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Brief Communication

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Impact of Grilling Meat or Fish at Home on Peak Expiratory Flow Rate in Adults With Asthma

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ABSTRACT

Grilling, a common cooking method worldwide, can produce more toxic gases than other cooking methods. However, the impact of frequently grilling meat or fish at home on airflow limitation in adult asthma has not been well elucidated. We performed a prospective cohort study of 91 adult patients with asthma enrolled from 2 university hospitals. Of the patients, 39 (42.9%) grilled meat or fish at least once a week and 52 (57.1%) less than once a week. Patients who grilled at least once a week tended to have lower peak expiratory flow rate (PEFR) than those who grilled less than once a week (median, 345.5 L/min; 95% confidence interval [CI], 291.8–423.2 L/min *vs.* median, 375.1 L/min; 95% CI, 319.7–485.7 L/min; $P = 0.059$). Among patients with severe asthma who received step 4–5 treatment, PEFR was significantly lower in patients who grilled at least once a week compared with those who grilled less than once a week (median, 297.8 L/min; 95% CI, 211.3–357.7 L/min *vs.* median, 396.1 L/min; 95% CI, 355.0–489.6 L/min; $P < 0.001$). Our results suggest that the frequency of grilling meat or fish at home may affect PEFR in asthmatic patients, especially those with severe asthma who needed a high level of asthma treatment.

Keywords: Peak expiratory flow rate; asthma; cooking; meat; fishes; pollution; indoor

INTRODUCTION

Adult patients with asthma can be at substantially increased risk of respiratory effects from exposure to indoor air pollution caused by cooking.[1-3] Cooking generates a complex mixture of toxic materials that can be pro-inflammatory.[4] Several studies of adult patients with asthma found significant associations between cooking, respiratory symptoms (e.g., wheezing), and lung function.[1-3]

Grilling is a common cooking method worldwide. Grilling meat by the Korean barbeque style can produce more toxic gases than other cooking methods,[5] so the frequency of grilling meat or fish at home can have adverse events in adult patients with asthma. However, most studies focus on the relationship between cooking, asthma control, and lung function in children.[6-10]

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There are no financial or other issues that might lead to a conflict of interest.

Accordingly, limited data are available on the relationship between cooking and asthma control in adults.[1,2,11] In addition, the literature does not have enough evidence as to whether specific types of home cooking methods, such as grilling meat or fish, are associated with poor outcomes in adult patients with asthma. Furthermore, few studies have measured peak expiratory flow rate (PEFR) as an objective outcome to study cooking on asthma control in adult patients with asthma.[2,11]

Thus, the current literature has uncertainties about the relationship between the effect of the frequency of meat or fish grilling at home and PEFR in adults with asthma. In this study, we hypothesized that the frequency of meat or fish grilling at home is negatively associated with mean daily PEFR in adult patients with asthma. We investigated the impact of the frequency of meat or fish grilling at home on PEFR in adult patients with asthma.

MATERIALS AND METHODS

Patients

This was a prospective cohort study of 91 asthmatic patients (27 from University Hospital located in Seoul and 64 from University Hospital in Bucheon, Republic of Korea) who answered a questionnaire about the mean number of times they grilled meat or fish at home per week for 2 months. Patients were divided into 2 groups according to the median number of grilling meat of fish at home as follows: 1) those who grilled meat or fish at home at least once a week and 2) those who grilled meat or fish at home less than once a week. A diagnosis of asthma was based on clinical history with recurrent episodes of asthma-related symptoms such as wheezing, dyspnea, and cough, and evidence of airway hyperresponsiveness to methacholine, based on a decrease in forced expiratory volume in 1 second (FEV1) (%) of 20% on a methacholine challenge test (PC20) ≤ 16 mg/mL or positive bronchodilator response, based on an increase in FEV1 of at least 12% and 200 mL after inhaling a bronchodilator or anti-inflammatory treatment.[12] All participants had been treated to control asthma symptoms according to the Global Initiative for Asthma guidelines.[12] Informed consent was received from each patient who agreed to participate in this study. The study protocol was approved by the Institutional Review Board (IRB) of our hospitals (IRB No. HY-2016-08-035 and IRB No. SCHBC-2016-08-010).

