Mid-expiratory flow versus FEV$_1$ measurements in the diagnosis of exercise induced asthma in elite athletes

J W Dickinson, G P Whyte, A K McConnell, A M Nevill, M G Harries

**Background:** A fall in FEV$_1$ of >10% following bronchoprovocation (eucapnic voluntary hyperventilation [EVH] or exercise) is regarded as the gold standard criterion for diagnosing exercise induced asthma (EIA) in athletes. Previous studies have suggested that mid-expiratory flow (FEF$_{50}$) might be used to supplement FEV$_1$ to improve the sensitivity and specificity of the diagnosis. A study was undertaken to investigate the response of FEF$_{50}$ following EVH or exercise challenges in elite athletes as an adjunct to FEV$_1$.

**Methods:** Sixty six male (36 asthmatic, 30 non-asthmatic) and 50 female (24 asthmatic, 26 non-asthmatic) elite athletes volunteered for the study. Maximal voluntary flow-volume loops were measured before and 3, 5, 10, and 15 minutes after stopping EVH or exercise. A fall in FEV$_1$ of >10% and a fall in FEF$_{50}$ of >26% were used as the cut off criteria for identification of EIA.

**Results:** There was a strong correlation between $\Delta$FEV$_1$ and $\Delta$FEF$_{50}$ following bronchoprovocation ($r=0.94$, $p=0.000$). Sixty athletes had a fall in FEV$_1$ of >10% leading to the diagnosis of EIA. Using the FEF$_{50}$ criterion alone led to 21 (35%) of these asthmatic athletes receiving a false negative diagnosis. Only one athlete had a fall in FEF$_{50}$ of >26% in the absence of a fall in FEV$_1$ of >10% ($\Delta$FEV$_1$ = 8.9%).

**Conclusion:** The inclusion of FEF$_{50}$ in the diagnosis of EIA in elite athletes reduces the sensitivity and does not enhance the sensitivity or specificity of the diagnosis. The use of FEF$_{50}$ alone is insufficiently sensitive to diagnose EIA reliably in elite athletes.
Voluntary ventilation (30% of hyperventilating for 6 minutes at a rate of 85% maximal O2, 5% CO2 and 74% N2). For both exercise and EVH during the EVH challenge was a medical gas containing 21% O2.

The lowest fall in FEV1 and FEF50 following either exercise or EVH were recorded and the change was calculated (Δ). A ΔFEV1 of ≥ −10% and a fall in FEF50 of ≥26% were considered cut off criteria for EIA diagnosis.

**RESULTS**

There was a strong positive correlation between ΔFEV1 and ΔFEF50 following bronchoprovocation (r = 0.94, p = 0.000). Sixty athletes (52%) had a ΔFEV1 fall of ≥10% leading to the diagnosis of EIA (fig 1). Using the FEF50 criteria alone led to 21 (35%) asthmatic athletes receiving a false negative diagnosis; thus, 39 athletes met both FEV1 and FEF50 criteria. The lowest fall in FEV1 was 14.3%. Reducing the FEF50 criterion to a 10% cut-off value resulted in 39 athletes meeting the cut off criteria for EIA diagnosis.

**Figure 1** Delta FEV1 versus delta FEF50.

![Graph showing Delta FEV1 versus Delta FEF50](image_url)

**Table 1** Mean (SD) changes in FEF50 and FVC following bronchoprovocation challenge

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<tr>
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<tr>
<td></td>
<td>FEV50 (l/s)</td>
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<td>FVC (l)</td>
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<td></td>
<td></td>
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<tr>
<td>Asthmatic</td>
<td>3.86 (0.92)</td>
<td>2.39 (0.84)**</td>
<td>4.99 (1.00)</td>
<td>4.45 (1.16)**</td>
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<tr>
<td>Non-asthmatic</td>
<td>4.79 (1.37)</td>
<td>4.43 (1.31)</td>
<td>4.81 (1.03)</td>
<td>4.65 (1.04)</td>
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Asthmatic athlete defined as having a ≥10% fall in FEV1 following bronchoprovocation.

**Significantly different (p = 0.05) from pre-test value.**
presented with EIA following bronchoprovocation. Of the 33 athletes who had been referred for testing but had no previous diagnosis of EIA, 10 athletes were diagnosed with EIA following bronchoprovocation challenge. Of the 60 athletes who were diagnosed with EIA and after bronchoprovocation challenge are shown in table 1. FEF50 (p = 0.000) and FVC (p = 0.000) were significantly lower after bronchoprovocation in the asthmatic athletes. There was no significant change in FEF50 or FVC before and after bronchoprovocation challenge in athletes who did not have a fall in FEV1 of ≥10%.

