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The Shuttle Run Test Is Not Valid for the Detection of Asthma in School Physical Education Programs

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OBJECTIVE: Certain sporting activities may trigger asthma exacerbations of varying intensity in children. Such exacerbations may lead to limitations in and rejection of such activities. During school hours, teachers are in a good position to observe these phenomena. The aim of the present study was to evaluate the shuttle run, a test of physical fitness used in school physical education programs, as a way of detecting asthma.

PATIENTS AND METHODS: We carried out a cross-sectional observational study of school children between the ages of 6 and 12 years using the asthma symptom questionnaire of the International Study of Asthma and Allergies in Childhood (ISAAC), a shuttle run test, and a free running test at maximum effort in order to study bronchial hyperresponsiveness. The principal measure of bronchial hyperresponsiveness used in both physical fitness tests was peak expiratory flow rate as measured with a peak flow meter. In comparing the results of the shuttle run test with those of the free running test and the ISAAC questionnaire we used the χ^2 test to measure association and the Cohen κ coefficient to measure agreement.

RESULTS: We distributed the ISAAC questionnaire (n=919) to 460 (50.1%) boys and 459 (49.9%) girls between the ages of 6 and 12 years. All the tests were completed by 826 children. The level of agreement between the shuttle run test and free running test was positive but low for decreases in peak expiratory flow rate compared to baseline of 15% (χ^2=5.6; *P*<.05; κ=0.093; SE, 0.042) and of 20% (χ^2=4.5; *P*<.05; κ=0.08; SE, 0.046). For 10% decreases association was not significant and agreement was low (κ=0.05; SE, 0.04). There was no agreement between the ISAAC questionnaire and the shuttle run test (κ=0.095; SE, 0.63).

CONCLUSIONS: The shuttle run test using peak expiratory flow rate as the principal measure of bronchial hyperresponsiveness is not valid for the detection of asthma in schoolchildren.

Key words: *Shuttle run test. Epidemiology. Asthma bronchial hyperresponsiveness. Children.*

La prueba *course-navette* no es válida para detectar asma en programas de educación física escolar

OBJETIVO: Determinadas actividades deportivas pueden desencadenar en el niño agudizaciones de asma de intensidad variable, limitaciones y rechazo de las actividades deportivas. Durante el horario escolar los profesores son observadores privilegiados de estos fenómenos. El objetivo del presente estudio ha sido evaluar la prueba *course-navette* ("carrera de ida y vuelta", PCN), prueba de rendimiento físico de los programas de educación física escolar, como medida para detectar asma.

PACIENTES Y MÉTODOS: Se ha realizado un estudio observacional y transversal en escolares de 6 a 12 años de edad, mediante cuestionario de síntomas relacionados con el asma (ISAAC) y pruebas de rendimiento físico (PCN) y de carrera libre con esfuerzo máximo para estudiar la hiperrespuesta bronquial, utilizando en ambas como medida principal el flujo espiratorio máximo (FEM) determinado con medidor del ápice de flujo espiratorio. En la comparación de los resultados de la PCN con los del test de carrera libre y el cuestionario ISAAC se midió el grado de asociación (con la prueba de la χ^2) y de acuerdo (estadístico kappa de Cohen).

RESULTADOS: Se distribuyó el cuestionario ISAAC (n = 919) a 460 niños (50,1%) y 459 niñas (49,9%) de 6 a 12 años de edad (mediana ± desviación estándar: 8 ± 1,87 años). Completaron todas las pruebas 826. Se observó una asociación con bajo acuerdo entre la PCN positiva y el test de carrera libre positivo para descensos del FEM, en relación con el basal, del 15% (χ^2 = 5,6; p < 0,05; kappa = 0,093; error estándar [EE] = 0,042) y del 20% (χ^2 = 4,5; p < 0,05; kappa = 0,08; EE = 0,046). Para descensos del FEM del 10% la asociación no fue significativa y el acuerdo resultó débil (kappa = 0,05; EE = 0,04). No hubo acuerdo entre ISAAC y la PCN (kappa = 0,095; EE = 0,63).