Measurements

At a first visit, medical history including smoking habits, height, weight, self-reported comorbidities, and asthma-related medications was collected. The average number of times meat or fish was grilled at home per week was collected using a questionnaire. Pre- and post-bronchodilator spirometry was performed according to the recommendations of the American Thoracic Society/European Respiratory Society.[13] Patients were trained to measure PEFR twice daily using a peak expiratory flow meter (MicroPeak; CareFusion, Basingstoke, UK). The mean value of morning and evening PEFR during the study period was used to compare the PEFR between the patients according to the number of grilling meat or fish at home.

In this study, indoor particulate matter with a diameter less than 2.5 micrometers (PM2.5) was measured in patients who agreed to installation of AirGuard K IAQ Station (K Weather, Seoul, Korea) in their home, which measures PM2.5 using a light-scattering method of irradiating indoor air with infrared light and converting the amount of light scattered by ultrafine dust into a mass concentration.[14] Stations were installed about 1.5 m from the ground, considered to be the breathing position in a household, to measure PM2.5 at 1-minute intervals.

Statistical analysis

For continuous variables, descriptive statistics were reported as mean and standard deviation (SD) or median and interquartile ranges (IQRs). Categorical variables were reported as the number of patients (%) per category and the frequency of response. Continuous variables were compared with the *t* test or the Mann-Whitney *U* test, and categorical variables were compared using the χ^2 test or Fischer's exact test, as appropriate. Multivariable linear regression analysis was performed to evaluate the effect of grilling frequency on the mean value of morning and evening PEFR during the study period. We adjusted for age and sex in model 1. We further adjusted for the allowance of tobacco smoking at home in model 2. In model 3, treatment steps (step 1–3 treatment *vs.* step 4–5 treatment) were further adjusted. In addition to these variables, we further adjusted for PM2.5 in model 4.

To evaluate the impact of the frequency of grilling meat or fish at home on PEFR by treatment step, we performed subgroup analyses according to the treatment steps. For each subgroup analysis, age and sex were adjusted in model 1. In model 2, the allowance of tobacco smoking at home was further adjusted. We further adjusted for PM2.5 in model 3. Based on the previous recommendation, the PEFR difference of at least 18.79 L/min was regarded as a significant change.[15] All statistical analyses were performed using STATA 15.0 (StataCorp LP, College Station, TX, USA) and a 2-sided $P < 0.05$ was considered significant.

RESULTS

Patients

Of the patients, 39 (42.9%) grilled meat or fish at least once a week and 52 (57.1%) less than once a week. No significant differences were observed in age, sex, body mass index, smoking history, comorbidities such as allergic rhinitis and atopic dermatitis, post-bronchodilator spirometric results, asthma treatment, or indoor PM2.5 level (**Table 1**).

Frequency of grilling meat of fish at home and PEFR

The mean number of PEFR measurements per patient was 1.4/day (SD = 0.4/day). There was no significant difference in the mean number of PEFR per patient in patients who grilled meat or fish at least once a week and those who grilled less than once a week (mean, 1.4/day; SD = 0.4/day *vs.* mean, 1.4/day; SD = 0.4/day; $P = 0.885$). Patients who grilled meat or fish at least once a week had lower PEFR than those who grilled less than once a week (**Fig. 1A**); however, this difference was only marginally significant (median, 345.5 L/min; IQR = 291.8–423.2 L/min *vs.* median, 375.1 L/min; IQR = 319.7–485.7 L/min; $P = 0.059$). When analyzed by sex, male patients who grilled meat or fish at least once a week tended to have lower PEFR than those who grilled less than once a week (median, 397.6 L/min; IQR = 309.0–467.0 L/min *vs.* median, 417.7 L/min; IQR = 376.8–550.3 L/min; $P = 0.070$). Among female patients, no significant difference was seen in median PEFR according to grilling frequency (median, 330.4 L/min; IQR = 240.4–375.5 L/min *vs.* median, 327.2 L/min; IQR = 289.7–373.4 L/min; $P = 0.549$) (**Fig. 1B**).

