Changes in Pulmonary Functions in Individuals with or without Past Medical Histories of Bronchial Asthma during Physical Education Classes in Summer and Winter

Yusuke Takagi¹, Mikio Nakase², Yugo Miyasaka³ and Sho Onodera⁴

¹Nara University of Education, Takabatake-cho, Nara-city, Nara, 630-8528, Japan
y-takagi@nara-edu.ac.jp
²National Institute of Technology, Kagawa College, 355 Chokushi-cho, Takamatsu-city, Kagawa, 761-8058, Japan
³Shobi University, 1-1-1 Toyoda-cho, Kawagoe-city, Saitama, 350-1110, Japan
⁴Kawasaki University of Medical Welfare, 288 Matsushima, Kurashiki-city, Okayama, 701-0193, Japan

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The purpose of this study was to investigate changes in pulmonary functions in individuals with past medical histories of bronchial asthma in physical education classes in summer and winter. Twenty-nine Japanese healthy male students (18.2 ± 0.5 years) with a past medical history of bronchial asthma (Asthma group) and twenty-one control (Non-asthma group) students (18.4 ± 0.5 years) volunteered to play a basketball game in summer (10 minutes) and a soccer game in winter (15 minutes) in physical education classes, in a national college, 2010 ~ 2012. The participants’ indices of objective pulmonary functions FEV1.0 (forced expiratory volume in one second), FEV1.0 fall (the percent fall in FEV1.0) were measured before the game (Rest) and at the time 5 minutes after each game (Rec. 5). The temperature of classroom was controlled 25-28°C throughout the year.

No significant changes were found on indices of pulmonary functions (FEV1.0, FEV1.0 fall) in both groups in summer, each year. On the other hand, significant reductions in FEV1.0 and significant increases in FEV1.0 fall were observed at Rec. 5 in Asthma group in winter each year (p < 0.05). However, there were no significant differences observed on FEV1.0 and FEV1.0 fall in Non-asthma group in both seasons.

Based on the results, it was able to consider that pulmonary function would decrease in the factors such as winter and aerobic exercise in the students with past medical histories of bronchial asthma.

Keywords: asthma, past medical history, pulmonary functions, physical education, season

1. Introduction

Bronchial asthma is a pulmonary disease of irreversible airway obstruction occurred by various initiating factors. When an asthmatic person develops heavy dyspnea, it can cause the fatal situation. Ministry of Education, Culture, Sports, Science and Technology (2007) reports that the number of children with a bronchial asthma is 5.7% of the population in Japanese school. Exercise-induced asthma (EIA) has been actualized in the physical education classes and the extracurricular activities in Japan. EIA is often developed 5-15 minutes after aerobic exercise induced with exercise intensity over 80% of estimated maximum heart rate (Godfray S. et al. 1973).

The experiments of EIA for patients have been reported a lot, however, there are a few researches on individuals with a past medical history of bronchial asthma (PHA) (Takagi Y. et al., 2013; Takagi Y. et al., 2015). PHA does not develop asthma attack in daily life. However, the recent study, Takagi Y. et al. (2013) reports that the pulmonary functions in PHA (21.6 ± 3.0 years) significantly decreased during mountain ascending under cold temperature in winter season. Takagi Y. et al.
(2016) indicated a significant decrease of peak expiratory flow in PHA (15.9±0.7 years) after long-distance running (8.8 km) in the national college in winter. It is considered that those factors were derived from specific environment conditions, low temperature and heavy exercise stress (Takagi Y. et al., 2013; Takagi Y. et al., 2015). These previous reports suggest that pulmonary functions in PHA also decreases near the level as an asthma patient after exercise under the several combined conditions. Especially, the effects of season changes are surely found in physical education classes. To our knowledge, however, there has been no report to evaluate pulmonary functions in PHA during physical education classes in several seasons.

The purpose of this study was to investigate changes in pulmonary functions in PHA during physical education classes in summer and winter for three years.

