

Pulmonary Function Analysis of Japanese Athletes: Possibly Even More Asthmatics in the Field

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ABSTRACT

Background: The prevalence of bronchial asthma (BA) in youth is increasing in Japan, but very few athletes are reported to be affected with BA. The aim of this study is to analyze pulmonary function test (PFT) in athletes from the aspect of BA retrospectively.

Methods: Medical history questionnaires of 2111 athletes (male: 1549, female: 562) were reviewed. All athletes participated in the institute's athletic test for the first time, from April 2003 through March 2006. Athletes were categorized into three groups; current-BA confirmed and treated by the physician, possible-BA according to the allergic history and/or BA symptoms, and non-BA that is neither of the above two groups. The PFT data were then analyzed.

Results: There were 24 current-BA (1.1%), 137 possible-BA (6.5%), and 183 cases with a past history of BA (PH; 8.7%). Percent of predicted forced expiratory volume in 1 second (%FEV₁) and of predicted peak expiratory flow rate (%PEF) in current-BA ($86.2 \pm 17.7\%$ and $81.6 \pm 19.1\%$, respectively) and possible-BA ($84.7 \pm 14.6\%$ and $81.2 \pm 17.3\%$, respectively) were significantly lower than those in non-BA ($93.9 \pm 13.7\%$ and $93.8 \pm 19.8\%$, respectively), without any significant difference between current-BA and possible-BA. Athletes with PH show impaired obstructive indices; even in non-BA with PH showed lower %FEV₁ ($91.3 \pm 13.9\%$, $p < 0.05$) and %PEF ($86.8 \pm 17.8\%$, $p < 0.001$) than non-BA without PH ($94.0 \pm 13.7\%$ and $94.2 \pm 19.9\%$, respectively).

Conclusions: The incidence of BA in Japanese athletes may be higher than currently recognized. More intervention is encouraged for the diagnosis of BA, to avoid any fatal asthma during sports by initiating preventive therapy.

KEY WORDS

asthma, athletic injuries, exercise-induced asthma, exercise-induced bronchospasm, pulmonary function test

INTRODUCTION

A negligible number of Japanese athletes requested the use of an inhaled beta agonist (IBA) at recent Olympic Games¹; only one out of 268 athletes from Japan applied for permission at the Sydney Games, where 112 out of 594 athletes from the United States of America notified the use. This low prevalence of notification by Japanese athletes may be partly due to

the relatively low prevalence of bronchial asthma (BA) patients in Japan.

The prevalence of BA among Japanese children has increased by 3% in the last 20 years, and two recently conducted government surveillances have revealed the rate in school-age children to be 5.7 and 7.6%. In 2003, the Global Initiative for Asthma (GINA) also reported a similar rate of 6.7% as the prevalence of BA symptoms in Japanese school-age children,

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Table 1 Medical questionnaire regarding history and symptoms of bronchial asthma and allergy

BA † history:

1. Is the athlete on the follow-up of BA at the clinic? (current-BA)
2. Has the athlete been diagnosed as BA during the childhood? (PH ‡)

BA symptoms:

3. Has the athlete ever been diagnosed as allergic disease other than BA?
4. Has any of the family (siblings or parents) been diagnosed as BA?
5. Does the athlete experience wheezing, chest tightness, breathlessness, cough, or excess of sputum at night or early in the morning?
6. Does the athlete experience wheezing, chest tightness, breathlessness, cough, or excess of sputum after exposure to the certain airborne substances (allergens or pollutants)?
7. Does the athlete experience wheezing, chest tightness, breathlessness, cough, or excess of sputum during and after the exercise?
8. Does the athlete experience wheezing, chest tightness, breathlessness, cough, or excess of sputum as the seasonal exacerbation?
9. Do the athlete's colds take more than 14 days to clear up?
(One point for each "yes" answer to question 3 through 9, and the athlete is considered possible-BA if the score is three or greater.)

† BA, bronchial asthma.

‡ PH, past history of asthma.

which is below the rate for the United States of America, 10.9%.²

The prevalence of BA in athletes is higher than in the general population,³⁻⁷ and considering the difference in prevalence between Japan and the United States of America shown above, many Japanese athletes possibly have undiagnosed BA; the percentage of Japanese athletes who applied for the use of IBA is too low referring to the prevalence of BA among Japanese children. Moreover, there is no published report so far, regarding the prevalence of asthma-related disorders among Japanese athletes.

Thus, we have decided to analyze the baseline pulmonary function test (PFT) data regarding the BA background of athletes, since our medical questionnaire for the health check-ups included the BA-related history and symptoms. Recent studies show that the medical questionnaires or interviews are not reliable in identifying the exercise-induced bronchospasm (EIB).⁸ EIB should be documented by evaluating the PFT in response to appropriate exercise or provocation tests. However, medical history is still a helpful guide in the clinical diagnosis of BA, and can be used in screening of BA regardless of EIB.

