The prevalence of malnutrition among high and low altitude preschool children of southwestern Saudi Arabia

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ABSTRACT

الهدف : تحديد نسبة حدوث سوء التغذية في الأماكن ذات العلو الكبير ومقارنتها بالأماكن ذات الإرتفاع القليل عن مستوى سطح البحر ودراسة العوامل المؤثرة وذلك عند أطفال ما قبل مرحلة الدراسة في المنطقة الجنوبية الغربية من المملكة العربية السعودية .

الطريقة : تمت الدراسة بالشكل المقطعي المعروف على ٥٧٢ و ٤٦٩ طفل سعودي (أعمارهم مابين سنة إلى خمس سنوات) ممن ولدوا و عاشوا بشكل مستمر و دائم في منطقة ذات علو كبير أو في منطقة ذات علو أقل عن سطح البحر على التوالي وذلك خلال السنه ٢٠٠٣م. تم معايرة الوزن مع العمر , الوزن مع الطول و العمر مع الطول (حسب توصية منظمة الصحة العالمية) لتحديد نقص الوزن،الهزال و التقزم على التوالي. تمت دراسة العلاقة بين معدل إنتشار سوء التغذية مع كلا من العمر، الجنس،الإرتفاع عن سطح البحر وحالة الأسرة الإقتصادية والإجتماعية .

النتائج : الأنواع الثلاثة لسوء التغذية كانت أعلى عند أطفال المناطق الأقل إرتفاع عن مستوى سطح البحر مقارنة بأطفال المناطق الأكثر إرتفاع عن مستوى سطح البحر وكذلك نفس النسبة كانت أعلى عند أطفال الآباء والأمهات الأميين مقارنة بأطفال الآباء والأمهات المتعلمين. تزداد نسبة حدوث نقص الوزن والتقزم مع زيادة عمر الطفل بينما تزداد نسبة حدوث نقص الوزن والهزال عند الأطفال الذكور مقارنة بالإناث . كان هناك تناسب عكسي بين دخل الفرد السنوي في الأسرة وبين نسبه حدوث نقص الوزن والتقزم. بينت الدلات الإحصائية المتعددة (بعد محايدة العوامل الأخرى) أن الأماكن الأقل إرتفاع عن مستوي سطح البحر تظل عامل رئسي لنسبة حدوث سوء التغذية عند الأطفال .

خاتمة : قد يعزى زيادة نسبة حدوث سوء التغذية لدى أطفال المناطق المنخفضة مقارنة بقرائنهم من أطفال المناطق المرتفعة إلى برودة واعتدال الطقس في المناطق المرتفعة من جهة، ومن جهة أخرى قد يعزى ذلك لكثرة نسبة حدوث الإنتنات المدارية عند أطفال المناطق القليلة الارتفاع عن مستوى سطح البحر. توصي الدراسة بعمل دراسات أخرى لتقصي الأسباب ومن ثم محاولة إيجاد الحلول .

Objective: To assess the current status of protein energy malnutrition (PEM) in the high and low altitude preschool children aged 12-71 months.

Methods: A cross-sectional study conducted during the year of 2003 and involved 572 and 469 preschool children of Southwestern Saudi Arabia born and living permanently at high and low altitude areas. Anthropometric measurements were carried out to assess the prevalence of PEM using 3 indicators such as underweight, wasting and stunting following World Health Organization standards. Prevalence differences were examined by age, gender, altitude, and parental socioeconomic status.

Results: The prevalence of the 3 types of PEM was significantly higher at low altitude than at high altitude and significantly higher among children born to illiterate than to educated parents. Older children were more underweight and stunted than younger children and underweight and wasting were significantly more common in boys than girls. Annual family income per person was negatively and significantly associated with underweight and stunting, but not with wasting. Multivariate analysis showed that after controlling for all sociobiological factors, low altitude remained a strong risk factor.

Conclusions: The difference in PEM between high and low altitude preschool children could be related to the milder environmental conditions at high altitude and the higher incidence of tropical infections in lowland children. Future studies are required to verify these speculations, and to establish programs to control and prevent PEM in preschool children at low altitude.

