Health problems in the forested mountains of southern Viet Nam
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Nutritional status following malaria control in a Vietnamese ethnic minority commune.

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Submitted
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ABSTRACT

Objective: To study whether control of malaria leads to catch up growth or an increase of obesity in a marginally nourished population.

Setting: A Vietnamese ethnic minority commune in southern Vietnam.

Design: Repeated annual anthropometric surveys were performed from 1995 to 2000. Z-scores for height, weight and BMI for age and weight-for-height were determined by using NCHS 1978 and CDC-2000 reference tables and by the LMS method.

Intervention: Active malaria control which reduced the parasite carrier rate from 50% in 1994 to practically nil in 1998.

Results: Inhabitants were generally of short stature and very thin. Using the US reference tables, the prevalence of moderate/severe stunting among children was 53% / 24% and of wasting 27% / 9% in the first survey in 1995. Physical condition and normal daily activities of most inhabitants were normal. The repeated LMS-Z-scores uncovered a significant recovery of stunting, extending into preadolescence, including the development of a pubertal growth spurt for girls and enhancement of pubertal growth in boys, after control of malaria. The mean (95% CI) annual increase of Z-height-for-age was 0.11 (0.09 – 0.12) for boys and 0.14 (0.13 – 0.15) for girls (p < 0.001). As a consequence, weight-for-age and BMI Z-scores decreased without indication of developing obesity.

Conclusion: Control of malaria induces catch up growth extending into preadolescent age in a Vietnamese ethnic minority population with a chronic state of low food intake, without indication of developing obesity.
INTRODUCTION

The rapid socioeconomic changes in Asia are paralleled by the so-called epidemiological and nutrition transitions. (1;2) Traditionally, public health programs focused on communicable diseases and malnutrition because these were the most important health hazards. The interaction between infection and nutrition, however, is not clear, and it difficult to define which of these problems should be addressed first. (3) To date the situation is even more complex due to the epidemiological transition to non-communicable diseases, many of which are associated with unbalanced diet and overweight.

The association between malnutrition in early life and overweight at later stages, has been addressed before. (4) Stunted growth during gestation or early infancy predisposes for overweight and obesity when nutritional intake increases. Overweight predisposes for cardiovascular disease and the metabolic syndrome. (5) It is the negative effect of a rapid nutrition transition. An important question is if control of infectious diseases has the same detrimental effect on body dimensions.

This matter is very complex because the epidemiological and nutrition transitions are unequally spread among the population of many middle and low income countries. Especially children of low income groups, suffer from nutrient deficiencies and communicable diseases, leading to retarded growth whereas the transition to high energy food intake with non-communicable diseases is affecting the more affluent strata of societies. (6)

The socioeconomic changes in Viet Nam over the last decade came at a variable pace for different population groups. (7) In the early 1990s Viet Nam was one of the poorest countries of the world. During the last decade it transformed rapidly into a middle income country and living conditions changed accordingly. The most vulnerable populations were and still are the ethnic minorities. They share much less in the economic progress than the economically more active ethnic Vietnamese (Kinh) and they endure hard living conditions with malnutrition, endemic malaria and other infectious diseases.

In 1994 a general health programme was initiated in Phan Tien village, an ethnic minority community located in the forested mountains of Binh Thuan province, in southern Viet Nam. Malaria was hyperendemic with parasite carrier rates of up to 50%. Inhabitants were thin and of short stature but without overt malnutrition, performing normal daily activities including cultivating the land and working in the forest. The hyperendemic malaria situation was brought to almost complete eradication within four years. (8) This was complemented by eradication of hookworm infections (unpublished data). Nutritional and socioeconomic improvements seemed to lack behind but solid anthropometric reference tables of the minority populations in Viet Nam and criteria of optimal values were lacking. Growth charts and tables of the National Center of Health Statistics/World Health
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Organization (NCHS/WHO) were based on a US reference population and criteria for optimal growth and body dimensions were not clear.

The first aim of this study was to establish the rate of malnutrition in this population and to see whether control of the infectious diseases, mainly malaria, had a positive effect on child growth and body dimensions. In this study we also laid down a methodology to construct growth charts with an accepted method, the LMS method, and a sensitive method to follow secular trends over a relatively short time span.