The primary aim of this study was to analyze screening PFT of Japanese athletes from the aspect of BA, by the groups categorized through the scoring of a medical questionnaire regarding asthma symptoms and allergic history.

METHODS

STUDY DESIGN

We conducted a cross-sectional retrospective study of regional elite athletes who participated in their first athletic test performed at the Niigata Institute for Health and Sports Medicine, from April 2003 through

March 2006. A total of 2111 athletes (1549 males, 562 females, age 18.0 ± 4.1 years) were included in this study. The data from screening tests were collected during the preparticipation health check-ups, including a medical questionnaire focused on history and symptoms of BA and allergy (Table 1), and baseline PFT. The study procedures including participant's anonymity preservation were approved by the Ethical Committee of the Niigata Institute for Health and Sports Medicine in accordance with the principles embodied in the Declaration of Helsinki, and each subject, parents, or legal guardian provided written informed consent.

ASTHMA AND ALLERGY QUESTIONNAIRE

A detailed BA and allergy history and review of symptoms were obtained using a medical questionnaire as shown in Table 1. The questionnaire consisted of 9 items relevant to the diagnosis of BA, also referring to the medical history consideration shown by GINA,⁹ and an athlete was categorized as current-BA, possible-BA, or non-BA. The athlete was considered current-BA if BA was confirmed and treated by the physician, possible-BA if scoring 3 or more items for the allergic history and/or BA symptoms, and non-BA if the athlete was neither current-BA nor possible-BA. Possible-BA, however, was defined as above in this study to categorize athletes into groups, simply for the sake of convenience to analyze baseline PFT retrospectively.

PULMONARY FUNCTION TEST BY SPIROMETRY

A baseline PFT by spirometry was performed for all participants. The best value from three measurements of vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in one second

Table 2 Categorical characteristics of the participants

	Number (%)	Male/Female
Total participants	2111 (100)	1549/562
Current-BA	24 (1.1)	17/7
(PH ⁺)	20	15/5
Possible-BA	137 (6.5)	97/40
(PH ⁺)	48	40/8
Non-BA	1950 (92.4)	1435/515
(PH ⁺)	115	80/35

(FEV₁), peak expiratory flow (PEF) were used and recorded by a spirometer, SpiroSift SP-470 (Fukuda Denshi, Tokyo, Japan.). Predicted values were calculated by the standard formulae originally programmed in the spirometer.

DATA ANALYSIS AND STATISTICS

Percent of predicted FEV₁ (%FEV₁), percent of predicted PEF (%PEF), and FEV₁/FVC (FEV₁%) were analyzed for each category of athletes, current-BA, possible-BA, and non-BA. The data were further analyzed according to the past history of asthma (PH) status. Values for all measurements are expressed as mean (%) ± SD.

Kruskal-Wallis test, and Mann-Whitney *U* tests were used to determine the levels of difference between all groups. Significance was assumed at *p*-values of <0.05.

RESULTS

There were 24 current-BA (1.1%), 137 possible-BA (6.5%), and 1950 non-BA (92.4%) cases. In 183 cases of PH (8.7%), there were 20 current-BA, 47 possible-BA, and 116 non-BA cases. Considering the rate of PH, cumulative morbidity of BA was estimated as 8.9%. The difference between male and female athletes was not discussed in this study, because 562 female athletes were analyzed, and there were only seven cases with current-BA and 40 cases with possible-BA, which resulted in numbers that were too few to see any significance (Table 2).

As shown in Figure 1, current-BA showed a significantly decreased %FEV₁ (current-BA vs. non-BA; $86.2 \pm 17.7\%$ vs. $93.9 \pm 13.7\%$), %PEF ($81.6 \pm 19.1\%$ vs. $94.3 \pm 26.2\%$) and FEV₁% ($84.6 \pm 8.3\%$ vs. $89.0 \pm 5.8\%$) compared to non-BA, even under the relevant treatment ($p < 0.001$). Interestingly, possible-BA is also significantly decreased in pulmonary function parameters compared to non-BA (possible-BA vs. non-BA; $84.7 \pm 14.6\%$ vs. $93.9 \pm 13.7\%$ in %FEV₁, $81.2 \pm 17.3\%$ vs. $94.3 \pm 26.2\%$ in %PEF, and $84.9 \pm 7.5\%$ vs. $89.0 \pm 5.8\%$ in FEV₁%, all with $p < 0.001$, respectively). However, there was no significant difference between current-BA and possible-BA (Fig. 1). %VC, which is one of restrictive indices in PFT, was of no difference among all groups (data not shown).

