

Original article

Asthma symptoms in rural living Tanzanian children; prevalence and the relation to aerobic fitness and body fat

Objective: To determine the prevalence of asthma symptoms in children from a rural district in North-Tanzania, and their relationship to aerobic fitness and body fat.

Methods: In Manyara region in Tanzania, children (aged 9–10 years) were randomly selected to participate in the present cross-sectional study. Hundred and seventy two participants completed a video questionnaire showing the symptoms and signs of asthma. Lung function was measured by maximum forced expiratory flow-volume curves. Aerobic fitness was estimated from a standardized indirect maximal cycle ergometer test and sum of three skinfolds reflected body fat.

Results: Twenty four per cent reported asthma symptoms last year. Severe wheezing attacks last year were reported in 5% of the participants. Thirty seven per cent of the participants were underweight. Underweight children had significantly lower ($P < 0.02$) lung function (per cent of predicted). Lower body fat was associated with higher occurrence of asthma symptoms (odds ratio and 95% CI; 0.45 (0.22–0.95; $P = 0.04$). Aerobic fitness was not associated with asthma symptoms.

Conclusions: More than every fifth 9–10 year old child from a rural district in North-Tanzania reported asthma symptoms. Lower body fat was associated with higher occurrence of asthma symptoms, but aerobic fitness was not associated with asthma symptoms.

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The percentage of children and adolescents reported to ever have had asthma or asthma symptoms has increased over the last decades (1); however, large variations in the prevalence of asthma symptoms have been observed between centres worldwide, with the highest prevalence in Western countries and the lowest in African, Asian and some east European countries (1).

The prevalence of exercise-induced bronchoconstriction (2) and asthma symptoms (3) have been shown to be higher in urban than in rural areas in some African countries. In South Africa, hospital admissions for asthma appear to have increased in parallel with rapid urbanization (4). No single factor that accounts for this urban-rural difference is identified (5). The cause of the increase in asthma is thought to be multi-factorial including allergen sensitization, lifestyle and environment changes (6) with increasing attention to 'Western

lifestyle', including an unhealthy diet and a sedentary lifestyle with decreased physical activity (7).

Paediatric aerobic fitness has decreased in the last decades in most 'Western societies' (8), whereas obesity and overweight among children and adolescents have increased dramatically in economically developed countries and in urbanized populations (9). Exercising more than once per week has been found to be inversely related to new onset of wheeze in adolescents (10). In addition, participation in vigorous physical activity may influence aerobic fitness (11) and lower levels of work capacity has been associated with higher risk of developing asthma (12). Furthermore, a number of longitudinal studies have reported increasing risk of developing asthma or asthma symptoms in obese children and adolescents (13); however, asthma symptoms have also been associated with underweight in children (14) and adolescents (15).

The associations between asthma, physical activity or fitness and body fat is not well known in children living in rural country districts where 'Westernized lifestyle' has not been adopted. The objective of the present study was to determine the prevalence of asthma symptoms in children from a rural district in North-Tanzania and their relationship to aerobic fitness and body fat.

Material and methods

Study design and subjects

Five primary schools were randomly selected from three areas in Mbulu district, Manyara region in northern Tanzania at an altitude about 1850 m above sea level. A detailed description of the study area and mode of living was published elsewhere (16). All schoolchildren ($n = 326$) aged 9 and 10 years (born in 1993) were identified at each of the five schools and invited to participate in the study. All 326 children carried out a 10 min cycle ergometer test to evaluate the child's ability to cycle on a stationary cycle ergometer. During the preliminary test, 106 (35%) of the participants were not able to maintain a steady pace, mostly because of frequently slipping off the pedal when cycling. Only the 190 children able to cycle satisfactorily with an aerobic fitness test were included in the present study (17). Hundred and seventy two children had complete asthma symptoms data and 156 children got an accepted aerobic fitness test.

The precise date of birth was not usually known and age was interpolated from the year of birth. Eight tribes were represented in the sample, with a representative 87% of the subjects belonging to the Iraqw tribe. Data were collected during a period of 6 weeks in May and June 2003 (17).

