European Journal of Clinical Nutrition (2002) 56, 484–489
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0954–3007/02 $25.00
www.nature.com/ejcn

ORIGINAL COMMUNICATION

Body mass index and morbidity in adult males of the War Khasi in Northeast India

R Khongsdier[1]*

[1]*Department of Anthropology, North-Eastern Hill University, Shillong, India*

Objective: Data on the relationship between obesity, or high body mass index (BMI), and morbidity in adult individuals are frequently reported, but little is known about the relationship between morbidity and low BMI especially in developing countries. The present study was therefore an attempt to evaluate the relationship between BMI and morbidity in adult individuals.
Design: The analyses were derived from the data based on self-reported morbidity and anthropometric measurements taken on adult males. The results were presented according to age and income groups for individuals of reporting and non-reporting illness.
Subjects: The total sample size was 575 adult males (18 – 59 y) of the War Khasi population.
Setting: Rural area of the state of Meghalaya in Northeast India.
Results: The prevalence of chronic energy deficiency (CED) was found to be 35%, although the mean BMI ($20.06 \pm 2.65\ kg/m^2$) in individuals of non-reporting illness was higher than in those reported for many populations of Northeast India. The relationship between BMI and reported illness was not significant, although the morbidity curve tended to be U-shaped, and the prevalence of reported illness (32%) was highest in the individuals with BMI below $17.0\ kg/m^2$. Moreover, the suggested cut-off 18.5 of BMI for screening the prevalence of CED did not correspond with the rise in morbidity, but both BMI and morbidity were significantly associated with age and income of the household.
Conclusion: In view of the present analysis and other related literature, BMI is likely to be a better indicator of standards of living than a predictor of illness as the latter may also predispose individuals to the former. Thus, morbidity and low BMI may be considered parts of ill health, which are influenced by a number of biological and environmental factors especially age, economic conditions, undernutrition, safe water sanitation, community pathogens, prevention and control measures of locally endemic diseases and infections.
European Journal of Clinical Nutrition (2002) **56,** 484 – 489. doi:10.1038/sj.ejcn.1601281

Keywords: body mass index; morbidity; economic condition; India

Introduction

Body mass index (BMI: weight in kg/height in m^2) has been widely adopted for assessing obesity and chronic energy deficiency (CED) of an adult individual, or a population. It is also well documented that mortality risk increases with the increase in BMI values (Garrow, 1981,1988; Garrow & Webster, 1985; WHO, 1990), besides its positive relationship with economic conditions (Bharati, 1989; Naidu & Rao, 1994; Sichieri *et al*, 1994; Cornu *et al*, 1995; Nubé *et al*, 1998; Reddy, 1998). With regard to the lower value of BMI, a number of studies have suggested the higher mortality rate in individuals with low BMI (Waaler, 1984, Harris *et al*, 1993). Henry (1994) has suggested that BMI below $13.0\ kg/m^2$ in adult males and $11.0\ kg/m^2$ in adult females may be considered the lowest thresholds of mortality risk. Of course, it has been reported that the relationship between BMI and mortality is U-shaped (Troiano *et al*, 1996). However, it is not yet clear whether the BMI $< 18.5\ kg/m^2$, which is suggested as the cut-off point for screening CED individuals (James *et al*, 1988; Ferro-Luzzi *et al*, 1992; Shetty & James, 1994; WHO, 1995), is also associated with morbidity,

*Correspondence: R Khongsdier, Department of Anthropology, North-Eastern Hill University, Mayurbhanj Complex, Nongthymmai, Shillong-793 014, India.
Guarantor: R Khongsdier.
E-mail: rkhongsdier@hotmail.com or romendro@sancharnet.in
Received 17 January 2001; revised 31 May 2001; accepted 6 June 2001