The secondary objective of this study was inspired by the difficulties in the interpretation of anthropometric data in this population. It was not clear if the use of international reference tables was justified. A marginally nourished population is much different from an industrialised country’s reference population. Using the US criteria generally overrates the rate of malnutrition in developing countries. (9) This may frustrate statistical analysis by crowding of data in the tail of the distribution curves as well as the mathematical conversion of cut off points to define desirable body dimensions. There are also physiological arguments to object to extrapolating the definition of optimal body dimensions to other populations, especially the ethnic minority groups in Viet Nam, whose members are generally shorter and leaner than the Kinh majority. (10-12)

Therefore, in order to improve the interpretation of the anthropometric indicators in the ethnic minority population of Viet Nam, the secondary objective of this study was to establish the correlations between body fat, the body mass index (BMI) or its Z-score, (Z)BMI, and the Z-score of weight for height, Z-WH.

SUBJECTS AND METHODS

Population and study site

The study population consisted of all inhabitants of Phan Tien who participated in the annual malariometric surveys from 1995 to 2000. The population of Phan Tien is composed of nine ethnic groups. Two thirds of the population belong to the Rac Lay and Ta Lop ethnic minorities. Remaining groups are ethnic Vietnamese (Kinh), Nung, Nop, K’Ho, Tay, Hoa and Cham. In 1994, when the village had just been established, the population was 716; it increased to 1088 in 2000. People lived family wise with 5 to 6 persons in one house, with clay walls and a thatched roof. The local economy was simple, based on small-scale slash and burn subsistence farming and on what the forest offered as food. During the dry season it took several hours to reach the village from the main road. During the raining season the village could not be reached by car. Governmental support included a program of rice supplementation for vulnerable groups, such as pregnant women and children, which was usually shared within families. Before July 1994, there was no health care facility and water supply was from a small river near the village. Mid 1994, three wells were drilled with the aid of UNICEF, but due to their limited supply of safe water most people adhered to
using river water. Safe drinking water was ensured at the end of 1997 by establishing eight functioning wells. Electricity was introduced at the end of 2000.

Despite the general socio-economic improvements in Viet Nam, which started at the end of the nineteen-eighties, the living conditions in Phan Tien remained very poor, largely similar to other ethnic minority communes in the remote areas of Viet Nam. Clinically significant malnutrition was not observed throughout the study period. A few children had slightly hypo-pigmented hair and approximately 15% of children younger than 16 years old had clinical signs of anemia (pallor). Hb was measured from 1996 onwards and this showed severe anaemia (Hb < 7g %) of maximally 2.1%, in 1996. Diarrhoea was noted infrequently while taking the interim history at the surveys, and this was confirmed by findings in four faeces examination surveys in 1997 (2x), 1998 and 1999 (rate of diarrhoea always less than 0.5%).

**Design and procedures**

In 1994, a full census was done, houses were numbered and all individuals were registered. A record was completed for each individual with name, unique identifier, age, sex, household and ethnic group.(8) Most of the inhabitants of Phan Tien do not usually record or remember their date of birth, only their age in years or the year of birth. In the database the date of birth was fixed to the middle of the solar calendar, i.e. 1st July, so that age could be recalculated to months. This introduces an error of maximally 6 months in age for every individual, but the group average is accurate, except for children under 1 year old. This small group, of maximally 35, was excluded from the analysis; their results appeared in the repeated measures analysis after they had passed the age of one year. For subgroup analysis, three age groups were recognised: children from 1 to 10 years, teenagers/adolescents from 10 through 23 years and adults older than 24 years.(13)

Malaria surveys were done annually at the end of the rainy season from 1994 to 2000. Demographic data were updated at every survey, registering newborns, deaths, newcomers and those who left. In 1997 an additional survey was performed at the end of the dry season in school children only.

From 1995 onwards, measurement of height and weight was added to the surveys.

Physical examination was performed of all subjects by the same physician and a short interim medical history was obtained. Waterlow’s criteria were used to classify the degree of malnutrition. The criteria differentiate between primary signs, i.e. growth retardation, oedema, mental unhappiness and hepatomegaly; and secondary signs, i.e. hypo-pigmentation of the hair or skin, anaemia and diarrhoea.(14;15)

Body weight and height were measured of all children through the primary school and all adults who were present in the village at the time of the annual surveys and did not refuse to participate in the survey. Height was measured in standing
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position on bare feet to the nearest 1cm by using a portable stadiometer, which was placed on the flat hard floor and against a bare wall. Body weight was measured to the nearest 0.1 kg with a digital electronic scale. The weight of children between one and two years was measured by weighing the mother with and without the child in her arms.