2. Methods

2.1. Subjects

Twenty-nine (age: 18.2±0.5 years, weight: 65.4±14.0 kg, height: 170.9±5.1 cm) Japanese healthy male students with a past medical history of bronchial asthma (Asthma group) and twenty-one (age: 18.4±0.5 years, weight: 60.9±8.3 kg, height: 169.9±5.7 cm) Japanese healthy control students (Non-asthma group) played a basketball game and a soccer game in physical education classes, in a national college, respectively summer and winter.

All participants’ members in Asthma group developed bronchial asthma in childhood by clinical diagnosis, and they have past medical histories of EIA. We got the response from their parents about the age of last asthma attack, initiating factor and asthma remedy. They had taken \( \beta_2 \) stimulator when EIA is developed. They have developed EIA when they were junior high school students, but rarely occur in present. None had a history of all pulmonary diseases including bronchial asthma in Non-asthma group. We conducted 3,000-meter trial as measurement of the physical fitness. In this result, there was no significant difference between the two groups each year (2010: 15’42”±2’51” vs. 15’07”±2’14”, 2011: 14’41”±3’22” vs. 13’28”±1’38”, 2012: 15’12”±2’41” vs. 13’55”±0’55”, respectively Asthma group vs. Non-asthma group). Informed consent was obtained from all participants after explaining the study purpose and potential risks on this study protocol. Thus, each participant voluntarily joined this program. Basically, if sleeping time is less than five hours, it is not able to participate in this investigation for safety management. There was none in this study. This investigation was accompanied by the other physical education class teacher and health fitness instructors who have a lot of experience of first aid for asthma attack. In addition, the school nurse stood for asthma attack at a nearby school building. We secured environments for emergencies. This study was approved by institutional (Kawasaki University of Medical Welfare) review board.

2.2. Investigation contents

The investigations were conducted in two seasons (summer: July, winter: December) each year. Before physical education class, the subjects took class in classroom. The temperature of classroom was controlled between 25-28°C throughout the year. In all physical education classes, the investigation was begun at the same time as the class bell rang. At the beginning of the class, the physical education teacher took attendance in the class member, after that the students performed moderate stretching, aerobic exercise (running a lap of the about 100-meter (summer) or the 400-meter (winter) track at their pace) as warm-up.

In summer investigation, the students were split into eight teams and they played a basketball game in gymnastic hall. Each game was 10 minutes (Temperature: 2010; 28.5±1.7°C, 2011; 26.6±1.3°C, 2012; 28.9±0.4°C, Relative humidity: 2010; 71.5±9.6%, 2011; 45.7±10.5%, 2012; 77.7±3.2%). On the other hand, in winter, the students were split into four teams and they played a soccer game for 15 minutes in ground (Temperature: 2010; 6.8±0.4°C, 2011; 6.8±0.4°C, 2012; 8.8±0.4°C, Relative humidity: 2010; 38.9±0.8%, 2011; 41.1±3.8%, 2012; 48.3±4.1%). Temperature and relative humidity were showed by mean values during physical education classes. Meteorological conditions were estimated by a thermometer of wet-bulb globe temperature at a one-meter height from the floor and ground.
2.3. Measurements