especially in developing countries. In Bangladesh, it has been suggested that morbidity rates among adult males increases when the BMIs are below 17.0 kg/m^2 (James *et al*, 1988). Using probit analysis of data collected by IFPRI and the World Bank from four developing countries, *viz* Philippines, Kenya, Pakistan and Ghana, Garcia and Kennedy (1994) have observed that the increase in morbidity is not consistent with the CED grades of BMI, although it is perceptible in Pakistan. However, a report from Brazil has indicated that there is a marked increase in morbidity among adult individuals with BMI below 18.5 kg/m^2 (de Vasconcellos, 1994). Also, Strickland and Ulijaszek (1993) have observed that the symptoms of self-reported illness are negatively associated with BMI among the Iban tribe of rural Sawarak. In the Indian subcontinent, less is known about such a relationship, although data from a South Indian population have revealed that mortality rate tends to increase with the decrease in BMI (Shetty & James, 1994). Thus, the present paper attempts to find out the possible relationship between BMI and morbidity in the War Khasi population of Northeast India.

Subjects and methods

Study area and sample

The present study was conducted in the East Khasi Hills district of the state of Meghalaya in Northeast India during the period between October 1993 and February 1994. The area lies between 25° 08′ and 25° 25′ north latitude and 91° 20′ and 92° east longitude, bordering Bangladesh. It is characterized by deep valleys with the Cherrapunji climate having the heaviest rainfall in the world. This area is mainly inhabited by the War Khasi, one of the sub-groups of the Khasi tribe, who speak the Monkhmer language of the Austro-Asiatic group, and have been following the matrilineal system of society.

The main occupation of the people is agriculture and their staple food is rice. They depend largely on the supply of rice from other states of the country. Our earlier studies showed that about 40% of the households consumed calories less than the recommended level for the Indian population, and there were widespread deficiencies of vitamins A and B_2 (Khongsdier, 1994). It was also suggested that people in this area experienced not only nutritional stresses, but also infections, especially in the monsoon season (Khongsdier, 1996), However, the present study was conducted in winter, or harvest season.

The present data were collected from 366 households of the five villages selected by means of systematic random sampling of the listed villages in the area. No statistical sampling of individuals was applied for collection of anthropometric data due to operational difficulties in the field. Instead an attempt was made to include in our sample all those adult males (aged 18–59 y) who were willing to cooperate in carrying out the present work.

Measures

Body weight and height are the two anthropometric measurements considered in the present study. A beam-balance scale (100 g precision) was used to weigh the subjects barefoot, wearing light apparel. The balance was checked against a standard weight after weighing each subject. The height was measured with a Harpenden anthropometer (1 mm precision), following as far as possible the methods described in Weiner and Lourie (1981). The subject was asked to stand on the horizontal platform or wall with both heels together, 'stretching upward to the fullest extent' in the Frankfurt horizontal plane. In doing so, the subject was helped by applying gentle upward pressure on the mastoid process and by encouraging him to stand erect and 'take a deep breath and relax'. Then the horizontal arm of the anthropometer was brought down to touch the vertex lightly. Measurement was repeated twice and the average thereof was recorded as the height of the subject.

Data on morbidity were based on 'self-reported illness experience' of an individual as generally adopted in a different survey, which did not involve a clinician (Strickland & Ulijaszek, 1993; Garcia & Kennedy, 1994; Strickland & Tuffrey, 1997). The self-reported illness method is also preferable from the point of view that a clinical diagnosis involves a lot of time, cost and technical expertise, which are not always possible in carrying out community-based studies in many developing countries like India. As such, a self-reported illness might be considered the second alternative proxy for assessing the morbidity status of a population in developing countries.

In this study, morbidity is defined in terms of the number of 'days ill' and/or 'days unable to work' in the last 4 weeks before the survey. Each adult male included in the study was asked whether or not he had been ill at any time in the last four weeks? If yes, how many days had he been in bed or unable to work due to illness? An individual who reported at least 2 days ill was classified as being 'ill'. No attempt was made to determine the frequency of a specific disease or symptom. Of 575 adult males included in the study, 23.83% (137) of them reported to have experienced illness for at least 2 days in the last 4 weeks prior to the survey. This proportion includes those who were still unable to go to work at the time of survey because of illness in the last 4 weeks.