Measurement of skin folds and middle upper arm circumference was only done in 1995. Thickness of skin folds was measured to the nearest 1mm with a standard Harpenden skin fold calliper at four sites: overlying arm biceps and triceps, subscapular and supra-iliac regions on the right side of the body, in standing position.(16) Mid-upper arm circumference (MUAC) was measured at the mid-point between the tip of the acromial process and the tip of the olecranon process.(13)

Data processing and analysis

Using the NCHS/WHO reference tables of 1978 and the Center for Disease Control (CDC) tables of 2000, Z-scores were calculated for children’s height-for-age (Z-HA), weight-for-age (Z-WA), weight-for-height (Z-WH) with the programme NutStat, a part of EPI-info 2000 (Centers for Disease Control and Prevention, Atlanta, GA, USA). This calculates the Z-HA and Z-WA for individuals from birth up to 18 years (NCHS/WHO) or 20 years (CDC 2000) of age. Z-WH is calculated for boys up to 11.5 years of age and shorter than 145 cm, and for girls up to 10 years of age and less than 137 cm with the NCHS/WHO tables. With the CDC 2000 tables ZHW is calculated up to the age of 36 months and for children from 77 to 121 centimeters in stature.

With both reference tables, the interpretation of results was similar: stunting: Z-HA < -2; underweight: Z-WA < -2; wasting: Z-WH < -2, severe malnutrition: any of these Z-scores < -3. The BMI was calculated as weight (kg)/height (m2). Z-scores were again calculated with the two US reference tables and with the LMS method, for all subjects, including adults. The interpretation of the BMI is different for the two US reference tables and is shown in Table 1. BMI and WH Z-scores were compared to skin fold thickness, a height and weight independent measure of body fat.

Table 1: The interpretation of US reference values for BMI for age.

<table>
<thead>
<tr>
<th>Cut off values for BMI-for-age</th>
<th>Reference tables</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>NCHS/WHO 1978</td>
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<tr>
<td>&lt; 5th percentile</td>
<td>Wasting</td>
</tr>
<tr>
<td>Z-scores &lt; -2</td>
<td></td>
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<tr>
<td>&gt; 85th and &lt; 95th percentile</td>
<td>At risk for overweight</td>
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<tr>
<td>&gt; 95th percentile</td>
<td>Obese</td>
</tr>
<tr>
<td>&gt; +2 Z-scores</td>
<td>Overweight</td>
</tr>
<tr>
<td>&gt; +3 Z-scores</td>
<td>Obese</td>
</tr>
</tbody>
</table>
Chapter 5

Growth charts were constructed by gender for HA, WA, WH and BMI, using the LMS method on the first measurements available in the dataset of children and adolescents. The LMS method generates smooth centile curves of data sets that do not necessarily show a normal distribution. For this purpose dedicated software was used: LMS-Pro (Cole and Green, Institute of Child Health, Aberdeen, UK).

Calculation of centiles is based on establishing smooth curves for skewness (L), the median (M) and the coefficient of variation (S). We aimed at smooth curves for LMS starting with the minimum degrees of freedom for the L, M and S. The goodness of fit with different degrees of freedom for L, M or S, was assessed with the Q-test, provided in the Pro-version of the LMS program. LMS also generates values of L, M and S for age specific intervals, which can be used to calculate the Z-score of every individual given age, height and weight, with the following formula:

\[ Z = \frac{[(y/M)L - 1]}{LS} \quad \text{when } L \neq 0 \]

\[ Z = \frac{\log(y/M)}{S} \quad \text{when } L = 0 \]

where "y" is weight or height for the respective age intervals or, weight for height specific intervals. By this method, the Z-scores of the repeated measurements were calculated, using the set of all first measurements as the reference table. Ages up to 24 years were included for constructing the HA and WA charts, ensuring that the data also included all individuals with recent cessation of growth. WH charts were constructed using the same age groups in order to increase the available number of data points for fitting. It is not conventional to calculate WH up to the age of 24 years but there is no objection to apply the LMS method to a larger age group and it assisted us in the interpretation of BMI. BMI is now the preferred indicator of overweight in all age groups, but it is unknown if that also applies to underweight.

