Original Article

Exercise-induced asthma in adult Nigerian asthma patients: a comparison of step test, free running, and bicycle ergometer

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Abstract

Exercise is not only a very common precipitant of acute asthmatic episodes but also a potent non-pharmacological test for diagnosis of asthma. Different exercise protocols have been used; however a simple exercise test would be valuable and helpful for detecting exercise-induced asthma (EIA). The main goal of this study was to compare the exercise-inducing capacity of free running, step test, and cycle ergometer.

Forty-eight asthma patients performed and completed the exercise tests reaching at least 80–85% of the predicted maximal heat rate. The peak expiratory flow (PEF) values and heart rate (HR) were used to monitor pulmonary function post-exercise and the intensity of the exercise respectively. The PEF values were measured at baseline, immediately after the exercise then at 5-minute intervals up to 30 minutes. Subjects who reached the percentage fall in PEF $\geq 15\%$ were considered positive for EIA.

Free running was found to be the most asthmagenic exercise followed by the step test and cycle ergometer: 36 subjects (75%) for free running versus 27 subjects (56%) for step test, versus 24 subjects (50%) for cycle ergometer. There is a strong and significant correlation between the percentage fall in PEF of cycle ergometer and step test (r=0.61, p<0.001).

Free running produced the most positive result. However, the step test is a safe, simple, portable, and readily available instrument which compares well with laboratory-based cycle ergometer. We conclude that the step-test is an inexpensive and responsive exercise protocol for assessing and evaluating asthmatics in low-income countries.

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Introduction

Exercise-induced asthma (EIA) is defined as an acute, transient airway narrowing occurring during, and most often, after strenuous exercise.[1–3] The diagnosis of EIA is suggested by the clinical history and demonstrated by a decrease of 15% in forced expiratory volume in one second (FEV_1) or peak expiratory flow rate (PEF) after an exercise challenge in accordance with European Respiratory Society (ERS) and American Thoracic Society (ATS) statements.[4,5]

The prevalence of EIA in Nigerian asthmatics has been studied using free running,[6] however this requires a large space. Other ergometers such as treadmills and cycle ergometers are complex and expensive. The step test is a relatively new, non-laboratory based, easily constructed instrument that can be used in the assessment of EIA. The use of the step test in assessment of EIA has been mainly investigated mainly in Europe.[7,8]

There are very few, if any, indexed works on the use of the step test in the assessment and diagnosis of EIA in sub-Saharan Africa. The main goal of this study was, therefore, to evaluate and compare the exercise-induced capacity of the step test with free running and cycle ergometer in view of its relevance and future application in a resource-limited country

Methods and patients

Sixty two (62) young adults attending the Asthma Clinic at the Department of Medicine, Obafemi Awolowo University Teaching Hospital, were recruited between December 2005 and December 2006. The diagnosis of asthma was made by consultant physicians based on recurrent episodes of symptoms consistent with asthma and documented chart spirometric values. Patients who met certain inclusion and exclusion criteria (see Table 1) were incorporated into the study

Fourteen patients did not complete the study for different reasons: they could not accomplish all three tests; they missed their follow-up appointment; or the climatic conditions were not appropriate. Each subject was evaluated at the medical rehabilitation gymnasium laboratory of Obafemi Awolowo University. They were tested between 09.00 and 12.00 each day so as to maintain the same environmental conditions.

The subjects were asked not to drink coffee, tea, or

Inclusion criteria
- A past history of asthma (physician diagnosed).
- Patients must not have smoked for at least 1 year.
- Patients must be clinically stable and be without acute exacerbation of asthma or respiratory tract infection in the preceding 6 weeks.
- Aged 16–45 years.

Exclusion criteria
- Patients whose diagnosis of asthma is uncertain.
- Patients whose severity of asthma would constitute a considerable risk if they exercised.
- Presence of other lung diseases.
- Patients with contra-indication to exercise such as presence of significant cardiovascular, renal or neurological disease.