Data on household income were collected directly from the head of the household after developing a rapport through a prolonged stay in the field, and they were cross-checked taking into consideration some aspects of socio-economic conditions like housing condition, types of occupation, land holding and monthly expenditure. A household with a per capita monthly income of Rs 300.00 (US\$1 = Rs31.37, February 1994) was considered appropriate by the people themselves as a minimum subsistence income level, and to delineate the poverty line in the present study. This per capita monthly income of Rs 300.00 is found to be more or less equivalent to $\bar{X} - 4\text{s.d.}/\sqrt{n}$, where n stands for the number of households and $\bar{X}$ is the average monthly per capita income of the households. In other words, the average per capita monthly income of 366 households covered under the present study was Rs 342.53 with a standard deviation of Rs 195.26. Accordingly, the three economic groups were classified as follows: above ($\bar{X}+4$ s.d./$\sqrt{n}$) = high income group (HIG); ($\bar{X}-4$ s.d./$\sqrt{n}$) to (mean + 4 s.d./$\sqrt{n}$) = middle income group (MIG); below ($\bar{X}-4$ s.d./$\sqrt{n}$) = low income group (LIG).

Statistical analyses

Statistical analyses for the results presented in this paper were carried out using Statistica/PC Software in which the level of significance was set at 5%. The analysis was first carried out to present the means and standard deviations of anthropometric variables *viz*, height, weight and BMI according to different age groups for individuals of reporting illness and non-reporting illness. The correlation coefficients were used to estimate the relationship between income and BMI as well as between age and anthropometric variables, while the differences between age groups in respect of each anthropometric variable were tested by one-way analysis of variance (ANOVA) including the Newman–Keuls multiple range test. On the other hand, the differences between individuals of reporting illness and non-reporting illness were determined, using Student's *t*-test. Then, analysis of covariance (ANCOVA) was used to test the differences between income groups in respect BMI with age as a covariate. Data were also analyzed on the distribution of BMI according to different grades of CED (James *et al*, 1988), and the prevalence of reported illness in each grade of CED. Then, the chi-square (χ^2) test was used to determine the differences between BMI categories in respect of the prevalence of illness. Finally, logistic regression was used to determine the factors that might influence morbidity. The morbidity dummy was 1 for those individuals who reported illness, and 0 for those who were not ill. The income variable was expressed in terms of individual score, whether a given adult male belonged to LIG, MIG or HIG (based on per capita monthly income of the household to which he belonged), which were graded as 1, 2 and 3, respectively. The other covariates relative to morbidity were the age (in years) and BMI of each individual.

Results

Table 1 gives the means and standard deviations of height, weight and BMI according to three broad age groups for individuals of reporting and non-reporting illness. It was found that the difference between individuals of reporting and non-reporting illness in height was not statistically significant ($P<0.05$), but the former are significantly heavier ($t=2.08$, $n=573$, $P<0.05$) and having a higher BMI ($t=3.37$, $n=573$, $P<0.001$) than the latter.

Among individuals of reporting illness, the coefficient of correlation ($r\pm$standard error) indicates that age is negatively associated with both weight ($r=-0.186\pm0.085$, $t=2.19$, $P<0.02$) and BMI ($r=-0.182\pm0.085$, $t=2.14$, $P<0.02$), but the one-way ANOVA indicates that the differences between age groups in respect of these two anthropometric variables are not significant ($P>0.05$). On the other hand, the differences between age groups are highly significant for both weight ($F(2, 435)=6.53$, $P<0.001$) and BMI ($F(2, 435)=4.59$, $P<0.001$) among individuals of non-reporting illness, in which age is negatively associated with both weight ($r=-0.221\pm0.050$, $t=4.42$, $P<0.0001$) and BMI ($r=-0.191\pm0.05$, $t=3.82$, $P<0.0001$). However, according to the Newman–Keuls multiple range-test, the younger (18–31 y) and middle aged (32–45 y) groups in individuals of non-reporting illness do not deviate

Table 1 Means and standard deviations of body weight, height and BMI by age groups

