THE EFFECT OF LOCAL WEATHER CONDITIONS ON THE LUNG FUNCTION OF MILD-TO-MODERATE ASTHMATICS

W. R. Cobern[1], P. E. McSharry[1], L. Tarassenko[1]
[1]Department of Engineering Science, University of Oxford, Oxford, UK
william.cobern@eng.ox.ac.uk

Abstract – The correlation between severe asthma attacks and weather conditions such as thunderstorms has been known for some time. However, the effect of local weather on the measured values of lung function on a daily basis has not been investigated. This study has identified a significant trend for a group with mild-to-moderate asthma; lung capacity decreases with increasing temperature and pressure. A model is presented that shows how lung function is affected by atmospheric conditions. It is proposed that weather conditions should be included when considering personal management plans for asthma.

I. INTRODUCTION

Many people with asthma are aware that their daily symptoms can be affected by local weather conditions; for example electric storms are well documented as triggering asthma exacerbations. Several studies [1]-[3] have investigated the correlation between weather and accident and emergency admissions amongst acute asthmatics, and have found correlations with lung function for both temperature and humidity [2]. In particular thunderstorms can be a predictor of exacerbations [3]. About two thirds of people with asthma are categorised as having mild-to-moderate asthma [4]. This study focuses on the effect of weather on day-to-day lung function of this category of patients.

II. DATA SET

Throughout the summer and autumn of 2003, Peak Expiratory Flow (PEF), the maximum flow generated during expiration performed with maximal force and started after a full inspiration, were measured, twice daily, by 91 people with mild-to-moderate asthma in the Thames Valley Region using a novel telemedicine system, described elsewhere [5]. Data from the 58 most compliant patients have been analysed to investigate correlations with local daily weather conditions.

Weather data were collected in the vicinity [6] at 1hr intervals throughout the study period. The following parameters were measured: temperature, pressure, humidity, precipitation and wind speed.

III. METHOD

To enable comparison of PEF values, measurements for each patient were calculated as percentage of personal best. Outliers were removed and then associated ‘smoothed’ weather conditions were attached to each PEF reading.

1. Outlier removal, defined as $\text{PEF} < 50\ \text{lmin}^{-1}$ and $\text{PEF} > \mu_{PEF} + 3\sigma_{PEF}$, due to poor technique, where μ_{PEF} and σ_{PEF} are the mean and standard deviation of the PEF values for that patient over the whole of the study period.
2. Compute “Percentage Adjusted Personal Best”
$$\text{PEF}' = \frac{\text{PEF}}{\text{mean(largest 5 PEF values)}} \times 100\% .$$
This is known as the percentage of personal best in the literature.
3. Apply a correction formula to remove the predictable effects of ageing and growth (see below); this is based on the Hankinson models [7].
4. Smooth the weather data to remove short-term effects. The weather data were sampled at hourly intervals and a one-week median filter was applied.
5. Assign associated weather data to each PEF value based on the time the reading was taken.
6. Regression coefficients were determined by fitting the following function: $\text{PEF}' = \mathbf{a}^T\mathbf{x} + b + \varepsilon$, where $\mathbf{x}$ is a vector of weather parameters and ε is the error term.

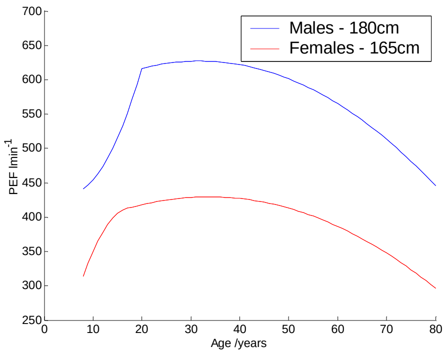
Hankinson [7] presents models (see Figure 1) which predict a person’s PEF based on their age and height. Lung capacity increases sharply during the childhood and teenage ears then gradually reduces over time. As the starting height and ages of the patients are known, we can combine this information with a growth chart [8], showing how a height changes with age to form a model that can predict how the underlying PEF should vary during the trial. This is used to calculate a scaling factor based on the time of the reading and hence compensate for temporal effects.

TABLE I
TWO MODELS ARE PRESENTED FOR PEF VALUES BASED ON WEATHER PARAMETERS, TIME AND TIME-SQUARED. THE FIRST MODEL CONTAINS ALL VARIABLES; THE SECOND ONLY CONTAINS THOSE FOUND TO BE SIGNIFICANT IN THE FIRST MODEL.

	Model 1		**Model 2**	
	coefficient	*p*	coefficient	*p*
Temperature /^{o}c	-0.2393	<0.05	-0.2458	<0.05
Pressure /mb	-0.0809	<0.05	-0.0678	<0.05
Humidity /%	0.0083			
Precipitation /mm	-0.5928			
Wind Speed /ms^{-1}	-0.1258			
Time /days	-0.0043			
Time Squared /days^{2}	0.0000			
Intercept	166.9928	<0.05	153.0330	<0.05
RMSE	12.36		12.37	
R-square	0.009728		0.009101	
F	22.62		74.05	
p	< 0.001		< 0.001	

The final model which is presented is: $\mathrm{PEF'} = 153.03 - 0.2458 \times Temp - 0.0678 \times Pres$

Figure 1. – Predicted values of PEF for males of height 180cm and females of height 165cm.



IV. RESULTS

Table I shows the results of multivariate regression applied using Matlab to the data set. The first model, comprising all weather terms, includes both time and time-squared. Only temperature and pressure have been found to be significant. The corrections implemented to compensate for the effects of age and growth have removed any temporal factors from the model. The second model which is presented contains only those factors which are significant (p<0.05).

V. CONCLUSION

This investigation has identified several independent relationships between local weather conditions and the lung function of mild-to-moderate asthmatics. The predominant effect is that of temperature whereby lung function decreases with temperature, so it is likely that people with asthma will suffer more in the summer months. High pressure has also been found as a factor which influences lung function. Such results could be considered by patients and clinicians when designing personal management plans; symptoms may be reduced by increasing medication usage during high temperature and/or high pressure weather conditions. Clinicians could also take into account the increasing lung capacity of children and consider recalibrating baseline values on a six monthly or yearly basis.

VI. REFERENCES

[1] A. de Deigo Damiá, M. León Fabregas, M. Perpiñá Tordera and L. Compte Torrero, “Effects of Air Pollution and Weather Conditions on Asthma Exacerbation”, Respiration 1999:66:52-58.

[2] M.A. Ivey, et al, “Associations between climate variables and asthma visits to accident and emergency facilities in Trinidad, West Indies”, Allergology International 2001:50:29-33.

[3] R. Newson, et al, “Acute asthma epidemics, weather and pollen in England, 1987-1994” Eur Respir J 1998:11:694-701.

[4] A.L. Fuhlbrigge, et al, “The burden of asthma in the United States: level and distribution are dependent on interpretation of the National Asthma Education and Prevention Program Guidelines”, Am J Respir Crit Care Med. 2002:166:1044-1049.

[5] D. Ryan, W. Cobern, J. Wheeler, D. Price and L. Tarassenko, “Mobile phone technology in the management of asthma”, J Telemed and Telecare, in press.

[6] Data provided by the Met Office – Recorded at Heathrow.

[7] J. L. Hankinson, J. R. Odencrantz, and K. B. Fedan. “Spirometric Reference Values from a Sample of the General U.S. Population” American Journal of Respiratory and Critical Care Medicine, 1999:159:179-187.

[8] Provided by the National Centre for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion. https://www.cdc.gov/growthcharts.