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Protein energy malnutrition (PEM) is a major health problem in children in developing countries worldwide.[1-3] In addition to having its serious effect on physical health,[4,5] it may also have adverse effects on cognitive and behavioral development.[6,7] Studies of PEM among different races and geographical areas can help to define risk factors and improve control measures. In the Kingdom of Saudi Arabia (KSA) only few studies have addressed PEM[8-12] and most of these were conducted in urban areas[9,10,12] where socio-economic conditions are typically higher than in rural areas. Southwestern Saudi Arabia is less urbanized than in other areas of KSA and is characterized by high and low altitude areas. There is a general impression that PEM is more common among highland than lowland children.[13-15] This study was therefore undertaken to determine the PEM prevalence in rural high and low altitude preschool children in Southwestern Saudi Arabia and to identify specific at risk groups. Prevalence differences were examined by age, gender, altitude, and parents socioeconomic status.

Methods. This study was carried out in high and low altitude areas of the Aseer province in the Southwestern region of Saudi Arabia. Alsoda village and villages around the Sabit Allia city were selected as high altitude regions (2800-3150 m) and the villages around Mohyel city were selected as low altitude regions (500 m). Environmental data on these areas are shown in **Table 1**.[16] Alsoda is approximately 600 km and Sabit Allia is approximately 520 km south of Jeddah (the second city in the Kingdom). Moyhel city lies in the Tihama valley approximately 550 km south of Jeddah. Health services in the study site areas are provided by health centers run by qualified physicians who used 2 referral hospitals within easy reach of paved roads and potable drinking water and electricity are available in all sites. The highlanders are primarily farmers, and the lowlanders are both farmers and cattle breeders, however, an increasing number of both regions have begun to commuting to work in urban centers. Meat, chicken, and rice are the major dietary components for people living in either region.

Data were collected from 572 preschool children between one and <6 years who lived at high altitude since birth (approximately 90.2% of the total preschool children registered at health centers in high altitude study sites) and 469 preschool children of comparable age who lived at low altitude since birth (about 91.3% of the total preschool children registered at health centers in the low altitude study sites). Local people working in the health centers were instructed to recruit preschool children who were registered in both regions. Subjects who had not lived at high or low altitude study site since birth were excluded from the study. All the subjects were Arab and Saudi nationals, and all measurements, and interviews were made in the health centers. Approval was taken from Health Affairs of Aseer Region and consent was obtained from the parents after explaining to them the purpose, methods, benefits and risks of the study.

This study was carried out during 2003. Age was calculated and recorded from the birth certificate of each child at the time of examination. Body weight was measured twice using a baby scale (Seca 725) for children <2 years and an Avery beam weighing scale (Seca 710) for children >2 years. Supine length was measured twice using a measuring board (Harpenden) for children <2 years and a stadiometer (Seca 214)) for children >2 years. Body weight of children in their minimal clothing was measured to the nearest 0.1 kg and the height was determined without shoes to the nearest 0.5 cm. A pre-structured questionnaire was used to collect other data including family size, family income, and education level. Family size included father, number of wives, number of children, and number of dependents (such as grandparents). Family income represented by annual income of the father and mother in Saudi Riyals (SR) (1 US dollar=3.75 SR). Annual family income per person (AFI/P) was then computed by dividing the family income by the family size and categorized it into 3 levels as low <3000, moderate 3000-12000, and high >12000 SR. Parental education was categorized into 4 levels: illiterate, primary school, secondary school, and university. Protein energy malnutrition was assessed using the following indices:[17] Underweight: proportion of preschool children below -2SD from the median weight-for-age of the World Health Organization/National Center for Health Statistic (WHO/NCHS) reference population.[17] Wasting: proportion of preschool children below -2SD from the median weight-for-height (WHO/NCHS) reference population.[17] Stunting: proportion

Table 1 - Environmental data on the high and lowland areas.