Longitudinal data were analysed to detect trends over the 5 years of the study period. The repeated post-rainy-season Z-scores of all individuals were analysed as a function of time in a linear mixed effects model. The linear regression coefficients were generated by restricted maximum likelihood methods (REML). The Z-scores of the single survey done at the end of the dry season was compared to the other surveys using generalised linear models ("repeated measures ANOVA").

In order to find whether the anthropometric indicators were different between the ethnic groups, subjects were re-classified into 3 main groups: Rac Lay, Ta Lop and remaining inhabitants. The latter also included subjects with parents of different ethnic groups. Z-scores of population sub-groups were compared using ANOVA.

All routine statistics were done by using SPSS 11.5.1 (SPSS Inc., Chicago, IL, USA) Mixed effects modelling was done with S-plus 2000 (MathSoft Inc., Seattle, WA, USA). Statistical significance was accepted when p<0.05.

RESULTS

Over the complete study period, 91% of the population of Phan Tien was examined at least once with a median of three times (male/female: 53%/47%;
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children/teenagers/adults: 35%/35%/30%). Children who were over 1 year in 1995 were examined every year.

Based on the Z-scores derived from the NCHS/WHO 1978 and the CDC 2000 reference populations, the overall prevalence of stunting during the first survey in 1995 was 53% with both tables. Severe stunting occurred in 24% and 22% of the overall population, respectively. The prevalence of wasting was 13% and 27% respectively, including 1.4% and 9% severe wasting. Less than 0.6% of the overall population was at risk for overweight. Among teenagers and adolescents stunting and wasting were particularly common: 60% stunting, over 12% wasting and no obesity, as compared to both US reference tables.

![Figure 1](image)

**Figure 1:** Growth charts of the population of Phan Tien, a Vietnamese ethnic minorities commune. *Charts were generated with the LMS method, based on the first of the measurements between 1995 and 2000. In all panels the 5th, 50th and 95th centiles are shown. Solid lines represent males and broken lines represent females.*

Charts for HA, WA, WH and BMI were established with LMS. Figure 1 shows the median and the 5th and 95th centiles. The annual growth rate was maximal in boys at the age of 11; for girls a growth spurt at pubertal age could not be discerned. A strong linear correlation between the LMS Z-scores and the Z-scores by US reference populations was observed but with a large intercept of >-2 to -1 SD (Figure 2). Longitudinal analysis showed a significant change of Z-scores among children and adolescents younger than 23 in 2000, over the years (Figure 3). In a linear mixed effects model, a significant increase of Z-HA and Z-WA of children of both sexes.
(p<0.001 for all) was observed. The mean (95% CI) annual increase of Z-HA was 0.11 (0.09 – 0.12) for boys and 0.14 (0.13 – 0.15) for girls (p < 0.001). HA increased faster than WA, particularly in girls. As a consequence, WH and BMI Z-scores decreased.

**Figure 2:** LMS and US Z-scores in Phan Tien, a Vietnamese ethnic minority commune. Open circles: NCHS 1978, crosses: CDC 2000.

**Figure 3:** Catch up growth in Phan Tien, a Vietnamese ethnic minority commune. Mean data of subjects < 23 years in 2000. Error bars indicate the 95% CI.
**Figure 4:** Mean annual increase of anthropometric Z-scores from 1995 to 2000, by the age in 2000, in the ethnic minority population of Phan Tien, southern Viet Nam. 

*The mean annual increase of Z-scores was calculated by a linear mixed effects population model of the repeated annual LMS Z-scores.*
To see whether this trend was age dependent, the individual linear regression coefficients of the mixed effects model, which reflect the change in growth rate, were plotted against the subjects’ age in 2000 (Figure 4). As an internal validation it was taken that at the age of 24 years in 2000, height growth rate should become zero. The growth rate increased most in those girls who were 15 years in 2000 and boys who were 16 years in 2000. On average, elderly people did not show an increase of BMI.

Increase of growth rate showed a negative correlation with the first Z-HA (R2 = 0.119, p <0.001), Z-WA (R2 = 0.045, p<0.001) and Z-WH (R2 = 0.153, p<0.001), indicating that catch-up growth was most outspoken in stunted children. The Z-scores of the survey at the end of the dry season in 1997 did not deviate from the secular trend (data not shown).

There was no significant difference between the increase of growth and having a positive blood smear for malaria during the surveys. There was also no significant difference between the three ethnic groups with respect to LMS Z-scores of all first measurements (ANOVA).