Frequency of grilling meat or fish at home and PEFR by a treatment step

Among patients with severe asthma who received step 4–5 treatment,[12] PEFR was significantly lower in patients who grilled at least once a week compared with those who grilled less than

Table 1. Baseline characteristics of the study population

Characteristics	Total	Grilling meat/fish ≥ 1/week	Grilling meat/fish < 1/week	*P* value
No. of patients	91 (100.0)	39 (42.9)	52 (57.1)	
Age (yr)	57 (48–65)	57 (44–67)	57 (51–65)	0.794
Sex (male)	44 (48.4)	18 (46.2)	26 (50.0)	0.716
Body mass index (kg/m²)	23.5 (21.3–26.2)	23.8 (21.9–26.8)	23.3 (21.1–24.8)	0.133
Smoking history (n = 85)				0.574
Never	45 (53.0)	18 (47.4)	27 (57.4)	
Ex-smoker	37 (43.5)	19 (50.0)	18 (38.3)	
Current smoker	3 (3.5)	1 (2.6)	2 (4.3)	
Pack-years	10 (23–30)	10 (30–40)	10 (23–30)	0.599
Allowance of tobacco smoking at home	6 (6.6)	4 (10.3)	2 (3.9)	0.396
Family income (n = 82) (won)				0.722
< 1,500,000	15 (18.3)	6 (17.1)	9 (19.2)	
1,500,000–3,000,000	22 (26.8)	8 (22.9)	14 (29.8)	
≥ 3,000,000	45 (54.9)	21 (60.0)	24 (51.0)	
Job-status (n = 85)				
Housewife or no occupation	38 (44.7)	18 (48.97)	20 (41.7)	0.521
Comorbidities (n = 87)				
Allergic rhinitis	46 (52.9)	22 (56.4)	24 (25.4)	0.551
Atopic dermatitis	6 (6.9)	1 (2.6)	5 (10.4)	0.218
Post-bronchodilator spirometry				
FVC (L)	3.0 (2.5–3.5)	3.0 (2.5–3.8)	3.0 (2.4–3.5)	0.975
FVC (%predicted)	85.5 (76.0–91.0)	86.3 (79.0–92.0)	83.9 (73.0–90.9)	0.416
FEV1 (L)	2.1 (1.8–2.5)	1.9 (1.6–2.4)	2.2 (1.9–2.6)	0.168
FEV1 (%predicted)	80.0 (68.5–89.0)	79.8 (61.1–88.0)	80.0 (71.0–90.0)	0.466
FEV1/FVC (%)	73.0 (64.0–79.0)	71.5 (62.0–76.0)	74.0 (64.2–80.4)	0.095
Asthma treatment (n = 87)				0.855
Step 1	4 (4.6)	1 (2.6)	3 (6.3)	
Step 2	6 (6.9)	3 (7.7)	3 (6.3)	
Step 3	34 (39.1)	16 (41.0)	18 (37.5)	
Step 4–5	43 (49.4)	19 (48.7)	24 (50.0)	
Indoor PM2.5 (μg/m³) (n = 48)	37.9 (27.7–45.3)	38.5 (27.3–47.4)	37.4 (28.2–44.5)	0.655
PEFR (L/min)	362.2 (298.4–461.7)	345.5 (291.8–423.2)	375.1 (319.7–485.7)	0.059

Data are median (interquartile range) or number (percentage), as appropriate. PEFR indicates the mean value of morning and evening PEFR during the study period.
FVC, forced vital capacity; FEV1, forced expiratory volume in 1 second; PM2.5, particulate matter with a diameter less than 2.5 micrometers; PEFR, peak expiratory flow rate.

once a week (**Fig. 2A**) (median, 297.8 L/min; IQR, 211.3–357.7 L/min *vs.* median, 396.1 L/min; IQR = 355.0–489.6 L/min; $P < 0.001$). By sex, male patients who grilled at least once a week had significantly lower PEFR than those who grilled less than once a week (median, 316.0 L/min; IQR = 253.7–442.5 L/min *vs.* median, 457.4 L/min; IQR = 378.5–570.6 L/min; $P = 0.017$). Although