Procedures

Video questionnaire. To overcome the potential problems of inaccurate translation and vocabulary differences from written questionnaires, a video questionnaire (International version AVQ 3.0) developed within the International Study of Asthma and Allergies in Childhood (ISAAC) (18) was carried out in the participating children. The video questionnaire shows the symptoms and signs of asthma: Wheezing at rest, exercise-induced wheezing, waking at night with wheezing, nocturnal coughing and severe wheezing attacks. Each sequence was followed by three questions: 'Has your breathing ever been like the subject's in the video', if 'Yes', 'in the last 12 months?' (classified as current) and if 'Yes' again 'In the last month'. The questions were translated into Swahili. The children were guided and interviewed by a Swahili and Iraqw (the local language) speaking research assistant. The term 'wheezing' was not mentioned at any stage in the video questionnaire.

Anthropometrics. Body mass was measured to the nearest 0.1 kg, using an electronic scale (Soehnle, Type 7516, Germany). Height was measured to the nearest 5 mm, using a tape measure attached to the wall. BMI was calculated as body weight (kg) divided by height (m) squared. Underweight was defined according to cut off points for children derived by Cole et al. (19). Skinfold thickness was measured with a Harpenden fat caliper at the triceps, subscapular and suprailiac.

Lung function and reversible airflow limitation. Forced expiratory volume in one second (FEV_1), forced vital capacity (FVC) and forced expiratory flow at 50% of FVC (FEF_{50}) were measured by maximum

forced expiratory flow-volume curves (MasterScope, Erich Jaeger® GmbH & Co KG, Würzburg, Germany) according to the general acceptability and reproducibility criteria of European Respiratory Society (20). All individual flow-volume curves were reviewed for technical acceptability. FEV_1 , FEF_{50} and FVC are presented as absolute values and per cent of predicted using the following prediction equations (height in cm; boy = 1 and girl = 0):

$$FEV_1: -0.23 + 0.03 \cdot \text{Height} - 0.12 \cdot \text{Gender}$$

$$FEF_{50}: -1.70 + 0.04 \cdot \text{Height}$$

$$FVC: -2.43 + 0.03 \cdot \text{Height} - 0.13 \cdot \text{Gender}$$

The prediction equations were derived from the same Tanzanian population as recommended by European Respiratory Society and American Thoracic Society (21). The highest FEV_1 , FVC and FEF_{50} are included in the analysis. Reversible airflow limitation was measured using 0.4 mg salbutamol (Airomir™ Autohaler™; 3M Pharmaceuticals, St. Paul, MN, USA). A $\geq 12\%$ increase in FEV_1 15 min after inhalation, compared to baseline [$\Delta FEV_1 = (FEV_1 \text{ post} - FEV_1 \text{ pre}) / FEV_1 \text{ pre}$] was defined as a reversible airflow-limitation (21).

Aerobic fitness. Maximal power output was measured from a standardized indirect maximal cycle ergometer test conducted on an electronically braked cycle ergometer (Monark 839 Ergomedic, Sweden) and aerobic fitness was estimated. Bicycle skill was examined in the participating children by observing the subjects riding a regular children's bicycle for about 100 m. Details regarding the maximal cycle ergometer test and bicycle skills are described in Aandstad et al. (17).

Ethics

Research clearance was obtained from the University of Dar es Salaam. Approval was also given by the local ministry of education, the local authorities in Mbulu district and headmasters from the five primary schools visited. All children were given verbal information about the test procedures and they could withdraw from the study at any time without any reason.

Statistical analysis

Demographic data are given as mean values and standard deviation (SD) unless otherwise stated and results as mean with 95% confidence intervals (CI).

Chi-square and independent *t*-tests were used to analyse differences between boys and girls, while Mann-Whitney was used, if data were skewed. Asthma symptoms were defined as wheeze at rest, after exercise, waking with wheeze or severe attack of asthma. Waking with cough as the only symptom was not included in the definition of asthma symptoms.

Difference in the outcome variables was assessed by analysis of covariance adjusting for gender [and bicycle skill for aerobic fitness as experience and skill in bicycling influenced the result of the maximal cycle ergometer test (17)]. The underlying assumptions of the analysis of covariance were assessed using Jackknife Residuals and Cook's *d*. The independent variables, skinfolds and aerobic fitness, as well as the included confounders, were also analysed for associations with asthma symptoms using logistic regression analysis. Further stratifying by gender was not feasible due to small groups. Statistical significance level was set at 5%. Statistical analyses were performed with Statistical Package for Social Sciences Version 15.0 (SPSS, Chicago, IL, USA).

