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Seasonal variability in exercise test responses in Ghana

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Exercise-induced bronchospasm (EIB) is widely used in epidemiological studies to investigate the prevalence of asthma. We aimed to determine seasonal variations in the prevalence of EIB in Ghanaian school children from urban-rich (UR), urban-poor (UP), and rural (R) schools. We have previously reported the prevalence of EIB in 9–16-year-old children to be 3.1% in the dry season, with UR children having a significantly higher prevalence of both EIB and atopy compared to UP or R children. In the current study, the prevalence of EIB was assessed in the same 1,095 children in the wet season (5 months following the initial study) using the same methodology. Exercise provocation consisted of free running outdoors for 6 min. In the wet season, 17/1,095 children [1.55%, 95% confidence interval (CI): 0.91–2.47] had a positive response to exercise, compared to our previous report of 34 children (3.1%, 95% CI: 2.15–4.32) with EIB in the dry season (dry vs. wet season, difference 1.55, 95% CI: 0.41–2.69). The proportion of children with a positive response to exercise in the UR school fell from 4.2% (25/599) to 1.3% (8/599) (difference 2.9, 95% CI: 1.2–4.5). In the wet season, there was no difference in the prevalence of EIB among the UR, UP, and R children. Only five of 1,095 subjects (0.5%, 95% CI: 0.15–1.07) demonstrated EIB in both seasons. In conclusion, although exercise challenge remains a useful tool for determining asthma prevalence in epidemiological studies, seasonal variations in the pattern of responses may occur and the results should be interpreted with caution.

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A large proportion of asthmatics have exercise-induced bronchospasm (EIB), but a few do not (1). Moreover, some individuals show EIB even though they do not have asthma symptoms (1). Despite these limitations, exercise test responses have been widely used as an objective method in epidemiological studies to investigate the prevalence of asthma (2–4).

However, exercise test responses may be influenced by climatic and environmental factors such as temperature and humidity (5), and circulating allergen (6). It is uncertain how these factors affect the relevance of exercise test results in relation to the estimation of asthma prevalence in different regions.

The aim of this study was to determine seasonal variations in the prevalence of EIB in urban and rural Ghanaian school children.

Materials and methods

In a previous study in Ghana, the prevalence of EIB in a group of 9–16-year-old children was reported to be 3.1% in the dry season (2). Urban children from rich homes had a significantly higher prevalence of both EIB and atopy (4.2% and 6.6%) as compared to urban poor (1.4% and 2.9%) and rural (2.2% and 1.5%) children (2).

In the current study, the prevalence of EIB was assessed in the same group of urban-rich (UR),

urban-poor (UP), and rural (R) schoolchildren in the wet season (5 months following the initial study) using exactly the same methodology. We compared the prevalence patterns in the two seasons and related them to atopy. The study was carried out during July and August (the wet season) in Kumasi. Schools were categorized according to the school fees charged, as previously described (2).

The normal response to exercise had been determined previously as $\leq$12.5% drop in peak expiratory flow rate (PEFR) after exercise (2). Exercise provocation consisted of free running outdoors for 6 min, aiming to achieve a heart rate of greater than 170 beats/min or 85% maximum for age, whichever was greater (7,8). The PEFR maneuver was carried out 5 and 8 min after the exercise, and the best of three readings was recorded. The lowest PEFR was taken as the final PEFR after exercise.

Skin tests were performed by the skin-prick method, as previously described (2). A wheal diameter of at least 3 mm greater than the negative control was regarded as a positive response.

The computations were performed using the Confidence Interval Analysis computer programme and SPSS for Windows, version 8.0 (SPSS, Chicago, IL, USA).

Results

A total of 1,095 schoolchildren underwent an exercise challenge test in both wet and dry seasons. The mean morning temperature and relative humidity in the wet season were 24.9°C and 83%, respectively, with little day-to-day variability, compared to 28°C and 60% in the dry season. The same methodology of exercise testing was used in both studies.

Prevalence of EIB in dry and wet seasons among UR, UP, and R schoolchildren

Table 1 shows the prevalence of EIB by age in the UR, UP, and R schools during the wet season. Seventeen children (nine boys) overall had a positive response to exercise, giving a prevalence of EIB in this season of 1.55% [95% confidence interval (CI): 0.91–2.47] and a male-to-female ratio of 1 : 0.9. We previously reported that in the dry season, 34 children (16 boys) were found to have EIB, with an overall prevalence of 3.11% (95% CI: 2.15–4.32) and a male-to-female ratio of 1 : 1.13 (3) (dry vs. wet season, difference between proportions 1.55, 95% CI: 0.41–2.69).

The prevalence of EIB in the wet season for the UP (1.4%, three of 220) and R (2.2%, six of 276) schools was similar to that found in the dry season. However, the proportion of children with a positive response to exercise in the UR school fell from 4.2% (95% CI: 2.7–6.1, 25/599) to 1.3% (95% CI: 0.6–2.6, eight of 599), difference between proportions 2.9, 95% CI: 1.2–4.5. In the wet season, there was no significant difference in the prevalence of EIB between the schools. However, the younger age-group (9–12 years) tended to have a higher prevalence of EIB than the older age-group (13–15 years) (2.16%, 95% CI: 1.21–3.55 vs. 0.5%, 95% CI: 0.05–1.79, younger and older age-groups, respectively, difference between proportions 1.67%, 95% CI –0.4–2.9).