		Height (cm)		*Weight (kg)*		*BMI (W/H^2)*	
Age groups (y)	*Number*	*Mean*	*s.d.*	*Mean*	*s.d.*	*Mean*	*s.d.*
Reporting illness							
18–31	28	159.04	5.71	48.21	4.57	19.04	1.68
32–45	49	158.32	4.47	49.41	7.03	19.76	3.24
46–59	60	157.27	4.87	47.41	6.22	18.77	2.47
18–59	137	158.19	4.90	48.29	6.67	19.18	2.67
ANOVA *F*-statistics		0.515		1.219		1.944	
Coefficient of correlation ($r\pm$s.e.)		0.015 ± 0.086		-0.186 ± 0.085**		-0.182 ± 0.085**	
Non-reporting illness							
18–31	151	157.78	4.97	50.25	6.31	20.22	2.41
32–45	153	157.75	4.59	50.57	6.79	20.39	2.95
46–59	134	157.33	4.56	47.91*	6.25	19.49*	2.45
18–59	438	157.64	4.71	49.65	6.73	20.06	2.65
ANOVA *F*-statistics		0.420		6.530***		4.590**	
Coefficient of correlation ($r\pm$s.e.)		-0.045 ± 0.048		-0.221 ± 0.05***		-0.191 ± 0.05***	

Significantly lower than the age groups 18–31 and 32–45 according to Newman–Keuls multiple range test; **$P<0.02$; ***$P<0.0001$.

significantly from each other in respect of both weight and BMI, but both of these age groups differ significantly from the older age group (46–59 y).

Tables 2 and 3 show that there is a significantly positive correlation between income and BMI for individuals of reporting illness ($r=0.242\pm0.047$, $t=5.21$, $P<0.0001$) as well as for individuals of non-reporting illness ($r=0.469\pm0.075$, $t=6.17$, $P<0.0001$). The one-way ANCOVA also indicates that the differences between income groups in BMI adjusted for age are highly significant in both individuals of reporting ($F(2, 133)=14.88$, $P<0.0001$) and non-reporting ($F(2, 434)=9.60$, $P<0.001$) illness. However, the Newman–Keuls multiple range test indicates that the differences between LIG and MIG are not statistically significant, but the BMIs in these two income groups are significantly lower than that in the HIG, and it holds good for both males of reporting and non-reporting illness.

The percentage distribution of BMI categories is given in Table 4. According to James *et al* (1988), adult individuals with BMIs of <16.0, 16.0–16.9 and 17.0–18.4 kg/m^2 may be classified as grades III (severe), II (moderate), and I (mild) CED, respectively. Following this classification of CED grades, about 35% of the adult men in the present population had suffered from CED. The table also shows the reported illness for more than 2 days in the last 4 weeks before the survey, which was higher in those adult males with lower and higher BMIs, as observed in the case of mortality in Western countries (Troiano *et al*, 1996). However, the differences between BMI categories in respect of the illness frequency were not statistically significant ($\chi^2=8.62$, d.f.$=4$, $P>0.05$). Further, there was not much difference between the normal (18.5–19.9 kg/m^2) and mild (17.0–18.4 kg/m^2) groups of CED in respect of illness frequency, although the curve tends to be U-shaped (Figure 1). Nevertheless, the prevalence of reported illness was highest in the individuals with BMI < 17.0 kg/m^2.

Figure 2 shows the illness pattern (illness days) by age and income group. It indicates that the duration, or days of illness, is higher in the lower income groups (LIG and MIG) than in the HIG across age groups, although the latter had higher duration than the MIG in the age group 32–45 y. With the exception of MIG, the duration of illness

Table 2 Means and standard deviations of BMI by income groups

	Non-reporting illness			Reporting illness		
Income group	n	*Mean*	*s.d.*	n	*Mean*	*s.d.*
LIG	161	19.50	2.24	63	18.42	1.62
MIG	143	19.96	2.60	50	18.96	2.02
HIG	134	20.82	2.96	24	21.65	4.27
ANCOVA *F*-statistics		9.602*			14.883**	
Coefficient of correlation (r±s.e)		0.242±0.047**			0.469±0.075**	

Table 3 Newman–Keuls multiple range test (probability level)

	Non-reporting illness		Reporting illness	
Income group	*LIG*	*MIG*	*LIG*	*MIG*
LIG	—		—	
MIG	0.1171	—	0.2345	—
HIG	0.0001	0.0050	0.0000	0.0000

*$P<0.001$; **$P<0.0001$.