Table 1. Descriptive data of the participating Tanzanian children (Mean and Standard Deviation unless otherwise stated)

	Boys (<i>n</i> = 101)	Girls (<i>n</i> = 89)	Gender differences (<i>P</i> -value)
Height (cm)	134 (5.5)	134 (5.5)	0.96
Body mass (kg)	26.5 (3.15)	26.8 (3.65)	0.68
BMI (kg/m ²)	14.8 (1.05)	14.8 (1.31)	0.70
Underweight; <i>n</i> (%)	40 (40)	31 (35)	0.75
Σ 3 skinfolds (mm)	13.4 (2.89)	15.8 (3.48)	<0.001
VO ₂ peak (ml/kg/min)	44.6 (5.78)	37.2 (4.55)	<0.001
FEV ₁ (l)	1.73 (0.230)	1.62 (0.275)	0.004
FVC (l)	1.76 (0.254)	1.63 (0.285)	0.001
FEF ₅₀ (l/s)	2.91 (0.620)	3.05 (0.621)	0.14

Body Mass Index, BMI; Sum of three skinfolds, Σ 3skinfolds; Peak estimated oxygen consumption, VO₂peak; Forced Expiratory Volume after one second, FEV₁; Forced Vital Capacity, FVC; Forced Expiratory Flow at 50% of FVC, FEF₅₀. Statistically significant values are given in bold.

Results

The descriptive data of the participating 9 to 10-year-old Tanzanian schoolchildren are presented in Table 1. Aerobic fitness was higher (*P* < 0.001) in boys, whereas body fat was significantly higher (*P* < 0.001) among girls. Thirty seven per cent of the participants were underweight. FEF₅₀ was similar in boys and girls, whereas the boys had higher FEV₁ and FVC (Table 1; *P* = 0.004 and 0.001). None of the participants reported use of asthma medications like inhaled corticosteroids or β₂agonists or reported a doctor's diagnosis of asthma.

Asthma symptoms last year by video questionnaire were reported by 24%, whereas wheeze at rest or current wheeze was reported by 17% and 12% respectively. Significantly more boys (27%) than girls (14%) reported exercise-induced wheeze ever (*P* = 0.04). Severe wheez-

Table 3. Lung function (% of predicted), aerobic fitness (VO₂ peak) and indices of body fat content in the Tanzanian children. Data are presented by those reporting asthma symptoms last year and children without asthma symptoms (Mean and 95% confidence intervals)

	Any asthma symptoms (<i>n</i> = 41)	No asthma symptoms (<i>n</i> = 131)	<i>P</i> -value*
FEV ₁ (% of predicted)	99.1 (95.5–102.7)	99.7 (97.6–101.7)	0.78
FVC (% of predicted)	99.7 (95.9–103.5)	99.5 (97.3–101.6)	0.91
FEF ₅₀ (% of predicted)	98.0 (91.8–104.3)	100.3 (96.7–103.8)	0.54
VO ₂ peak(ml/kg/min)‡	42.6 (40.7–44.5)	41.2 (40.3–42.2)	0.20
Σ 3skinfolds (mm)†	13.7 (12.7–14.7)	14.9 (14.3–15.4)	0.04

Sum of three skinfolds, Σ 3skinfolds; Peak estimated oxygen consumption, VO₂peak; Forced Expiratory Volume after one second, FEV₁; Forced Vital Capacity, FVC; Forced Expiratory Flow at 50% of FVC, FEF₅₀.

*Difference between groups.

†Adjusted for gender.

‡Adjusted for gender and bicycle skill.

Statistically significant values are given in bold.

ing attacks in the last 12 months were reported in 5% of the participants (Table 2). There was a tendency for higher occurrence of severe wheezing attacks last year in underweight children (*P* = 0.08).

No children had a FEV₁/FVC below 0.80 and one boy and four girls had a reversible airflow-limitation, with a ≥ 12% increase in FEV₁ 15 min after inhalation of salbutamol, compared to baseline. Lung function was similar in children with and without asthma symptoms (Table 3); however, underweight children had significantly lower FEV₁, FVC and FEF₅₀ (per cent of predicted) compared with children of normal weight (Table 4). The underweight children had significantly lower body fat (*P* < 0.001) than children of normal weight (Table 4).