Environmental parameter	Highland	Lowland
Altitude (meter)	2800-3150	500
Barometric pressure (mm Hg)	550-590	720
Atmospheric oxygen tension (mm Hg)	110-120	145
Relative humidity (%)	20-30	50-90
Summer temperature (shade) (^{0}C)	16-28	30-45
Winter temperature (shade) (^{0}C)	5-15	25-35

of preschool children below -2SD from the median height-for-age (WHO/NCHS) reference population.[17] At different stages of the study the collected data were compiled and entered into a computer. We used SPSS Version 10 for statistical analysis. Student t-test and chi-square test were used as an appropriate to measure statistical significance. Crude odd ratios (cOR) and 95% confidence interval (CI) were computed to identify the risk of developing PEM. Multivariate logistic regression was then used to estimate the combined odd ratios, and their attendance were adjusted for confounders at 95% confidence interval.[18] The probability value of <0.05 was considered statistically significant.

Results. The total number of children in the high altitude study site was 572 with a response rate of 90.2% and in the low site 469 with 91.3% response rate. Two hundred eighty-seven (50.2%) boys and 285 (49.8%) girls were included in the high altitude cohort and 252 (53.7%) boys and 217 (46.3%) girls were included in the low altitude group. There was no significant difference between the gender percentages at either altitude. The mean ages ± SD of boys was 3.5 ± 1.3 years at high altitude and 3.7 ± 1.3 years at low altitude, and the mean age ± SD of girls was 3.6 ± 1.3 years at high altitude and 3.7 ± 1.4 years at low altitude. There were no significant differences in the mean age of each gender at either altitude.

Table 2 - Number and (percentage) of preschool children born to parents in the 4 educational categories and 3 levels of annual family income per person in Saudi Riyals.

Characteristics	High altitude		Low altitude	
Education of father				
Illiterate	88	(15.9)	183	(40.5)
Primary	169	(30.6)	236	(52.2)
Secondary	131	(23.7)	29	(6.4)
University	165	(29.8)	4	(0.9)
Total*	**553**	**(100.0)**	**452**	**(100.0)**
Education of mother				
Illiterate	322	(58.1)	340	(73.4)
Primary	156	(28.1)	108	(23.3)
Secondary	58	(10.6)	15	(3.2)
University	18	(3.2)	0	
Total*	**554**	**(100.0)**	**463**	**(100.0)**
AFI/P (SR)				
<3,000	83	(15.0)	126	(28.0)
3,000-11,999	281	(50.7)	267	(59.3)
>12,000	190	(34.3)	57	(12.7)
Total*	**554**	**(100.0)**	**450**	**(100.0)**

AFI/P - annual family income per person,
*The differences in total between characteristics attributed to missed values.

Parental education and AFI/P[19] were used as indicators for socioeconomic status (SES). **Table 2** shows the number and percentage of children born to parents in each educational category. In both high and low altitude regions, significantly more children were born to educated than illiterate fathers ($p<0.0001$). The opposite trend was observed when the percentage of children born to educated, and illiterate mothers were compared ($p<0.0001$). None of the mothers in the low altitude region had a university education and only a small proportion of lowland children (0.9%) were born to fathers who finished college. The mean AFI/P of the highland parents (10536.2 ± 9261.7 SR) was significantly higher than the lowland parents (5822.7 ± 4461.6 SR) ($p<0.0001$). Approximately 85% of highland preschool children were born to parents with AFI/P ≥3000 SR as compared to approximately 73% of lowland preschool children. The remaining percentages (15% of highland and 27% of lowland children) were born to parents with AFI/P <3000 SR ($p<0.0001$) (**Table 3**). The overall prevalence of underweight, wasting and stunting at the 2 study sites were 32.2%, 17.3% and 23.9%. The effects of altitude, age, gender, and 2 indicators of SES on the 3 types of PEM were individually studied. To avoid null cells, the comparison was carried out by dividing the children into 2 age groups, one to <4 years, and 4 to <6 years. Low AFI/P was defined as <3000 SR and moderate to high income was defined as ≥3000 SR. Parental education level was classified as either illiterate or educated. **Table 3** shows the prevalence of the 3 types of PEM by altitude, age, gender and parental SES. The prevalence of underweight, wasting and stunting was significantly higher at low altitude than at high altitude. Of children in both areas, the prevalence of children who were underweight and stunted, but not wasted, increased significantly between the youngest and the oldest age group. Boys were more commonly underweight and wasted than girls yet no significant relationship was observed between stunting and gender. The prevalence of the 3 types of PEM was significantly higher among preschool children born to illiterate than educated parents. Annual family income per person was negatively associated with underweight and stunted children but not with wasted children. **Table 4** summarizes the risk factors of the 3 types of PEM in the Aseer region of Southwestern Saudi Arabia.