Table 2 Demographic characteristics of the patients

Characteristics	Values
Anthropometric measurement	
Age (years)	24.08±4.97
Weight (kg)	59.07±8.63
Height (m)	1.66±0.06
BMI (kg/m^2)	21.29±2.67
Gender	
Male	24 (50%)
Female	24 (50%)
Occupation	
Secondary school students	9 (18.7%)
University students	26 (54.2%)
Non students	13 (28.1%)
Duration of asthma (years)	
<5	14 (29.2%)
5–9	12 (25.0%)
10–14	2 (4.2%)
>15	20 (41.7%)
History of EIA	
Yes	28 (58.3%)
No 2	0 (41.7%)

NB. Data are presented as mean±standard deviation, frequency and percentages

soft drinks containing caffeine for 2 hours before the test and to discontinue the oral and inhaled β_2 agonist or antihistamine 12 hours before the test. Oral and inhaled corticosteriods were also withdrawn 24 hours before the test. The study was approved by the Hospital Research Ethics Committee of Obafemi Awolowo University Teaching Hospitals Complex and all subjects gave informed written and verbal consent.

PEF was measured using a micro peak flow meter after due explanation of the procedure and accompanied demonstration. The best of three satisfactory readings was recorded.

Exercises
1. Free running. The subjects were encouraged to run as fast as they could for 1–2 minutes, breathing in the ambient air until they reached 80% of the maximal target heart rate, and to maintain this pace for the next 4–5 minutes before stopping.

2. Bicycle ergometer. Subjects were asked to exercise on a bicycle ergometer. The workload was adjusted in order to reach a heart rate between 80 and 90% of maximum heart rate after a warm-up period of 1–2 minutes.

3. Step test. Subjects were asked to step up and down a 15 cm double stairs wooden step. The level of intensity of the exercise was selected to maintain a heart rate between 80–90% of the maximum (stepping continuously for 5 minutes after reaching the target heart rate). A standard metronome was used to maintain the stepping rate and subjects were encourage to step to the beat.
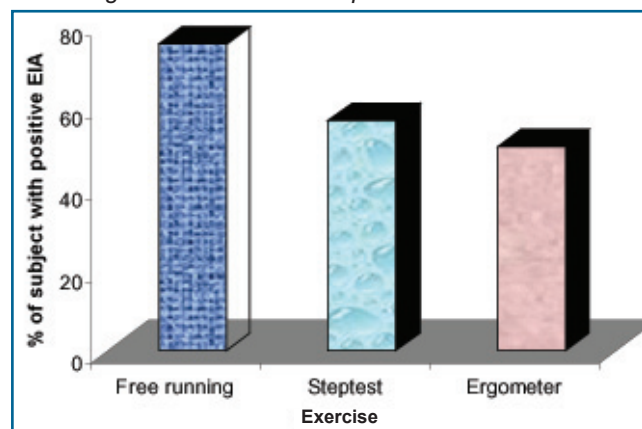
Statistical analysis
The data were expressed as mean ± standard deviation (SD). Comparison between means was performed through ANOVA (analysis of variance) of repeated measures. The concordance between the qualitative results of the test was established by using the McNemar test. The correlation of percentage fall in PEF between the exercise tests was made using Pearson's correlation coefficient. The analysis of specific differences between

Figure 1 Prevalence of exercise-induced asthma according to the three-exercise protocol

the different time periods was made by Tukey's test. A p value of < 0.05 was considered to indicate statistical significance. All statistical tests were made using SPSS version 11 (Chigaco, IL).

Results

The demographic characteristics of the patients who participated in the study are shown in Table 2. The baseline PEF and mean heart rate before the exercise tests showed no significant differences. The maximum heart rate attained during the exercise was also similar after the three exercise tests. The frequency of EIA for each test is shown in Figure 1. Free running is the most asthmagenic exercise followed by the step test and then cycle ergometer.