Aerobic fitness was not associated with current asthma symptoms (*P* = 0.19) when adjusting for gender and bicycle skill (Table 3). In the logistic regression analysis,

Table 2. Asthma symptoms in Tanzanian children using video questionnaire [per cent with 95% confidence intervals (CI)]

	Total (<i>n</i> = 172)		Boys (<i>n</i> = 94)		Girls (<i>n</i> = 78)		Gender differences (<i>P</i> -value)
	<i>n</i>	% (95% CI)	<i>n</i>	% (95% CI)	<i>n</i>	% (95% CI)	
Wheeze at rest							
Ever	29	17.0 (11.7–23.4)	15	16.0 (9.2–25.0)	14	18.2 (10.3–28.6)	0.83
In last year	21	12.3 (7.8–18.2)	11	11.7 (6.0–20.0)	10	13.0 (6.4–22.6)	0.82
Wheeze after exercise							
Ever	39	22.7 (16.6–29.7)	27	28.7 (19.9–39.0)	12	15.4 (8.2–25.3)	0.04
In last year	27	15.7 (10.6–22.0)	18	19.1 (11.8–28.6)	9	11.5 (5.4–20.8)	0.21
Waking with wheeze							
Ever	29	16.9 (11.7–23.4)	14	14.9 (8.4–23.7)	15	19.2 (11.2–29.7)	0.54
In last year	13	7.6 (4.1–12.6)	9	9.6 (4.5–17.4)	4	5.1 (1.4–12.6)	0.39
Waking with cough							
Ever	57	33.1 (26.2–40.7)	30	31.9 (22.7–42.3)	27	34.6 (24.2–46.2)	0.75
In last year	37	21.5 (15.6–28.4)	21	22.3 (14.4–32.1)	16	20.5 (12.2–31.2)	0.85
Severe wheezing attacks							
Ever	22	12.9 (8.2–18.8)	12	12.8 (6.8–21.2)	10	13.0 (6.4–22.6)	0.99
In last year	8	4.7 (2.1–9.1)	5	5.3 (1.7–12.0)	3	3.9 (0.8–11.1)	0.73

Statistically significant values are given in bold.

Table 4. Lung function (% of predicted), aerobic fitness ($\dot{V}O_2$ peak) and indices of body fat content (skinfolts) in underweight and normal weight children (Mean and 95% confidence intervals)

	Underweight (n = 71)	Normal weight (n = 119)	P-value*
FEV ₁ (% of predicted)	95 (92–97)	103 (101–105)	<0.001
FVC (% of predicted)	95 (92–97)	103 (101–105)	<0.001
FEF ₅₀ (% of predicted)	95 (90–100)	103 (100–106)	0.01
$\dot{V}O_2$ peak(ml/kg/min)‡	42.4 (41.0–43.7)	41.1 (40.1–42.1)	0.14
Σ 3skinfolts (mm)†	13.2 (12.5–13.9)	15.5 (14.9–16.0)	<0.001

Sum of three skinfolts, Σ 3skinfolts; Peak estimated oxygen consumption, $\dot{V}O_2$ peak; Forced Expiratory Volume after one second, FEV₁; Forced Vital Capacity, FVC; Forced Expiratory Flow at 50% of FVC, FEF₅₀.

*Difference between groups.

†Adjusted for gender.

‡Adjusted for gender and bicycle skill.

Statistically significant values are given in bold.

adjusting for gender and bicycle skill, the odds ratio (OR) for asthma symptoms in children with lower aerobic fitness was 1.07 (95% CI; 0.97–1.17) and not significant ($P = 0.19$).

Body fat was significantly ($P = 0.04$) lower in children with current asthma symptoms than in those without symptoms (Table 3). A logistic model showed an OR of 0.45 (0.22–0.95; $P = 0.04$) for asthma symptoms if increasing sum of three skinfolts by 5 mm.

Discussion

In the present study, we aimed to determine the prevalence of asthma symptoms in children from a rural district in North-Tanzania and their relationship to aerobic fitness and body fat. Twenty four per cent reported asthma symptoms last year. Lower body fat was associated with higher occurrence of asthma symptoms, but aerobic fitness was not associated with asthma symptoms.

The prevalence of asthma symptoms in children from a rural district in North-Tanzania where 'Westernized' lifestyle is not adopted was higher than previously reported by written questionnaire based studies conducted in the sub-Saharan African countries (3, 5, 22–24) and was comparable to those reported from many 'Westernized societies' (1). Thirty years ago, Carswell et al. (24) found a prevalence of recurrent episodes of wheeze and breathlessness in 7.8% of children in South-West Tanzania. A recent study (23) conducted in an urban (Dar es Salaam) and rural region in Tanzania (in the foothills of Mount Killimanjaro) showed wheeze prevalence in 1.9–5.2%. Both studies were based on self-reported symptoms of wheeze or asthma from written questionnaires. Two studies (2, 25), including a free running test screening for exercise-induced bronchoconstriction conducted in urban and rural South-Africa and Kenya, demonstrated a prevalence of exercise-induced bronchoconstriction ranging from 8.9 to 22.9% with large regional differences.