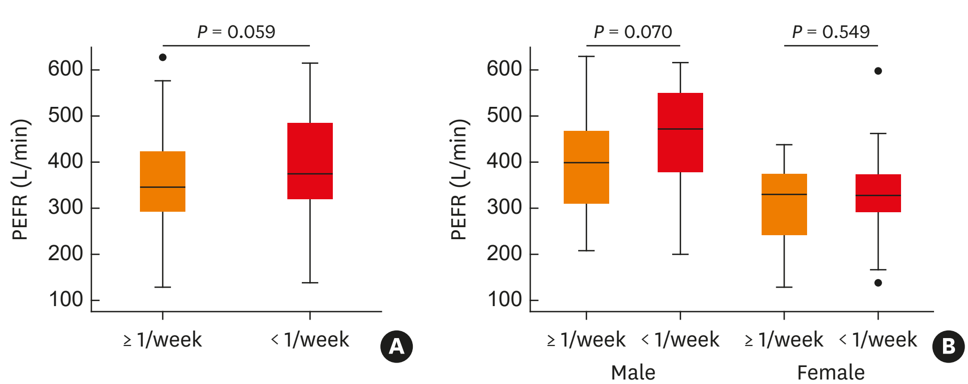

Fig. 1. (A) PEFR by frequency of grilling meat or fish at home. (B) PEFR by frequency of grilling meat or fish at home and sex. PEFR indicates the mean value of morning and evening PEFR during the study period.
PEFR, peak expiratory flow rate.

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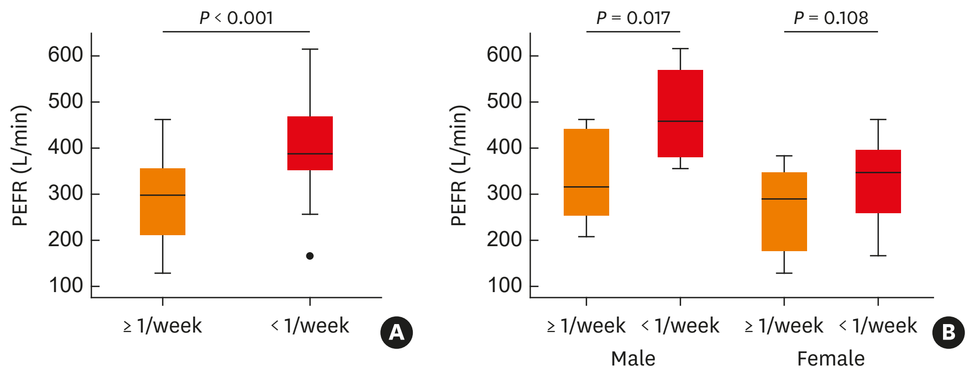

Fig. 2. (A) PEFR among patients with severe asthma who received stage 4–5 treatment by frequency of grilling meat or fish at home. (B) PEFR among patients with severe asthma who received stage 4–5 treatment by frequency of grilling meat or fish at home and sex. PEFR indicates the mean value of morning and evening PEFR during the study period.
PEFR, peak expiratory flow rate.

female patients who grilled at least once a week had lower PEFR than those who grilled less than once a week (median, 294.0 L/min; IQR = 175.6–348.6 L/min *vs.* median, 324.6 L/min; IQR = 258.7–397.0 L/min), this difference was not significant (*P* = 0.108). No significant difference in PEFR was seen among patients who received step 1–3 treatment by frequency of home grilling (median, 377.0 L/min; IQR = 310.3–457.6 L/min *vs.* median, 350.6 L/min; IQR = 303.7–479.1 L/min; *P* = 0.444).