To determine the influence of PH on pulmonary function, comparison between groups either with or without PH was performed. Among all participants, the group with PH (PH⁺) showed decreased pulmonary function parameters compared to the group without PH (PH⁻) (PH⁺ vs. PH⁻; $89.9 \pm 14.3\%$ vs. $93.5 \pm 14.0\%$ in %FEV₁, $p < 0.001$. $87.2 \pm 17.8\%$ vs. $93.4 \pm 20.0\%$ in %PEF, $p < 0.005$. $86.8 \pm 6.6\%$ vs. $88.8 \pm 6.0\%$ in FEV₁%, $p < 0.001$). In regard to non-BA, PH⁺ also revealed decreased airway function compared to PH⁻ (PH⁺ vs. PH⁻; $91.3 \pm 13.9\%$ vs. $94.0 \pm 13.7\%$ in %FEV₁, $p < 0.05$. $86.8 \pm 17.8\%$ vs. $94.2 \pm 19.9\%$ in %PEF, $p < 0.001$. $87.3 \pm 6.0\%$ vs. $89.1 \pm 5.8\%$ in FEV₁%, $p < 0.005$). In contrast, when the samples are limited to possible-BA, the findings were vice versa; PH⁻ had decreased airway function in comparison with PH⁺ (PH⁺ vs. PH⁻; $87.6 \pm 13.1\%$ vs. $83.2 \pm 15.2\%$ in %FEV₁, $p = 0.104$. $89.0 \pm 17.6\%$ vs. $77.1 \pm 15.7\%$ in %PEF, $p < 0.005$. $86.8 \pm 6.8\%$ vs. $84.0 \pm 7.7\%$ in FEV₁%, $p < 0.05$). And even in 24 current-BA, though sample numbers were too small to make conclusions, PH⁻ in this category had a tendency for decreased airway function compared to PH⁺ except for FEV₁% (PH⁺ vs. PH⁻; $87.0 \pm 18.5\%$ vs. $81.6 \pm 14.4\%$ in %FEV₁, $84.2 \pm 19.5\%$ vs. $67.3 \pm 10.8\%$ in %PEF, $84.5 \pm 8.5\%$ vs. $85.1 \pm 7.8\%$ in FEV₁%) (Table 3).

DISCUSSION

The study by Hammerman, *et al.* showed that there were 5.7% BA or EIB among American high school athletes, and another 6.1% were identified as having undiagnosed BA.¹⁰ In the present study, although the athletes defined as possible-BA were not medically confirmed as BA at the time of visit, the obstructive indices of PFT showed similar results compared with current-BA. These data suggest that a considerable number of these athletes may also have undiagnosed BA.

A recent nation-wide survey on the health and welfare status by the Japanese government revealed that 71.3% of the all-age patients with BA symptoms were under antiasthmatic medication, but only 54.6% of such patients aged between 15 and 34 years were under relevant treatment.¹¹ Of 161 athletes with either current-BA or possible-PA in our study, less than 15% of them were current-BA who were on medication, thus indicating that the prevalence of untreated BA may also be higher among athletes. Importantly, a 7-year observation of BA deaths by Becker, *et al.* report that of 61 casualties during sport activities, 55 cases had mild intermittent or persistent BA before their fatal attack, and that only 3 of them used long-term controller medication.¹² Although most of the non-current-BA athletes tested in our study had little respiratory symptoms during and after the usual exercise, the undiagnosed BA should thoroughly be detected, in order to avoid any future BA deaths related to exercise and sport activities.

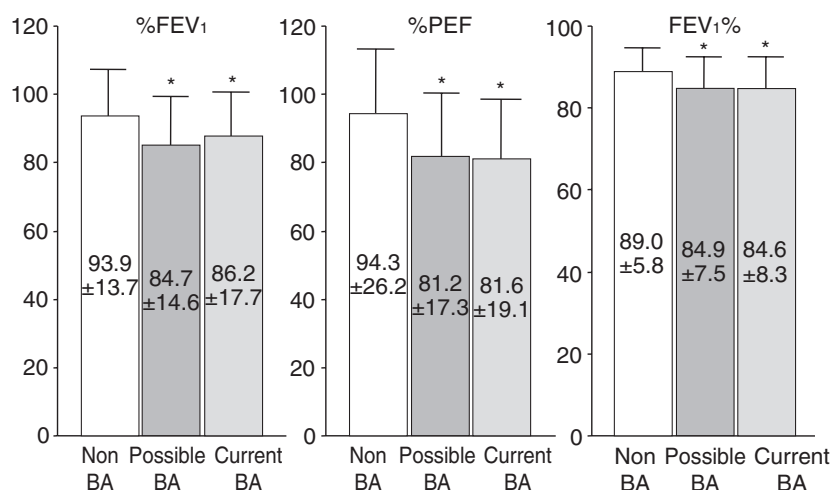


Fig. 1 Obstructive indices of pulmonary function tests (%FEV₁, %PEF, and FEV₁%) in athletes. Data express mean (%) ± SD. * $p < 0.001$ by the Kruskal-Wallis test.