Different methodology to diagnose or define asthma, environment and living conditions may explain the divergent prevalence of asthma symptoms among countries and districts. Our participants lived in a rural setting in the highlands of northern Tanzania, whereas other studies have included urban populations or populations from areas more similar to 'Westernized societies' (3, 5). Prevalence of diagnosed asthma may be underestimated in rural districts in developing countries due to social, financial, cultural and socio-economic barriers as well as the organization of national health care systems (26). The relatively high occurrence of asthma symptoms in the present study could also be due to lack of asthma control because of little or no disease-specific treatment. None of the children reported use of asthma medications.

The divergence among centres could also be due to the children's different understanding of the concept of wheezing, a word which is important, but not synonymous with asthma. As in most European languages, an exact equivalent of 'wheeze' in the Swahili language is absent (18) and a translated written questionnaire may not have the same precision as the original validated questionnaire (27). In general, agreement between written- and video questionnaire tends to be higher for English-speaking children (18). The children participating in the present study had a non-English speaking background and most of them preferred to speak the local language Iraqw and not Swahili which is the official language in Tanzania.

The high report of asthma symptoms in the present study could also be due to factors other than asthma. Non-atopic wheeze related to viral infections (28), other respiratory symptoms due to tuberculosis or malaria (29) or exposure to the combustion products of indoor fires (30) have been reported to be common in rural part of East-Africa. Cough or difficult breathing has been reported to be frequent in this population of Tanzanian children and 22% of all paediatric admissions to public hospitals in North-Tanzania are due to pneumonia (28).

The inverse association between body fat and asthma symptoms has, to our knowledge, not been reported previously; however, Kwon et al. (14) found a U-shaped curve with the extremes of BMI percentile in urban US boys) with parent/guardian reporting current asthma symptoms. Boys who were underweight had almost threefold OR of reporting asthma symptoms vs. boys of normal weight. This is consistent with the results from a study (15) conducted in 17-year-old Israeli males where underweight (BMI below 5th percentile) was associated with 80% increase in odds for bronchial and lung conditions like asthma compared with males of normal weight.

The higher occurrence of asthma symptoms in children with lower body fat might be related to nutritional and growth restriction affecting normal lung growth. Rural children who are underweight may be malnourished

because of either inadequate diets or frequent infections (31). In the present study, underweight children had reduced lung function compared to children of normal weight; however, lower body fat was not associated with reduced lung function. Lower correlations between skinfold measurements and body mass have been found for African-American children compared with Caucasians (32) and could explain this divergence.

We could not detect any association between aerobic fitness and current asthma symptoms. The explanation could be the homogeneous characteristics of the participants. None of the children was actually unfit. In contrast, Rasmussen et al. (12) found lower levels of work capacity to be associated with higher risk of developing asthma in a prospective study.

Strength and limitations

Due to the cross sectional design of the present study, we cannot conclude that there is any causal relationship between body fat and asthma symptoms.

There are difficulties and problems associated with questionnaire responses across languages and cultures. Recent studies suggest that lack of general asthma knowledge as well as understanding the word 'wheeze' may affect detection of asthma based on written questions alone (18). We used the standardized video questionnaire to provide the participating children with a visual representation of wheezing or depictions of asthma symptoms on the assumption that they might not understand the concept of wheezing; however, we cannot exclude the possibilities of bias with differential diagnosis of asthma. The other strengths of the present study are the standardized and objective methods when measuring

index of body fat, lung function and aerobic fitness. On the other hand, because of the great overlap of measurements between healthy children and those with previous asthma symptoms, the diagnostic accuracy of baseline lung function tests is generally poor (33). None of the children had FEV₁/FVC ratios below 80%, indices of obstructive airways and 3% of the children had reversible airflow limitation. Therefore, we could not test the association between asthma symptoms and abnormal FEV₁/FVC ratio or reversible airflow limitation. In addition, the precise date of birth was not usually known and age was interpolated from the year of birth. All participating children were considered to be of the same age, and we were therefore unable to adjust for age.

In conclusion, more than every fifth 9–10 year old child from a rural district in North-Tanzania reported asthma symptoms. The higher occurrence of asthma symptoms in children with lower body fat indicates the importance of improving nutritional status to prevent development of respiratory disease; however, whether low body fat increases the risk of developing asthma has to be confirmed using a longitudinal study design. Aerobic fitness was not associated with asthma symptoms.

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