CONCLUSIONES: La PCN con el FEM como medida principal del efecto no es válida para detectar asma en escolares.

Palabras clave: Course-navette. *Epidemiología. Asma. Hiperrespuesta bronquial. Niños.*

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Introduction

The study of the prevalence of asthma consists of administering questionnaires on the signs and symptoms associated with the disease, such as those developed by the European Community Respiratory Health Study[1] and the International Study of Asthma and Allergies in Childhood (ISAAC),[2] along with tests of bronchial hyperresponsiveness.[3-6] However, while questionnaires are easy to administer in large population samples,[7] bronchial challenge and reversibility testing involves higher costs and greater difficulties in terms of both performance and acceptance. This difficulty has been avoided in large population studies by using exercise testing as a measure of bronchial hyperresponsiveness.[8,9]

In view of the high prevalence of asthma in children, it would appear opportune to develop detection programs that meet the efficiency criteria required for their widespread use. Physical exercise allows bronchial hyperresponsiveness to be observed in children with asthma.[10] If we accept that children with exercise-triggered bronchial hyperresponsiveness show low levels of performance in physical activity, exercise testing could be useful in identifying those children with undetected or poorly controlled asthma within their own environment.[11,12]

For these reasons, we consider the present study to be justified. The aim of the study was to determine the diagnostic precision of a physical fitness test, the Leger Lambert or shuttle run test,[13,14] originally designed to determine maximal aerobic capacity (peak oxygen consumption [VO_{2max}] =5.857×speed [km/h]–19.458). This test is well known and can easily be conducted in schools by physical education instructors, and for this reason may be useful in establishing a diagnosis of suspected asthma.

Patients and Methods

We carried out a cross-sectional observational study of school children between the ages of 6 and 12 years in 3 nonrandomly selected schools in Guipúzcoa. Participation of schools in the study was dependent on their cooperation and on the approval of the parents' associations. One public and 2 private schools participated. The determination of the sample size was based on prevalence studies carried out in Guipúzcoa[15,16] and on the prevalence of exercise-related signs and symptoms of asthma.[8,9]

The study was carried out between November 2000 and November 2001. The ISAAC questionnaire on asthma-related symptoms was distributed together with the informed consent document. Primary school teachers gave out and collected the questionnaires, which were completed at home with the help of parents. The following questions of the ISAAC questionnaire were analyzed: "Has your child ever experienced wheezing?"; "Has your child experienced wheezing in the last 12 months?" "Has your child ever had asthma?"; and "Has it been confirmed by the child's doctor?"

Two exercise tests were carried out: the shuttle run test and the free running test at maximum effort. Both were carried out in the schools' open-air playgrounds and, whenever possible, during the pupils' physical education classes. Two observers coordinated both tests, which were carried out on 2 different days. The pupils were tested in groups of 8.

The shuttle run test was carried out on flat terrain and between 2 parallel lines 20 m apart. An audio tape was used to give the signals so that the subjects would move at the speed indicated. The test results were measured in units of a level and a half level, which corresponded to the distances marked. A level was equivalent to 8 shuttle laps (160 m). At each level, the intensity of the exercise increased compared to the previous one. The test ended when the participant failed to come within 2 m of the ends of the lines at the moment indicated by the tape. The level of physical fitness of each participant was determined by the number of levels completed. The tests were carried out in the open air and the atmospheric conditions at the time (temperature, barometric pressure, and humidity) were recorded. The physical education instructor, in addition to the 2 observers, was in charge of conducting the tests. Using a Mini-Wright peak flow meter (Clement Clark International, Harlow-Essex, UK), we took the best measurement of 3 tries at rest, and at 5, 10, and 15 minutes following exercise. The test was considered positive if there was a decrease in peak expiratory flow rate (PEFR) of 15% or more compared to baseline.