Table 3 Obstructive indices of pulmonary function test in athletes with or without past history of asthma.

	%FEV ₁ (%)	%PEF (%)	FEV ₁ % (%)
All participants			
PH ⁺ (n = 183)	89.9 ± 14.3***	87.2 ± 17.8**	86.8 ± 6.6***
PH ⁻ (n = 1928)	93.5 ± 14.0	93.4 ± 20.0	88.8 ± 6.0
Current-BA			
PH ⁺ (n = 20)	87.0 ± 18.5†	84.2 ± 19.5†	84.5 ± 8.5†
PH ⁻ (n = 4)	81.6 ± 14.4	67.3 ± 10.8	85.1 ± 7.8
Possible-BA			
PH ⁺ (n = 48)	87.6 ± 13.1	89.0 ± 17.6**	86.8 ± 6.8*
PH ⁻ (n = 89)	83.2 ± 15.2	77.1 ± 15.7	84.0 ± 7.7
Non-BA			
PH ⁺ (n = 115)	91.3 ± 13.9*	86.8 ± 17.8***	87.3 ± 6.0**
PH ⁻ (n = 1835)	94.0 ± 13.7	94.2 ± 19.9	89.1 ± 5.8

Data express mean ± SD, * $p < 0.05$, ** $p < 0.005$, *** $p < 0.001$; compared with PH⁻.

† Insufficient sample numbers for statistical analysis.

Another important message is derived from the results concerning the influence of PH on pulmonary function. The present study has shown that athletes with PH, who were even considered as non-BA, had impaired pulmonary function indices, suggesting they may not have fully recovered from their childhood asthma. In general, it has been reported that up to 70% of BA patients in childhood lose their symptoms during puberty.^{13,14} Oswald, *et al.* conducted 28-year follow-up study for mild asthmatics in childhood, and suggested that airway obstruction or hyperresponsiveness of the patients would be restored normally even if they did not use inhaled corticosteroids.¹⁵ On the contrary, Agertoft, *et al.* showed that a delay in the introduction of inhaled corticosteroids resulted in incomplete recovery of pulmonary function.¹⁶ Moreover, Pederson, *et al.* reported that early

intervention with sufficient doses of inhaled corticosteroids could cure the disease with no recurrence.¹⁷ In this regard, our data may also indicate the possible insufficiency of the treatment approach to childhood BA leading to the symptom takeover through the youth generation, and we should be careful with PH⁺ in non-BA patients who have little BA symptoms. Another valuable finding regarding the effect of PH status is that PH⁻ in possible-BA had decreased airway function compared with PH⁺. This tendency is also observed in current-BA (Table 3). Although the details in the treatment history of BA is limited in the medical record, it is more likely that PH⁺ in these categories received treatment intervention in the past, which may apparently improve the respiratory function, assuming possible-BA has high potential for being true BA.¹⁸

We included questionnaires of respiratory symptoms and PFT at baseline medical check-ups, with the belief that these findings are important in the clinical diagnosis of BA. However, they may be insufficient for the diagnosis of EIB. Rundell, *et al.* found that among elite athletes, a diagnosis based on self-reported symptoms is no more accurate than a coin toss. In that study, 61% of EIB-positive athletes reported symptoms, and 45% of normal pulmonary function athletes reported symptoms of EIB.¹⁹ Methacholine challenge test is often used for BA/EIB diagnosis in Japan, but it should be noted that a relatively low sensitivity for EIB diagnosis especially in summer sports is reported for this provocation.²⁰ We have recently started additional bronchial challenge tests such as eucapnic voluntary hyperpnea and hypertonic saline inhalation, together with exercise challenge which are the current challenge tests also recommended by the International Olympic Committee for the diagnosis of BA/EIB in athletes.

In summary, the PFT results at the Niigata Institute for Health and Sports Medicine were analyzed, according to the historical background of BA, and the prevalence of current-BA, possible-BA, and the cumulative morbidity of BA among the regional elite athletes were 1.1, 6.5, and 8.9%, respectively. A limitation of this study is in the retrospective analysis using a medical questionnaire, of which data had been adopted from sufficient but non-uniform medical record formats. The effectiveness of this medical questionnaire in the uniform medical record format on scoring should be confirmed, and is currently under prospective investigation.

Finally, considering the epidemiological data on BA in athletes available so far, the incidence of BA among the Japanese athletes may be higher than currently recognized. More intervention is encouraged for diagnosing BA and related subtypes to avoid any fatal asthma attacks during sport activities, and to restore originally expected athletic performance of the affected individuals.

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