Impact of frequent grilling meat or fish at home on PEFR

Compared with patients who grilled meat or fish less than once a week, those who grilled at least once a week tended to have lower PEFR (−48.6 L/min; 95% CI = −98.5 to 1.2 L/min; *P* = 0.056, **Table 2**) in univariable analysis. When results were adjusted for age and sex, PEFR was significantly lower in patients who grilled at least once a week compared with those who

Table 2. Impact on PEFR of grilling meat or fish at home ≥ 1/week relative to < 1/week

Groups	Change of PEFR (L/min)	*P* value
All asthma patients*		
Crude model	−48.6 (−98.5 to 1.2)	0.056
Model 1 (n = 91)	−41.3 (−81.4 to −1.2)	0.044
Model 2 (n = 91)	−40.4 (−81.0 to 0.2)	0.051
Model 3 (n = 87)	−36.9 (−78.3 to 4.5)	0.080
Model 4 (n = 48)	−45.8 (−99.6 to 8.0)	0.093
Mild-to-moderate asthma patients who received step 1–3 treatment†		
Crude model (n = 44)	24.4 (−48.7 to 97.5)	0.504
Model 1 (n = 44)	7.6 (−53.0 to 68.1)	0.802
Model 2 (n = 44)	9.5 (−52.1 to 71.1)	0.756
Model 3 (n = 21)	−7.3 (−98.8 to 84.2)	0.868
Severe asthma patients who received step 4–5 treatment†		
Crude model (n = 43)	−112.7 (−179.8 to −45.6)	0.022
Model 1 (n = 43)	−88.1 (−143.3 to −33.0)	0.002
Model 2 (n = 43)	−90.1 (−148.2 to −32.0)	0.003
Model 3 (n = 27)	−81.8 (−156.3 to −7.16)	0.033

Values are presented as median (95% confidence interval). PEFR indicates the mean value of morning and evening PEFR during the study period.
*Model 1 adjusted for age and sex. Model 2 further adjusted for the allowance of tobacco smoking at home. Model 3 further adjusted for treatment steps (step 1–3 treatment vs. step 4–5 treatment). Model 4 further adjusted for PM2.5; †Model 1 adjusted for age and sex. Model 2 further adjusted for the allowance of tobacco smoking at home. Model 3 further adjusted for PM2.5.
PEFR, peak expiratory flow rate; PM2.5, particulate matter with a diameter less than 2.5 micrometers.

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grilled less than once a week (−41.3 L/min; 95% CI, −81.4 to −1.2 L/min; $P = 0.044$ in model 1). Significance disappeared after adjustment for the allowance of tobacco smoking at home in model 2 (−40.4 L/min; 95% CI, −81.0 to 0.2 L/min; $P = 0.051$), treatment steps in model 3 (−36.9 L/min; 95% CI, −78.3 to 4.5 L/min; $P = 0.080$) and indoor PM2.5 in model 4, (−45.8 L/min; 95% CI, −99.6 to 8.0 L/min; $P = 0.093$).

In subgroup analysis for patients who received step 3–4 treatment, compared with grilling less than once a week, grilling at least once a week was significantly associated with lower PEFR in both univariable analysis (−112.7 L/min; 95% CI, −179.8 to −45.6 L/min; $P = 0.022$) and multivariable analysis (−81.8 L/min; 95% CI, −156.3 to −7.2 L/min; $P = 0.033$) that further adjusted for age, sex, the allowance of tobacco smoking at home, and PM2.5. No significant relationship was seen between PEFR and grilling frequency for patients who received step 1–3 treatment ($P = 0.504$ in univariable analysis and $P = 0.868$ in the final model).

DISCUSSION

This study evaluated the impact of grilling meat or fish at home on PEFR in adult patients with asthma. Our study showed that adult patients with asthma who grilled meat or fish at home frequently (≥ 1/week) had decreased PEFR compared with those who grilled at home less frequently (< 1/week). The effects were especially significant in patients with severe asthma who received step 4–5 treatment.