When comparing the free running and step tests, 26

of 48 subjects studied (54.2%), both tests induced EIA and in 11 subjects (22.9%); both tests were negative for EIA. Of the remaining 11 subjects, 10 had EIA after free running but not after the step test and only 1 had EIA after the step test but not after free running. For the free running and cycle ergometer comparison, in 21 out of 48 subjects (43.8%) both tests induced EIA and in 9 subjects (18.75%) both tests were negative. Of the remaining 18 subjects, 15 had EIA after free running but not after ergometer and 3 EIA after ergometer but not after free running. However, by performing the same analysis between cycle ergometer and step test, 18 out of 48 subjects (37.5%) had a positive response on both tests and in 15 subjects both tests were negative (31.25%). Of the remaining 15 subjects, 9 were positive only after step test and only 6 were positive after cycle ergometer (p=0.439, NS). There is significant and good correlation between the percentage values of maximum decrease in PEF during step test and cycle ergometer (r=0.61, p<0.001).

Figure 2 shows changes in PEF (percentage of baseline value) after the three exercise tests, according to the duration of exercise. The greatest decrease occurred on the free-running test (p<0.05) .

Discussion

This study shows that free running was most asthmagenic. This is in agreement with Erhabor and colleagues, in Nigeria, who reported a prevalence rate of 77.5% using free running as an exercise protocol.[6] Treadmill running has been found to be similar to free running although less asthmagenic.[9]

The use of the step test as an exercise protocol in evaluating EIA is new, but this modality is becoming an established means for evaluating EIA. The step test has various advantages. It does not involve the use of sophisticated instruments; it is inexpensive, can be carried out with little training, and requires less space. Moreover, it can be as effective as the cycle ergometer. Support for the step test as an alternative to the treadmill or other laboratory-based studies comes from a landmark study by Feinstein and colleagues.[8] They showed that the step test is more sensitive than physical

Figure 2 Rate of fall in PEF post-exercise after the three exercise tests

examination, pre-exercise pulmonary function testing, and self-administered questionnaires in identifying EIA in adolescent athletes and in elementary school children. This is further collaborated by Young and Holst.[7] In their study of 32 adolescent asthmatic patients, they reported a positive test in 27 subjects after a treadmill test and in 25 after a step test. They also observed a strong correlation between the maximum percentage falls in FEV_1 after the two exercise challenges (r=0.92; p<0.0001).

Our study also shows that the positive test between step test and cycle ergometer is comparable. It also shows a strong and significant correlation between the maximum percentage PEF fall after free running and step test. Although free running is widely used as an exercise test in epidemiological studies, it requires more space unless it takes place in an indoor gymnasium. This space is often not available in the out-patient and public setting and is not reproducible in the community setting.[10] Tancredi and co-authors[11] further corroborated the usefulness of step tests and reported that it yielded high diagnostic power, and good and negative predictive values in comparison with the treadmill in detecting EIA in asthmatic children.

We used PEF as a measure of pulmonary function post-exercise because it is very useful in low-income countries, readily available, portable, and can be used by general health practitioners. It is, however, limited in that it has significant intra- and inter-personal variation .

Conclusion

Exercise challenge tests are very valuable in evaluating young adult asthmatics; while free-running tests produce more bronchoconstriction, laboratory-based cycle ergometers offer no significant advantage over the step test.

The step test is a quick, economical, safe, and portable alternative procedure that can be used for identifying EIA or bronchial asthma in out-patients and epidemiological studies.
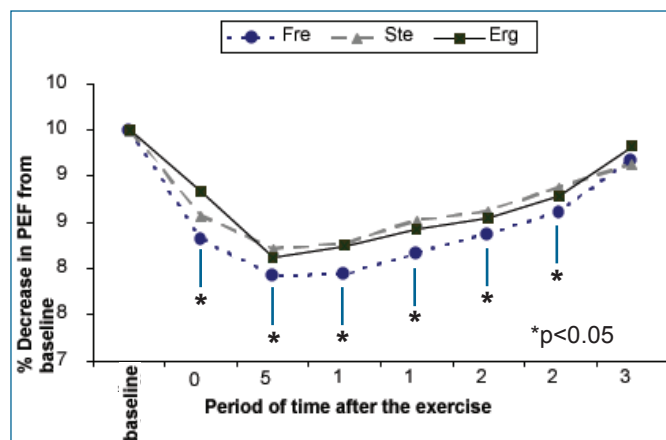
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