Participant’s forced expiratory volume in one second (FEV₁₀₀), the degree of dyspnea sensation (DDS), heart rate (HR) and rating of perceived exertion (RPE) for fatigue were measured before the game (Rest) and at the time 5 minutes after the game (Rec. 5) using spirometer (micro: Vitalograph) for FEV₁₀₀, the modified Borg’s scale (Borg G.A. 1982) for DDS, hear rate monitor (Rs 400: POLAR) for HR and Borg’s scale (Borg G. 1970) for RPE. We had the subjects perform maximum forced exhalations with a spirometer. The subjects conducted spirometric evaluation twice and we adopted the maximum value. We estimated the percent fall in FEV₁₀₀ (FEV₁₀₀ %fall) between Rest and Rec. 5. FEV₁₀₀ and FEV₁₀₀ %fall are important indices as clinical EIA estimation. They are also indices of central airway size and are diagnosed EIA more than 15% of FEV₁₀₀ %fall (Eggleston P.A. and Guerrant J.L. 1976). EIA often are developed at the time of 5 minutes after high-intensity aerobic exercise (Godfray S. et al., 1973). Therefore, we conducted the measurements at the time of 5 minutes after exercise. Borg scale for DDS indicates 0~10 scale (0: Nothing at all, 0.5: Very, very weak, 1: Very weak, 2: Weak, 4: Somewhat strong, 5: Strong, 7: Very strong, 10: Very, very strong). Borg scale for RPE indicates 6~20 scale (7: Very, very light, 9: Very light, 11: Fairly light, 13: Somewhat hard, 15: Hard, 17: Very hard, 19: Very, very hard) and other scores are indicated only in number. The subjects answered orally those scale. HR was recorded per minute and the peak HR was measured during the game. In addition, we also calculated %HRmax using peak HR and age-predicted maximum HR (%HRmax = (peak HR/220-age)*100).

2.4. Statistics

The data were presented as mean ± standard deviation except for DDS (median and range). It is necessary to compare the indices of pulmonary functions between the two groups and within the group. Therefore, we analyzed with or without repeated two-way analysis measurements of variance to examine differences between the means of two groups. If it was recognized significant interactions, we would analyze the data by simple main effects test. And we conducted post hoc test (Bonferroni) only in the case that if it was recognized significant simple main effects test. Friedman test was performed to detect changes of DDS within each group and Kruskal-Wallis test was performed between the two groups. Statistical significance was accepted less than 0.05. The data were analyzed by SPSS ver. 12.0 for Windows.

3. Results

3.1. Exercise intensity

HR (Asthma vs. Non-asthma: summer 71 ± 8 bpm vs. 66 ± 8 bpm, winter 70 ± 8 bpm vs. 67 ± 8 bpm) and RPE (Asthma vs. Non-asthma: summer 6 ± 1 vs. 6 ± 0, winter 6 ± 1 vs. 6 ± 1) were no significance in those measuring value in Rest between the two groups. HR (Asthma: summer 127 ± 21 bpm ・ winter 125 ± 15 bpm, Non-asthma: summer 128 ± 19 bpm ・ winter 126 ± 17 bpm) and RPE (Asthma: summer 12 ± 3 ・ winter 12 ± 3, Non-asthma: summer 12 ± 3 ・ winter 11 ± 2) in Rec. 5 were significantly higher than those of Rest in group in both seasons (p < 0.05). There was no significance in peak HR (Asthma vs. Non-asthma: summer 178 ± 12 bpm vs. 176 ± 11 bpm, winter 175 ± 12 bpm vs. 180 ± 10 bpm) and %HRmax (Asthma vs. Non-asthma: summer 88 ± 6% vs. 87 ± 5%, winter 87 ± 6% vs. 89 ± 5%) between the two groups.

3.2. Changes in the indices of pulmonary functions

Table 1 showed changes in FEV₁₀₀, FEV₁₀₀ %fall and DDS. There was no significance in FEV₁₀₀ and DDS in Rest between seasons each group. There was no significance in FEV₁₀₀ and FEV₁₀₀ %fall during basketball between the two groups.

On the other hand, in Asthma group, significant reductions in FEV₁₀₀ and significant increases in FEV₁₀₀ %fall were observed at Rec. 5 compared with Rest and Non-asthma in winter (p < 0.05). No significant differences were found on FEV₁₀₀ in Non-asthma group. DDS in Rec. 5 was significantly higher than that of Rest in each group in both seasons (p < 0.05).

4. Discussion

We found no significant changes in the objective indices of pulmonary functions (FEV₁₀₀ and FEV₁₀₀
Table 1  The comparison of pulmonary functions Rest and Rec. 5.