With respect to our second objective, the BMI is shown for all age groups in Figure 5. LMS had difficulties in fitting the BMI-centiles for all aggregated age groups, so that Z-BMI for children was taken from the curves shown in Figure 1. The highest BMI was observed in young adults. Elderly people had very low values for BMI.

BMI was positively correlated to the LMS values of WH Z- in boys (R2 = 0.4072, p<0.001) and girls (R2 = 0.40, P < 0.001). In teenagers this correlation was weaker (R2 = 0.32, p<0.001 and R2 = 0.36, p<0.001 respectively).

To study whether in these thin subjects, the BMI, was a measure of subcutaneous body fat, the correlation with skin fold thickness was sought. The calculation of the percentage of body fat, based on the sum of the four skinfolds, yielded unrealistic values indicating that these equations are not appropriate for this population.(22-24) Therefore only the summated skin fold thickness was used for further analysis. In children, the BMI and sum of skin folds decreased by ageing and reached the lowest value at 8 years in girls and 9 years in boys. During puberty they increased again. In general the correlation between BMI or Z-BMI and the sum of four skin folds was weak. Only in females over 10 years, there was a positive correlation between the sum of the four skin folds and the BMI (R2 = 0.5229, p < 0.001 in teenagers/adolescents and R2 = 0.4892, p < 0.001 in adult females) or Z-BMI (R2 = 0.4476, p < 0.001 for teenagers/adolescents and R2 = 0.4595, p < 0.001 for adult females).
**DISCUSSION**

This study uncovered catch up growth, especially in previously stunted children, and the development of a pubertal growth spurt, during a period of five years during which the main health intervention was to bring malaria under control.

The strength of this study was based on the registration and follow up of individual inhabitants, and the survey examiners being not informed of the results of the previous years. Other potential sources of bias, e.g. by preferentially attracting children with complaints or growth retardation, were circumvented by examining all children of Phan Tien through the primary school.

The prevalence of clinical malnutrition was low, with a few cases with slightly hypopigmented hair, a low rate of severe anaemia and no other signs or symptoms of malnutrition. Almost all children, though stunted, continued to grow and childhood mortality, which usually accompanies severe malnutrition in malarious areas, was practically nil throughout the study period. (25) In contrast, the international cut-off values of the anthropometric indicators gave an entirely different picture. According to the US reference tables the prevalence of stunting and wasting as well as severe malnutrition would be very high in Phan Tien. This seems incorrect.

Correct interpretation of anthropometric measures is important because they are used to detect subjects or populations at risk for poor health and to design and follow up health interventions. (26) In industrialized countries, reference tables are usually available and regularly updated. (27-31) In developing countries, local reference tables are often not available and thus reference tables from industrialized countries are used instead. Our study shows that the use of US reference tables, suggested unrealistic rates of (severe) malnutrition.

The LMS method gave a better description of the anthropometric data in this population. It has become the gold standard for constructing growth charts based on large reference populations. (32) In this study it served well to normalise the data, to

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**Figure 5:** BMI for age in Phan Tien, a Vietnamese ethnic minority commune. *Data points represent the first of the measurements between 1995 and 2000*
produce Z-scores and draw growth charts for the entire population of Phan Tien. No association was found between ethnicity and anthropometric indicators. This is valid for the two largest groups, Rac Lay and Ta Lop, but a possible difference with the Kinh subjects, who definitely have a different physiognomy, cannot be excluded because of the small size of the Kinh group in Phan Tien. Since the majority of Vietnamese are Kinh, the Phan Tien chart cannot be extrapolated to the general Vietnamese population.

The difficulties in interpretation of anthropometric data may benefit from longitudinal follow up. We are not aware of any report using mixed effects population models on LMS Z-scores for this purpose, although Cole already outlined the use of LMS for longitudinal studies.(33) However, from a methodological point of view, we argue that the analysis of the repeated measures, based on LMS results, is the appropriate approach for data sets like ours. In theory, if fitted centiles would not accurately describe the real distribution in the population, the repeated Z-scores would show a tendency to correct this over the years, simulating a secular trend. It is unlikely that this also happened in this study for several reasons. Firstly because only a systematic fitting error in the initial growth charts, would mimic a secular trend in all growing age groups and such errors are unlikely to occur with the LMS method.(34) Secondly, the trends in HA and WA and the opposite trends in BMI and WH, are meaningful and thus argue against erroneous fitting with LMS. Thirdly, the precision of the LMS method was maximised by using the first measurements of all subjects who ever participated and, lastly, the LMS Z-scores showed a strong linear correlation with Z-scores based on the US reference populations. Our fear that the distribution of the data of Phan Tien would be distorted by squeezing them into the tail of the distribution of the US reference population did not bear out. But, because of the large intercept it seemed more appropriate to use the LMS Z-scores than the US reference populations.