Multivariate analysis was used to further study the low altitude as a risk factor for the 3 types of PEM. The results presented in **Table 5** show that controlling variables in the univariate analysis (**Table 4**) did not substantially change the odd ratios (ORs) for low altitude, indicating that these variables did not alter the association between low altitude and being underweight, wasted and stunted.

Table 3 - The prevalence of underweight, stunting and wasting by altitude (high versus low), gender (male versus female), age (<4 years versus ≥4 years), parental education (illiteracy versus education) and annual family income per person (<3000 Saudi Riyals versus ≥3000 Saudi Riyals).

Parameters	Underweight	Wasting	Stunting
Altitude			
High altitude	68 (11.9)	34 (5.9)	85 (14.9)
Low altitude	267 (56.9)†	146 (31.1)†	164 (35.0)†
Gender			
Boys	191 (35.4)**	109 (20.2)**	139 (25.8)‡
Girls	144 (28.7)	71 (14.1)	110 (21.9)
Age (years)			
1-<4	149 (29.4)	96 (19.0)‡	108 (21.3)
4-6	168 (34.8)*	84 (15.7)	141 (26.4)*
Educational attaintment (father)			
Illiterate	136 (50.2)†	69 (25.5)†	84 (31.0)**
Educated	186 (25.3)	104 (14.2)	159 (21.7)
Educational attaintment (mother)			
Illiterate	247 (37.3)†	128 (19.3)**	186 (25.4)*
Educated	80 (22.5)	49 (13.8)	72 (20.3)
AFI/P (Saudi Riyals)			
<3000	92 (49.7)†	35 (18.9)‡	66 (35.7)†
≥3000	154 (29.3)	107 (14.3)	154 (20.6)

Data are expressed as number and (percentage). †p=0.0001, *p=0.04, ‡not significant, **p=0.001, x^2 - Chi square, AFI/P - annual family income per person.

Table 4 - Unadjusted crude odds ratios (cOR) and 95% confidence intervals (CI) of significant sociobiological factors that contribute to protein energy malnutrition (PEM) development. These include children ≥4 years versus <4 years, boys versus girls, low altitude children versus high altitude children, children who born to illiterate parents versus children born to educated parents and children who their family income <3000 Saudi Riyals versus children who their family income ≥3000 Saudi Riyals (SR).

Risk factor	Underweight		Wasting		Stunting	
	cOR	95% CI	cOR	95% CI	cOR	95% CI
Age >4 years	1.28	(0.98-1.66)	0.80	(0.58-1.10)	1.32	(0.99-1.76)
Boys	1.37	(1.05-1.77)	1.54	(1.11-2.14)	1.24	(0.93-1.65)
Low altitude	9.80	(7.17-13.39)	7.15	(4.80-10.65)	3.08	(2.29-4.15)
Illiteracy of father	2.97	(2.22-3.97)	2.07	(1.47-2.92)	1.62	(1.19-2.22)
Illiteracy of mother	2.05	(1.52-2.75)	1.50	(1.05-2.14)	1.34	(0.98-1.83)
AFI/P <3000 SR	3.05	(2.19-4.26)	1.40	(0.92-2.13)	2.14	(1.51-3.03)

AFI /P: annual family income per person, SR: Saudi Riyals, cOR: Crude odds ratios, CI: confidence intervals.

Table 5 - Multivariate logistic regression model: Adjusted odds ratio (OR) and 95% confidence intervals (95% CI) of significant sociobiological factors that contribute to protein energy malnutrition (PEM) development. These include children who older than 4 years versus younger than 4 years, boys versus girls, low altitude children versus high altitude children, children who born to illiterate parents versus children born to educated parents and children who their family income <3000 Saudi Riyals versus children who their family income ≥3000 Saudi Riyals.