<table>
<thead>
<tr>
<th>Season</th>
<th>Measurements</th>
<th>Asthma group (n = 29)</th>
<th>Non-asthma group (n = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rest</td>
<td>Rec. 5</td>
</tr>
<tr>
<td>Summer</td>
<td>FEV(_{1.0}) (L)</td>
<td>3.92 ± 0.58</td>
<td>3.91 ± 0.60</td>
</tr>
<tr>
<td>(Basketball)</td>
<td>FEV(_{1.0})%fall (%)</td>
<td>—</td>
<td>0.26 ± 5.44</td>
</tr>
<tr>
<td></td>
<td>DDS</td>
<td>0 (0–0.5)</td>
<td>2 (0.5–5)(^{\dagger})</td>
</tr>
<tr>
<td>Winter</td>
<td>FEV(_{1.0}) (L)</td>
<td>3.95 ± 0.48</td>
<td>3.58 ± 0.51(^{\dagger,\dagger})</td>
</tr>
<tr>
<td>(Soccer)</td>
<td>FEV(_{1.0})%fall (%)</td>
<td>—</td>
<td>9.16 ± 8.96(^{\dagger,\ast})</td>
</tr>
<tr>
<td></td>
<td>DDS</td>
<td>0 (all 0)</td>
<td>3 (0.5–7)(^{\dagger})</td>
</tr>
</tbody>
</table>

FEV\(_{1.0}\) & FEV\(_{1.0}\)\%fall: Mean ± SD, DDS: Median (range)
FEV\(_{1.0}\): Forced expiratory volume in one second, DDS = The degree of dyspnea sensation
FEV\(_{1.0}\)\%fall = the percent fall in FEV\(_{1.0}\)
\(^{\dagger}\): vs. Rest (p < 0.05), \(^{\dagger}\): vs. Summer (p < 0.05), \(^{\ast}\): vs. Non-asthma group (p < 0.05)

%fall) between before (Rest) and after (Rec. 5) basketball in both groups in summer. However, in Asthma group, significant reductions in FEV\(_{1.0}\) and significant increases in FEV\(_{1.0}\)\%fall were observed at Rec. 5 compared with Rest and Non-asthma during soccer in winter.

Asthmatic person receives to enhance airway reactivity after a great amount of exercise. Many studies note two factors; water loss theory (Anderson S.D. et al., 1982) and heat loss theory (Strauss R.H. et al., 1978). With regard to this knowledge, Strauss R.H. et al. (1978) demonstrates that EIA completely is inhibited under heat and high-humidity environment because it is considered that high-humidity inhibited water loss and enhancement of osmotic pressure in airway. Takagi Y. et al. (2012) indicates that FEV\(_{1.0}\) did not decrease in PHA during ascending exercise in summer. The finding of Strauss R.H. et al. (1978) and Takagi Y. et al. (2012) supports the results of summer in this study. On the other hand, Takagi Y. et al. (2015) reports that PHA enhances the airway reactivity during high-intensity exercise under the cold temperature (6.8°C). In addition, in this study, \%HRmax (average score) were over 87%. DDS in Rec. 5 was significantly higher than that of Rest despite the fact that subjects recovered by sitting for 5 minutes after the game in both groups in each season. It was indicated in a great amount of exercises in both sports. Therefore, we considered that the decrease of pulmonary functions was caused by increase of oral-breathing from a great amount of exercises in cold temperature (approximately 7~9°C).

We could not observe the significant difference in pulmonary functions in those Rest between summer and winter in each group. However, pulmonary functions in Asthma group significantly decreased after the soccer game in winter. It would be suggested that the results were caused by the additive effects in increase of an amount of exercises and cold temperature conditions. For safety physical education class, it is suggested that teachers and leaders of school club should take measures of meteorological condition and care of exercise-induced airway constriction after exercises for PHA the same as asthmatic children.

5. Conclusion

There were found on decrease of pulmonary function during the soccer game in winter and was not significantly change that during the basketball game in summer. The results of pulmonary function in PHA decrease from the additive factors in a great amount of exercises and cold temperature conditions in physical education class such as the ground in annual situation.

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References


Changes in FEV$_{1.0}$ with Asthmatic Persons during Physical Education Class