Previous studies have found a close relationship between indoor air pollution related to cooking at an ordinary study population or asthmatic children's home. A previous study showed that exposure to gas stoves increased risk of asthma symptoms, such as breathlessness, chest tightness, or wheezes, in children with asthma under 12 years of age.[6] Other studies showed that exposure to gas from cooking with natural gas was associated with asthma symptoms, however, these studies evaluated only pediatric patients.[7,9] In the US, the primary source of indoor nitrogen dioxides (NO_2) is gas stove which is used for cooking. A study of US patients with asthma aged 5–10 years found that exposure to indoor NO_2 at levels lower than the Environmental Protection Agency's outdoor standard of 53 ppb led to increased asthma symptoms and increased emergency drug use.[8] In adults, a study evaluating 16 non-smoking adult females with asthma showed that acute short term exposure to cooking was associated with a significant fall in PEFR, which is also correlated with the mean exposure to NO_2.[2]

Although previous studies have revealed a close relationship between cooking habits and PEFR, no clear evidence indicates that a certain type of cooking habits such as grilling meat or fish at home is closely associated with decreased PEFR. Overcoming these limitations, we showed that the frequency of grilling meat or fish at home was closely associated with decreased PEFR, especially in patients with severe asthma who required step 4-5 treatment. Although no clear data indicates that patients with severe asthma are more vulnerable to indoor air pollutants, our study results align with previous research which suggested that control of indoor environmental pollutants can modify asthma severity.[16,17] Future studies using severe asthma registries[18] would provide information on whether changing cooking habits can be helpful to control asthma in patients with severe asthma.

It has been well revealed that indoor PM levels were closely associated with asthma control. In a study on the association of indoor PM levels and asthma control, increased indoor PM10 and PM2.5 exposure decreased pulmonary function in children with asthma and PM2.5 level was positively associated with exhaled nitric oxide.[19] Another study found that an increase of 10 μg/m^3 in PM10 and PM2.5 at home increased asthma-related symptoms by 7%–14% and patients used relievers more frequently as PM10 and PM2.5 increased.[20] An indoor epidemiological study evaluating adults including asthma patients showed that PM2.5 was associated with acute respiratory symptoms and decreased PEFR.[11] Another study showed that women who used gas for cooking had an increased risk of asthma-like symptoms such as wheezing, dyspnea, and asthma attacks.[1] However, contrast to those studies, in our study, there was no significant difference in PM2.5 level between patients by frequency of grilling meat or fish at home although its level tended to be higher in patients who grilled at home frequently than those less frequently. One possible reason for this phenomenon is the relatively small sample size. Another potential reason is that grilling meat or fish may also have yielded more toxic gases such as NO_2 rather than PM2.5. However, as we could not measure toxic gases other than PM2.5, further studies are needed for this issue.

Our study had several limitations. First, there was no health control, and the number of patients was relatively small, which limits the generalizability of our results. Secondly, we divided patients into 2 groups according to whether they grilled meat or fish more than once a week or not. As we could not find validated reference or scientific rationale, we used the median number of grilling meat or fish at home as a cutoff value. In addition, as we did not measure the exposure period and time of grilling meat or fish, we used the frequency, a crude indicator for the exposure. Thus, future studies evaluating the effect of cooking at home on PEFR should consider measuring the exposure period and time of cooking Thirdly, in contrast to previous findings that women were more prone than men to indoor air pollution,[1,2] no significant difference in PEFR was seen among females by the frequency of cooking meat or fish in our study; this result may have been attributed to the small number of patients. Other possible reasons are socioeconomic status and job status among males. When we compared socioeconomic status using family income, there was no significant difference between the groups. However, the number of patients who did not have a job among males was higher in patients who grilled meat or fish at least once a week than in those who grilled meat or fish less than once a week (35.3% [6/17] vs. 17.4% [4/23]). Although this difference was not statistically significant (P = 0.195), this might have affected our results. Since our study could not clearly explain this phenomenon, further studies are needed. Fourth, we did not measure PEFR before and after grilling meat or fish at home. Thus, the direct effect of grilling meat or fish at home on PEFR has not been evaluated. However, an immediate fall in PEFR after cooking has been reported previously.[1] Finally, in general, low-cost PM sensors are convenient to get real-time data with better spatiotemporal resolution. But, the reliability and accuracy of the data remain as concerns. Further studies should be conducted in terms of evaluation of performance of low-cost sensors. And, we could not evaluate the impact of gases such as NO_2 other than PM2.5 on PEFR as AirGuard K could only measure PM2.5.

In conclusion, our study suggests that adult patients who require high levels of asthma-related medications may be cautious about their daily lung function, which can be influenced by the frequency of grilling meat or fish at home.

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