The specificity, sensitivity, predictive value of positive test and efficiency of FEF50 cut off criteria of 26% and 14% are shown in tables 2, 3 and 4, respectively.

DISCUSSION

This study shows that the addition of FEF50 reduces the sensitivity of EIA diagnosis following exercise or EVH challenge. Of the 60 athletes who were diagnosed with EIA using IOC-MC criteria of a ≥10% fall in FEV1, 21 (35%) would have received a false negative diagnosis using a combination of FEV1 and FEF50 falls. Furthermore, only one athlete exceeded the criterion for FEF50 but not for FEV1. Our study therefore suggests that FEF50 does not improve the diagnosis of EIA in elite athletes using the IOC-MC criteria.

In previous studies, measurements of FEF25–75 have been used to supplement FEV1 in the diagnosis of EIA in children and athletes. The studies conducted on children have supported the addition of FEF25–75 measurements to improve the diagnosis of EIA. It has been suggested that FEF25–75 is a more sensitive measure of obstruction in the small airways than FEV1. Thus, EIA may be a disease that consistently affects the expiratory flow through the small airways. Fonseca-Guedes et al noted that only 60% of children with “interruption” EIA met the criteria for both FEV1 and FEF25–75 compared with 94.4% of children with “severe persistent” EIA. They suggested that FEF25–75 is more likely to fall significantly than FEV1 in children with mild EIA. Our data do not agree with this finding and suggest that FEV1 is more likely to fall significantly in athletes with mild asthma. Indeed, only one athlete had a significant fall in FEF50 (≥26%) in the absence of a significant fall in FEV1, while 21 athletes had a significant fall in FEV1 (≥10%) in the absence of a significant fall in FEF50. Only 39 athletes met both criteria for FEF50 and FEV1, which would have resulted in 21 (35%) athletes (who met FEV1 criteria) receiving a false negative diagnosis for EIA. The reduced sensitivity found following the inclusion of the FEF50 measurement suggests that, in elite athletes with mild EIA, expiratory airflow is just as likely to be restricted in the larger airways as in the smaller airways. It is therefore appropriate to assess expiratory flow using an index of function for both the larger and smaller airways of the lung— that is, FEV1.

A number of studies have examined the diagnosis of EIA in athletes but they have not specifically used mid-expiratory flow rates as a criterion for making the diagnosis. Rundell et al suggested that a fall in FEF25–75 of 14% is significant in the diagnosis of EIA in winter athletes. This lower limit was calculated by taking the mean post exercise change from baseline spirometry and subtracting 2 standard deviations. Lowering the FEF50 cut off value in our data to ≥14% resulted in an increase in the sensitivity but a decrease in the specificity from 98% to 77%. Using a 14% cut off value, 13 athletes would have been diagnosed with EIA who did not meet the IOC-MC criterion of a 10% fall in FEV1 from baseline values.

A further problem associated with the use of FEF50 as a criterion measurement is that its reliability is dependent upon the constancy of FVC. Our results show that the mean fall in FEF50 following bronchoconstriction was accompanied by a mean fall in FVC in athletes with EIA. The fall in FEF50 seen in some of athletes following a bronchoprovocation test may therefore be partially attributable to a reduction in FVC. The reduction in FVC in asthmatic athletes may be due to the prolongation and discomfort associated with exhaling to residual volume during bronchoconstriction. Despite standard controls, this may cause the athlete to stop exhaling before reaching residual volume. This shortcoming further undermines the potential value of FEF50 for diagnosing EIA.

In conclusion, the addition of FEF50 to FEV1 reduces the sensitivity of a diagnosis of EIA in elite athletes. Our data suggest that a more global measure of maximal expiratory airflow (FEV1) provides the most sensitive and specific criteria for making the diagnosis. Rundell et al suggested that a fall in FEF25–75 of 14% is significant in the diagnosis of EIA in winter athletes. This lower limit was calculated by taking the mean post exercise change from baseline spirometry and subtracting 2 standard deviations. Lowering the FEF50 cut off value in our data to ≥14% resulted in an increase in the sensitivity but a decrease in the specificity from 98% to 77%. Using a 14% cut off value, 13 athletes would have been diagnosed with EIA who did not meet the IOC-MC criterion of a 10% fall in FEV1 from baseline values.

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