Table 4 Distribution of BMI and prevalence of illness

			Prevalence of reported illness	
BMI categories	n=575	*Percent*	n	*Percent*
<17.0	65	11.30	21	32.31
17.0–18.4	137	23.83	37	27.01
18.5–19.9	124	21.57	33	26.61
20.0–22.0	167	29.04	28	16.77
>22.0	82	14.26	18	21.95

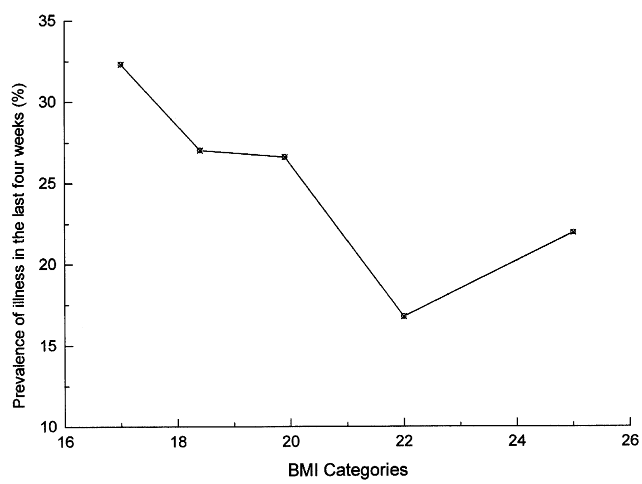

Figure 1 Frequency of illness by BMI categories.

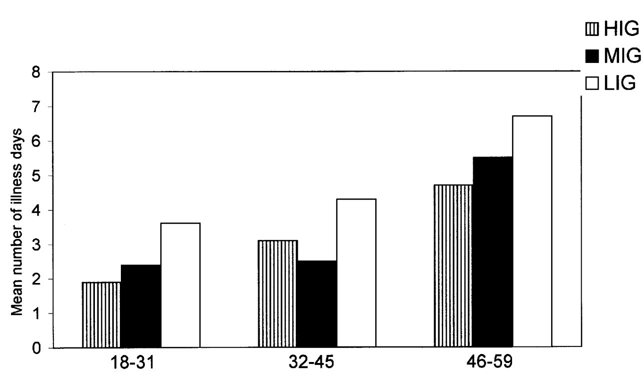

Figure 2 Morbidity by age and income groups.

increased with the advance in age for all the income groups. Thus, both age and income levels are likely to play an important role in patterning the duration of illness in the adult males of this population. Table 5 also shows that the logistic regression coefficient ($\beta \pm$ standard error) of illness on age was positively significant (0.045 ± 0.009, $P < 0.000$). It also indicates that income had a significantly negative effect on illness ($\beta = -0.269 \pm 0.133$, $P < 0.04$). The effect of BMI on illness is, however, not statistically significant ($\beta = -0.071 \pm 0.044$, $P > 0.05$). Therefore, the absence of a significant effect of BMI on illness makes it difficult to give an explanation as to whether low BMI predisposes illness of individuals, or illness is responsible for low BMI. But it is obvious that illness is significantly associated with economic condition and age of a person.

Discussion

The mean BMI ($20.06 \pm 2.65\,kg/m^2$) for individuals of non-reporting illness in this population was higher than in many populations in Northeast India (Khongsdier, 2001) and south Indian populations (Ferro-Luzzi *et al*, 1992), although it was not as high as those reported for the well-to-do classes (Visweswara Rao *et al*, 1990, 1995; Reddy, 1998). It is also observed that body weight and BMI are significantly higher in the individuals of non-reporting illness than in those of reporting illness, although the relationship between BMI and morbidity in the present population is not clearly perceptible. The logistic regression analysis has revealed that other factors like age and income are very important in influencing morbidity.

The relationship between age and BMI is negatively significant. Despite the absence of statistical difference between the young (18–31 y) and middle-aged (32–45 y) men, body weight and BMI are significantly lower in the older age group (46–59 y) than in the younger age groups, as also reported for other populations (Berio *et al*, 1985; Mott *et al*, 1999). It may be noted that, in this terrain population of Northeast India, the nature of work (agricultural work) is similar to all age groups considering the daily wages given to a male labourer. As such, the nature of work compounded by age and poor economic conditions may be associated with such a low BMI in the elderly men. Of course, it warrants further in-depth studies with a view to understanding this problem.