The free running test was also carried out in the school playgrounds during physical education classes and in the open air. Temperature and relative humidity were recorded before each test. If humidity was more than 10 mg H_2O/L, the test was postponed to another date with suitable atmospheric conditions.[17] The children began the test after a rest period of at least 2 hours. Any medication taken during the 48 hours prior to the test was recorded, as well as any associated symptoms. The test consisted of a 6-minute run at maximum effort. Heart rate was monitored with a Sport Tester P-300 heart rate monitor (Polar Electric Oy, Rovaniemi, Finland) by means of an elastic chest band. The watch receiver was held by the person monitoring the test. After 1 minute of running, if heart rate was less than 170 beats/min, the participant was encouraged to increase the effort in order to reach and maintain that heart rate for at least the last 4 minutes.[11]

A Mini-Wright peak flow meter was used to measure PEFR and the best measurement of 3 tries was recorded, at rest, and at 5, 10, and 15 minutes after exercise. The test was considered positive if there was a decrease in PEFR of 15% or more compared to baseline. If the expected heart rate had not been reached by the end of the run, the free running test was not considered valid.

Statistical Analysis

The data obtained were introduced into a specifically-designed Microsoft Access data base. A preliminary analysis was carried out to detect inconsistencies, values outside the logical range, violations of inclusion criteria, etc. A descriptive and comparative statistical analysis was then performed to study the differences between subgroups.

For the analysis of the main variables, we compared groups of subjects with 10%, 15%, and 20% decreases in PEFR during the shuttle run test and of subjects with those decreases during the free running test. The level of agreement between shuttle run test and free running test positivity was assessed for subjects who had PEFR decreases of 10%, 15%, and 20%. For the comparison of qualitative variables, we used the χ^2 and the Fisher exact tests. Significance was set at a value of P less than .05. The level of agreement was analyzed by calculating the Cohen κ coefficient (SE).

Results

We distributed the ISAAC questionnaire to 919 children, 460 (50.1%) boys and 459 (49.9%) girls. The mean (SD) age was 8.17 (1.66) years (range, 6-12 years. The questionnaire was answered by 855 (93%) of the 919 children. The group that did not answer (7%) included those who did not complete the questionnaire correctly and those whose parents did not authorize participation in the study. All the tests were completed by 826 (89.9%) children. The composition of the sample is shown in Figure 1.

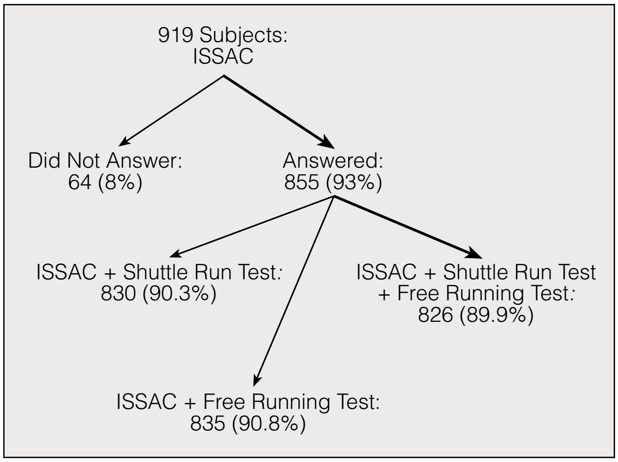

Figure 1. Study population and sample.

On the ISAAC questionnaire (asthma section), 25.5% of the children surveyed reported a previous history of wheezing. Of the total sample, 25.5% reported having experienced wheezing in the previous 12 months. Fifteen percent reported having had asthma on some occasion and 16% had been diagnosed with asthma by their pediatrician. Exercise-related symptoms were reported by 8.5% and nighttime cough by 13%. Some medication belonging to the group of drugs prescribed for asthma (short-acting bronchodilators, inhaled and/or oral corticosteroids) was currently being taken by 6.9%.

