficiency pointing to the dominant affect of age. All the lung functions declined with advancing age. BMI is independently associated with both lung functions and age.

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