Table 5 Summary of logistic regression of morbidity on age, BMI and income

Parameters	*Coefficient (β)*	*Standard error*	*Wald test*	*Probability level*
Intercept	−1.157	1.003	1.33	0.249
Age	0.045	0.009	23.53	0.000
BMI	−0.071	0.044	2.61	0.107
Income	−0.269	0.133	4.09	0.044

Deviance (likelihood ratio) $\chi^2 = 41.753$, d.f. = 3, $P < 0.000$.
Deviance goodness of fit = 439.221, d.f. = 499, $P = 0.975$.

Allowing for age, the BMIs are significantly higher in the HIG when compared with the LIG and MIG. Thus, the present findings confirm those earlier reports for other populations, which indicate the positive effect of economic conditions on BMI (Bharati, 1989; Reddy, 1998; Nubé *et al*, 1998). Also, the high prevalence of CED, as per the suggested cut-off point of 18.5 BMI, in the adult males of the present population seems to be consistent with the earlier observations in other Indian populations (Ferro-Luzzi *et al*, 1992; Naidu & Rao, 1994; Khongsdier, 2001).

As regards morbidity, the present results indicate that the reported illness according to BMI categories tends to be U-shaped with the highest frequency when the BMI is below $17.0\,kg/m^2$. Despite the absence of statistical significance, this observation is to a certain extent similar to that reported for the relationship between BMI and mortality in Western countries (Troiano *et al*, 1996). Nevertheless, the overall relationship between BMI and morbidity is not clear in this population of Northeast India. For this reason, we are not in a position to argue that BMI predisposes illness, or the latter is attributable to the former. It may be noted that Garcia and Kennedy (1994) have also observed the absence of a significant relationship between BMI and illness in the Philippines and Ghana, although data from Pakistan and Kenya suggest to a certain extent that 'illness predisposes individuals to low BMI'. Also, their observation that the suggested cut-off of BMI 18.5 is inconsistent with the rise of morbidity seems to be corroborated by the present findings.

Since the present study is concerned neither with the symptoms nor with specific diseases, it is premature to give any proper conclusion, but it may be surmised that both morbidity and low BMI are confounded by undernutrition, poor hygienic and economic conditions as well as little access to medical aid facilities, and so on, as generally observed in many developing countries (Chandra, 1983; Mitra, 1985; WHO, 1990; Shetty & James, 1994). It is obvious that both BMI and morbidity are significantly associated with age and income of the household in the present population. Thus, morbidity and low BMI are likely to be symptoms of ill health in this population, which are subject to the influence of other biological and environmental factors, especially age, economic conditions, undernutrition, safe water sanitation, community pathogens, prevention and control measures of locally endemic diseases and infections. In fact, it has been suggested that BMI may be considered an indicator of standards of living, especially in developing countries (Nubé *et al*, 1998). The results of the present study support such a contention.

Summary and conclusions

The present study is an attempt to disseminate information on the association between low BMI and morbidity, taking into account the economic conditions of a population. The study population is characterized by a high prevalence of CED, which is a common characteristic of rural populations in the Indian subcontinent. The association between BMI and morbidity is, however, not clearly perceptible, although the curve tends to be U-shaped. The logistic regression analysis has revealed that the morbidity pattern in the War Khasi is associated not only with economic conditions, but with age as well, and its significant relationship with BMI disappears after allowing for these variables. Moreover, the suggested cut-off point of BMI 18.5 for screening the prevalence of CED is inconsistent with the rise in morbidity in this population. However, it may be concluded that BMI and morbidity are significantly associated with income of the household, and the former is likely to be a better indicator of standards of living.

Acknowledgements

The author wishes to express his gratitude to his colleagues in the Department of Anthropology at North-Eastern Hill University, Shillong, for encouragement to carry out the study. Thanks are also due to all the adult males of the study area who kindly cooperated and participated in the study.

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