Of the 835 children who performed the free running test, 2 experienced considerable dyspnea, cough, and wheezing that prevented them from completing the test. There was a 10% decrease in PEFR in 285 (34%) subjects, a 15% decrease in 177 (21.2%), and a 20% decrease in 69 (8.2%).

Mean decreases in PEFR during the free running test are shown in the histogram in Figure 2. The distribution was skewed to the left and most values were between 0 and –20. The interval with the largest concentration of results (approximately 20% of the total sample) was between –5 and –10.

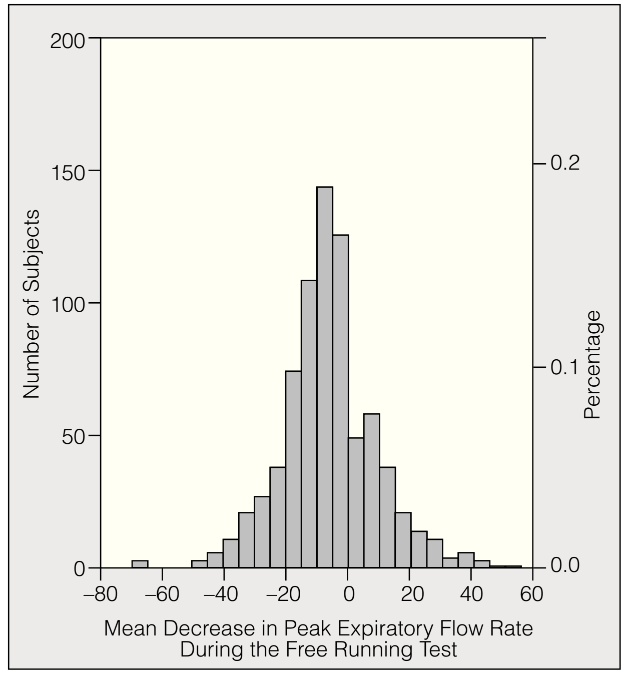

Figure 2. Histogram of mean decrease in peak expiratory flow rate during the free running test

The shuttle run test was completed by 830 children. There was a 10% decrease in PEFR in 268 (32.3%) subjects, a 15% decrease in 160 (19.3%), and a 20% decrease in 86 (10.3%). The number of levels completed is shown in Figure 3; the most common category corresponded to 1.5 levels, and the majority completed between 1.5 and 5 levels. Mean PEFR decrease during the shuttle run test is shown in the histogram in Figure 4, with the same configuration as the one described for the free running test. The

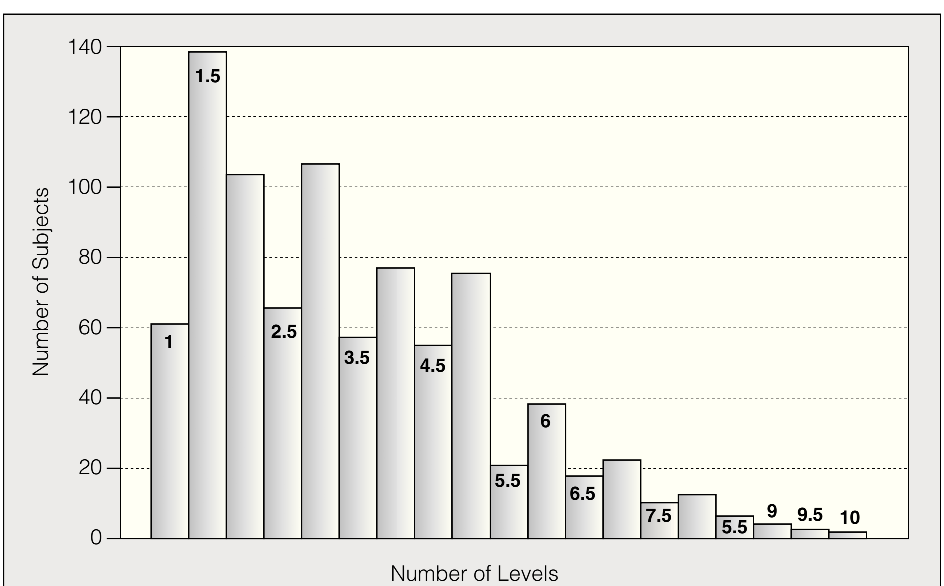

Figure 3. Number of levels completed by subjects in the shuttle run test.