Only five out of 1,095 children (0.5%, 95% CI: 0.15–1.07) consistently demonstrated EIB in both wet and dry seasons, representing 10.9% (95% CI: 3.6–23.6) of the group of 46 children demonstrating EIB in one season or the other. Interestingly, none of these subjects was from the R school. A total of 1,049 schoolchildren (95.8%, 95% CI: 94.4–96.9) did not show EIB in either season, 28 (2.6%, 95% CI: 1.7–3.7) had EIB only in the dry season and 12 (1.1%, 9% CI: 0.6–1.9) only in the wet season (difference 1.5, 95% CI: 0.3–2.6).

It is interesting to note that of the five children with EIB in both the wet and dry seasons, two were atopic. The prevalence of atopy was 10% (95% CI: 2.1–26.5; three of 30) among those demonstrating EIB in the dry season, and 4.2% (95% CI: 3–5.8, 37/876) among those without EIB in either season (difference between proportions 5.8, 95% CI: –5.0 to 16.6). However, none of the 12 children with EIB only in the wet season was atopic.

Discussion

This study investigated bronchoconstrictor responses to exercise tests 6 months apart and in different seasons in a tropical climate. The results suggest that exercise tests conducted in epidemiological studies in the same group of children at different times of the year could yield different estimates of asthma prevalence.

Urban and rural differences in the prevalence of EIB have suggested that, in addition to genetic predisposition, social and environmental factors were important determinants in the expression of asthma. We made similar observations in previous studies (2). The results of the current study, however, suggest that the group of children with EIB in the dry season may be different from those with EIB in the wet season, with very little overlap.

Differences in the prevalence rates of EIB observed in the dry and wet seasons may be

Table 1. Proportion of children with exercise-induced bronchospasm (EIB) in the wet season among urban rich, urban poor, and rural schoolchildren

Age group	Urban rich	Urban poor	Rural
9–12 years, n	7/406	3/139	5/148
Proportion (95% CI)	1.7% (0.7–3.5)	2.2% (0.4–6.2)	4.3% (1.1–7.7)
13–16 years	1/193	0/81	1/128
Proportion (95% CI)	0.5% (0.02–2.8)	0% (0–4.5)	0.8% (0.02–4.3)
Overall	8/599	3/220	6/276
Proportion (95% CI)	1.3% (0.6–2.6)	1.4% (0.3–3.9)	2.2% (0.8–4.7)

CI, confidence interval.

explained by differences in climatic and other environmental factors (e.g. temperature, relative humidity, environmental pollution, and exposure to prevalent inhalant allergens to which children are sensitized) (9,10). The observed difference in the mean morning temperatures in the dry and wet seasons (28°C vs. 25°C) may not have contributed significantly to exercise test responses. However, the difference in relative humidity was substantial (60% vs. 83%). The higher relative humidity of the wet season could reduce the exercise test response. The ambient air in Kumasi during the dry season is usually dry with haze, and is perceptibly much less comfortable to breathe with the onset of the wind harmattan, and this effect may enhance airway reactivity, resulting in a greater number of positive exercise test results in children. Air pollution in Ghana has not yet been studied, although it is deemed to be considerable in the cities. The average age of cars is around 10 years and there is considerable pollution from exhaust fumes, especially from commercial vehicles. Levels of atmospheric SO_2, which is known to potentiate the response to exercise, may be very high. Bush fires are very common in the dry season, and there is increased outdoors domestic waste incineration. In the wet season soluble air pollutants are probably washed out of the atmosphere by the frequent rains, resulting in a relatively less polluted environment. Environmental factors that could increase the response to exercise could have greater effects in the dry season than in the wet season, and this would explain why the prevalence of EIB in the dry season seems greater than in the wet season.

Similarities in the pattern of prevalence of atopy among the UR, UP, and R schools were observed in the dry season study (2), whereas this was not the case in the wet season. The major sensitizing agent ($\approx$ 6%) in this study population was dust mite (2). The mean temperatures and relative humidity observed in the seasons could well support the growth of mites all year round. It is therefore unlikely that the observed difference in prevalence of EIB between the seasons is caused by seasonal differences in dust mite allergen levels. Seasonal differences in mould/fungal allergens are unlikely to contribute to differences in EIB responses as sensitization to these allergens in children was insignificant. Seasonal variations in the distribution of circulating pollens may be important. However, this has not been studied in Ghana.

It is possible that the group of children demonstrating EIB positivity in the dry season might include children with mild airway reactivity who are only detected by exercise challenge under the unfavorable climatic/environmental conditions. In the wet season, however, the relatively less polluted environment and higher humidity may suppress positive exercise test responses in most of the children with mild asthma. The group of children showing EIB only in the wet season might belong to the group of non-atopic, non-asthmatic children with a positive response to exercise. This is supported by the observation that none of the children demonstrating EIB only in the wet season was atopic. Although numbers were very small, it is worth noting that the proportion of atopic children was highest among those with positive exercise challenge in both seasons, and none of these children came from the rural school. Given the well-known relationships among asthma, airway reactivity, and atopy, EIB prevalence results during the dry season might give a better representation of the true prevalence and pattern of distribution of asthma in Ghanaian children.

In conclusion, although exercise challenge remains a useful tool in epidemiological studies for determining asthma prevalence, seasonal variations in the pattern of responses may occur. Results therefore need to be interpreted with caution.

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