The longitudinal analysis of LMS Z-scores enabled us to recognise catch up growth. Catch up growth is an intriguing phenomenon with largely unknown dynamics.(35) It appears that child survival benefits from better nutrition and catch up growth.(36) On the other hand, catch up growth in stunted children is mainly translated into weight gain and increased risk of obesity and thus has a negative impact on long term health.(37) This is made painfully clear by the steep increase of obesity rates in areas of rapid nutrition transition.(38)

Recovery from stunting however is a rather flexible process which may extend well into preadolescence.(39) Our data show similar results and in addition, an emergence of growth spurt at pubertal age in girls, where this was not evident before, and its enhancement in boys. Catch up growth was most evident in short and low weight children but the changes were small and these findings have to be confirmed.

The control of malaria probably contributed to this trend.(8) At the start of the study the local malaria transmission in the village was very high with equal exposure to all inhabitants. Thereafter the malaria prevalence declined rapidly. At the
individual level, no interaction was found between carrying malaria parasites at the
time of the survey and the Z-scores or acceleration of growth. This is probably related
to the fact that malaria surveys only indicate the point prevalence of malaria but do
not measure cumulative exposure over time. However, at population level, the
improvements of the health in Phan Tien, by controlling malaria and helminth
infections, and the introduction of a primary health care post were the most
significant changes which took place between 1994 and 2000.

Intake of nutrients, remained unchanged at a low level throughout the study
period. Although this is based on our non-quantified observations, it is supported by
the persistence of high anaemia rates after control of malaria and hookworm
infections. It is also supported by other data which show that the diet of ethnic
minorities and poor people in Viet Nam hardly improved on protein and lipid intake
during the same period, despite the socioeconomic changes for other groups in the
population.(40) We tentatively argue that the improvements of health, and not so
much improvements of diet, promoted the catch up growth.

Severe malnutrition was not frequent, and it may have been over estimated
with the US reference tables, but the population of Phan Tien was indeed very thin
and clearly at risk for deficiency of macro and micronutrients. The BMI and the
amount of body fat, assessed by measuring skin folds, were extremely low, and there
was no indication of gaining body fat, for example by elderly subjects, over the years.

The BMI is known to differ between different ethnic groups, especially in the
lower ranges and has not been validated as an indicator of malnutrition.(41) (42) In
this study, the correlation between skin fold thickness and BMI was weaker in males
than in females, illustrating that at low values, the muscular body mass contributes
significantly to BMI. This study also revealed that the BMI and WH may even mimic
deterioration of the nutritional status when recovery of stunting occurs which in itself
is a clear sign of an improved health situation. Notably, the interpretation of BMI as
an indicator for obesity associated health risks, is also fraught with difficulties. It was
recently concluded that it is not feasible to define cut offs for optimal body
dimensions and overweight for the general Asian populations.(43) The summated
skin folds are by nature a height and weight independent indicator of the amount of
body fat. But, as our results show, also their predictive value for pathologic
conditions declines when they reach the very low range.

It is tempting to speculate on the nutrition transition in Viet Nam. Viet Nam is
a country with very rapid socioeconomic changes but for the ethnic minorities these
changes are less rapid. In this study cohort we observed catch up growth probably
caused by controlling malaria without any indication of the obesity pandemic
affecting this commune. However, prolonged follow up in Phan Tien may teach us
more about the dynamics of the transition from marginal nutritional status to
overweight. We tentatively suggest that in areas with marginal food supply, it is
advisable to start with interventions for infectious diseases, especially malaria control,
because that stimulates catch up growth without inducing overweight. This certainly needs further study.

CONCLUSION

In conclusion, in a chronic state of low food intake, cut-off values for anthropometric indicators, based on international reference tables, have limited diagnostic and prognostic value. Repeated annual surveys in a Vietnamese ethnic minority population analysed with the LMS method and repeated measures analysis, uncovered catch up growth extending into preadolescent age, without any indication of the obesity pandemic affecting this community. The almost complete eradication of malaria in this population was probably the most important cause for these beneficial effects.

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