TABLE 1
Agreement Between 15% Decreases in Peak Expiratory Flow Rate in the SRT and in the FRT*

	No Decrease in the FRT	Decrease in the FRT	Total
No decrease in the SRT	394	109	503
Decrease in the SRT	94	43	137
Total	488	152	640

*SRT indicates shuttle run test; FRT, free running test.

TABLE 2
Agreement Between 10% Decreases in Peak Expiratory Flow Rate in the SRT and in the FRT*

	No Decrease in the FRT	Decrease in the FRT	Total
No decrease in the SRT	268	151	419
Decrease in the SRT	94	43	137
Total	398	242	640

*SRT indicates shuttle run test; FRT, free running test.

TABLE 3
Agreement Between 20% Decreases in Peak Expiratory Flow Rate in SRT and in the FRT*

	No Decrease in the FRT	Decrease in the FRT	Total
No decrease in the SRT	500	71	571
Decrease in the SRT	54	15	69
Total	554	86	640

*SRT indicates shuttle run test; FRT, free running test.

TABLE 4
Agreement Between 15% Decreases in Peak Expiratory Flow Rate in the SRT and Question 2 of the ISAAC questionnaire*

	Negative Response	Positive Response	Total
No decrease in the SRT	161	46	247
Decrease in the SRT	50	23	73
Total	211	69	280

*SRT indicates shuttle run test; ISAAC, International Study of Asthma and Allergy in Childhood.

distribution was skewed to the left and most values were between 0 and –15. The interval with the largest concentration of results (approximately 22% of the total sample) was between –5 and –10.

The level of agreement between shuttle run test and free running test positivity was assessed for subjects who had PEFR decreases of 10%, 15%, and 20% after each test. Table 1 shows the level of agreement between PEFR decreases of 15% during the shuttle run and the free running tests: in 94 (14.6%) cases there was a decrease of more than 15% in the shuttle run test, but not in the free running test. In 109 (17%) cases, the reverse was the case. The level of association, assessed by the χ^2 statistic, was 5.6 ($P<.05$); the level of agreement, assessed by the Cohen κ coefficient, was 0.093 (0.042).

Table 2 shows the results for 10% decreases. In 130 (20.3%) cases, the decrease was more than 10% in the shuttle run test but not in the free running test. In 151

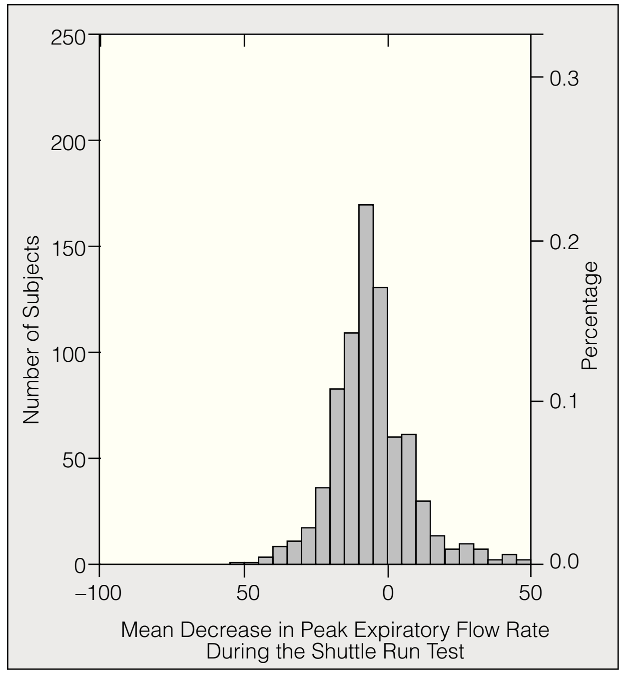

Figure 4. Histogram of mean decrease in peak expiratory flow rate during the shuttle run test.