Independent variable	Underweight		Wasting		Stunting	
	OR	95% CI	OR	95% CI	OR	95% CI
Age >4 years	1.33	(0.95-1.86)	0.75	(0.51-1.10)	1.28	(0.93-1.77)
Boys	1.38	(0.99-1.93)	1.40	(0.95-2.0.7)	1.28	(0.93-1.76)
Low altitude	9.08	(6.43-12.83)	7.31	(4.68-11.41)	3.07	(2.21-4.26)
Illiteracy of father	1.50	(1.01-2.22)	1.09	(0.69-1.71)	1.11	(0.75-1.64)
Illiteracy of mother	1.21	(0.83-1.75)	1.00	(0.65-1.55)	1.02	(0.71-1.64)
AFI/P <3000 SR	2.08	(1.39-3.10)	0.99	(0.0.62-1.57)	1.63	(1.11-1.40)

AFI/P - annual family income per person, SR: Saudi Riyals, OR: Adjusted odds ratio, CI: confidence intervals
Confounders include age, gender, altitude, parents education and family income.

Discussion. The present study shows that the prevalence of the 3 types of PEM (underweight, wasting, and stunting) was significantly higher at low than high altitude. This is surprising considering that the high altitude hypoxia can result in retarded body growth.[13,14] Studies show that children living at high altitude are shorter and more linear than similar aged children who live at low altitude.[13-15] The difference is attributed to the growth-retarding effect of high altitude hypoxia as well as racial, dietary, and economic factors.[20] However, retarded body growth did not appear to be a feature of highlanders in the tropical regions. Studies of children who live in the Simen Mountains of Ethiopia[21] and the Sarwat Mountains of Saudi Arabia[22] show that highlanders are taller and heavier than lowlanders. In this case, the difference is attributed to the higher incidence of malaria and other tropical infections in the lowland populations.[21] In this study, we eliminated racial and dietary factors by ensuring that the highland and lowland children had the same ethnic background and dietary habits. When other socio-biological factors were controlled for the multivariate analysis (see result) the low altitude remained a strong risk factor that could not be masked. Thus, the factor that appeared to be at work in this situation seems to be purely environmental. Lowland children experience continuously high temperature and high humidity and therefore more prone to tropical infections. A survey administered by the regional office of the Ministry of Health in Abha City showed that the Southwestern highlands of Saudi Arabia are malaria free while the Tihama valley has high rates of malaria infection.[23,24] Malaria is considered a major cause of PEM in children.[25,26] The incidence of other tropical infections such as leishmaniasis is also higher in lowland than in highland regions.[27] Thus, it is most likely that the difference in PEM prevalence between high and lowland children is related to the beneficial effects of milder environmental conditions present at high altitude. Of the 2 indicators of parental SES, education was founded to be negatively and significantly associated with the 3 types of PEM. The relationship between low socioeconomic conditions and increase prevalence of PEM has been documented in a number of studies worlds wide.[28-31] In this study, the low family income was significantly associated with underweight and stunting but not with wasting. This may indicate that wasting was primarily the result of incorrect feeding practices by illiterate parents rather than lack of food.[32] The present study also shows gender and age differences in PEM prevalence among preschool children at high and low altitude. In this study, the 3 types of PEM were more prevalent in boys than girls and increased in both gender as age increased, although the relationship between wasting and age was not significant. Similar findings are reported in a number of other studies.[27,30] Stunting is a major public health problem induced by a number of long term factors including insufficient dietary intake, frequent infection, poor feeding practice and low parental SES and wasting reflect acute growth disturbances due to insufficient energy intake and repeated infections.[17] However, underweight is the composite index which is reflective of stunting and/or wasting.[8] Using WHO criteria,[17] the present study showed that the prevalence of the 3 types of PEM among preschool children in Aseer Region was high in the low altitude region (prevalence ≥30%) and normal in the high altitude region (prevalence <20%).

In conclusion, the present study identified PEM risk factors in the Aseer region of KSA. Of these, low altitude was the strongest and independent factor that could not be masked. It is speculated that the mechanism by which low altitude influence PEM is related to the higher incidence of tropical infections at this elevation. The limitation of this study is that we were unable to collect data on previous tropical infections on malnourished children. Thus, further studies are required to verify this speculation and to look for other possible mechanisms by which low altitude affects PEM in preschool children. These studies will help to establish programs to control and prevent PEM in preschool children at low altitude.

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