(23.5%) cases the decrease occurred in the free running test, but not in the shuttle run test. The association between the 2 tests for this decrease was not significant (χ^2=1.62; P=.202). The Cohen κ coefficient was 0.05 (0.04). The data were similar (χ^2=4.58; $P<.05$; Cohen κ coefficient, 0.084 [0.04]) for 20% decreases (Table 3).

When we compared the data for PEFR of 15% in the shuttle run test with affirmative responses to the question "Has your child experienced wheezing in the past 12 months?" on the ISAAC questionnaire (Table 4), we found no significant association (χ^2=2.5; P=.113; Cohen κ coefficient, 0.095 [0.06]).

The sensitivity of the free running test for the detection of asthma (positive response to the question "Has your child experienced wheezing in the past 12 months?" and a decrease in PEFR of 15% or more during the free running test) was 62.7% and the specificity, 79.9% The sensitivity of the shuttle run test for the detection of asthma (positive response to the above-mentioned question and a decrease in PEFR of 15% or more during the shuttle run test) was 40% and the specificity, 80.4%.

Discussion

During school hours teachers are direct observers of various aspects of their pupils' health. Certain school sports activities can trigger asthma attacks or exacerbate asthma symptoms. There are clearly certain signs and symptoms of asthma that are only observed in the school environment. This has given rise to various studies designed to assess the level of knowledge about asthma among teachers and educators[18,19] and to the development of instruction programs aimed at such professionals. The results have been encouraging.[20]

Ours was the first study designed to evaluate whether or not a test of physical fitness (the shuttle run test) commonly used in school physical education programs is valid for the detection of asthma. The selection of the schools where the tests were carried out was not random, and was based on the feasibility of the study with regard to the person coordinating the tests, a physical education instructor in the participating schools, who had to be trained in how to conduct both the shuttle run and the free running tests, The aim of this measure was to avoid inter-rater variability.

The questions on the ISAAC questionnaire that we analyzed were those related to cumulative and current prevalence of asthma-related signs and symptoms as well as those related to the group of subjects who had already been diagnosed with asthma.

We defined bronchial hyperresponsiveness as a PEFR decrease of 15% or more in the free running test at maximum effort. We chose to use PEFR rather than forced expiratory volume in 1 second, which is less dependent on voluntary effort and more reproducible than PEFR in lung function studies,[21,22] because it is technically easier to measure.

The sensitivity and specificity of the free running test for the diagnosis of bronchial hyperresponsiveness are affected by other factors. Seear et al[23] recently demonstrated this by pointing out the bias that may result from the subjects' exaggeration of symptoms, from the presence of certain psychological problems, or from the presence of other local diseases, such as vocal cord dysfunction.

Furthermore, sometimes there is a failure to control for the bias that may be introduced by certain variables, such as variations in the intensity of physical exercise,[24] its duration, or the temperature and humidity of the air inhaled,[17] all of which may alter the result of the test and, therefore, the number of children diagnosed with exercise-induced bronchial hyperresponsiveness. Variation in the definition of in PEFR decreases of 10%, 15%, or 20% may also lead to differences in the results.

After comparing PEFR values obtained during the shuttle run test with those obtained during the free running test for decreases of 10%, 15%, and 20%, we observed that the level of agreement was low and that there was no association between the 2 tests. The sensitivity of the shuttle run test was about 40%. This low sensitivity may be due to the fact that the test is a progressive one and that the subject may enter a refractory period; the free running test, on the other hand, is always carried out at maximum effort and begins rapidly, as described by Godfrey et al.[25]

In conclusion, the shuttle run test using PEFR measured with a portable peak flow meter as the principal measure is not valid in our setting to confirm suspected asthma.

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