Identifying Asthmatic Children using Tidal Breathing Parameters Measured by Structured Light Plethysmography (SLP)

H. Hmeidi[1], S. Motamedi Fakhr[3], E. Chadwick[1], F. Gilchrist[2], R. Wilson[3], W. Lenney[2], R. Iles[4], J. Alexander[2]

1 – Institute for Science and Technology in Medicine, Keele University; 2 – University Hospitals of North Midlands, Stoke-on-Trent; 3 – PneumaCare Ltd, Cambridge; 4 – Addenbrookes Hospital, Cambridge

ABSTRACT

SLP is a novel technique which measures breathing patterns by measuring chest and abdominal wall movements during tidal breathing (1). We have previously shown that several tidal breathing parameters measured using SLP varied between asthmatic children and healthy (2). However, we did not test the classification power of a model which incorporates the identified parameters.

In this study a classifier was constructed and its performance was evaluated in differentiating asthmatic children from healthy.

30 clinically diagnosed asthmatic children with abnormal spirometry (FEV1 <80% predicted) aged 7-16 years and an age matched cohort of 41 healthy children were analysed. Tidal breathing parameters that showed trend level significance (p<0.01) in our previous study were selected as predictors. These were: median inspiratory time (Ti), inspiratory to expiratory time ratio (Ti/Te), duty cycle (Ti/Ttot), time to peak tidal expiratory flow over expiratory time (TPTEF/TE) and its variability, inspiratory to expiratory displacement rate at 50% of displacement (IE50) and its variability. Employing a K-fold cross validation procedure (K=5), a linear discriminant analysis classifier was trained and tested on this dataset. The overall accuracy was 80.3%, (sensitivity=80.0%, specificity=80.5%). Area under the receiver operating characteristic curve (AUROC) was 0.85.

Sensitivity, specificity and AUROC all suggest there is potential in exploring tidal breathing for diagnostic purposes. Given that all the information required for the classification are parameters extracted from five minutes of quiet tidal breathing using a non-contact device. It may be useful to explore the use of SLP to assist in diagnosing children with asthma.

INTRODUCTION

Asthma, the single most common chronic disease during childhood starts very early in life in the majority of cases.

Asthma is not a curable disease, however an early and accurate diagnosis and monitoring is very important for breathing assessment.

- Conventional techniques to measure lung function, such as spirometry, are challenging in young children, as the child's full cooperation is required to perform the test (2).
- Structured light plethysmography (SLP) is a novel technique developed at Cambridge to determine the parameters of tidal breathing in a non-invasive and zero-contact environment.

STUDY AIMS

- Evaluate the performance of a constructed classifier in differentiating asthmatic children from healthy.

METHODOLOGY

- 30 child visiting the outpatient clinic with a diagnosis of asthma and reduced lung function (with FEV1< 80% predicted) were recruited (age range 7-16 years).
- Five minutes of tidal breathing was recorded using SLP (Thora-3Di, PneumaCare Ltd).
- A group of age matched healthy children with no history of respiratory diseases were recruited (n=41), this group underwent the assessment with SLP to generate comparative data for normal subjects.
- Tidal breathing parameters that showed trend level significance (p<0.01) were selected as predictors. These were: median inspiratory time (Ti), inspiratory to expiratory time ratio (Ti/Te), duty cycle (Ti/Ttot) (Figure 2A), time to peak tidal expiratory flow over expiratory time (TPTEF/TE) and its variability (Figure 2B), inspiratory to expiratory displacement rate at 50% of displacement (IE50) and its variability (Figure 2C).
- Parameter's magnitudes were calculated using the median value from the successive breaths, whereas their within-subject variability using the IQR.
- A linear discriminant analysis classifier was trained and tested on this dataset using a K-fold cross validation procedure (K=5).

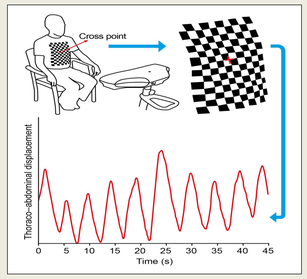

Figure 1: Structured Light projected onto the thoraco–abdominal (TA) wall of a participant seated 1 meter from the device (Thora-3DiTM, PneumaCare, Cambridge, UK).

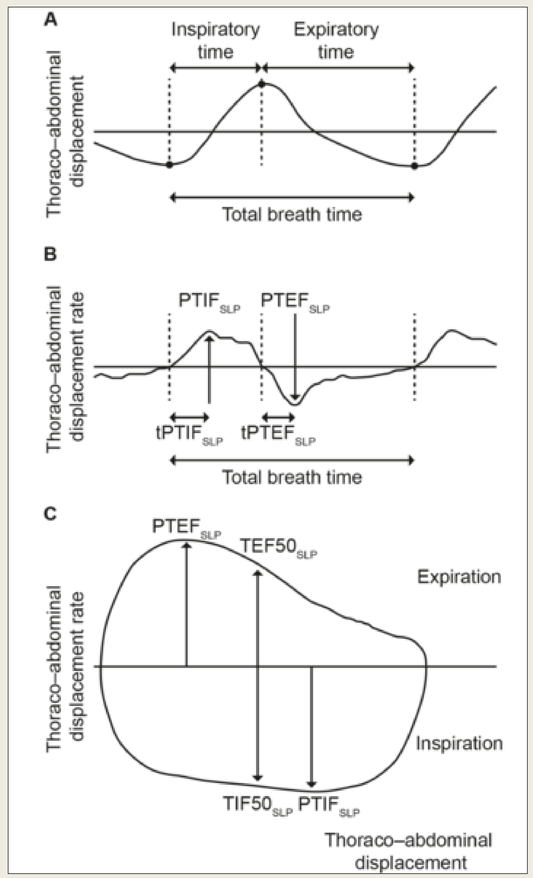

Figure 2: Structured light plethysmography tidal breathing traces and derived parameters. (A) Timing indices. (B) Thoraco–abdominal (TA) displacement rate-derived parameters; $PTIF_{SLP}$ (Peak tidal inspiratory Flow), $PTEF_{SLP}$ (Peak tidal expiratory flow), $tPTIF_{SLP}$ (time to peak tidal inspiratory Flow), $tPTEF_{SLP}$ (time to peak tidal expiratory Flow). (C) TA displacement rate with TA displacement-derived parameters.

RESULTS

- The overall accuracy, sensitivity, specificity and area under the receiver operating characteristic curve (AUROC) are shown in table 1.

Measure	Results
Sensitivity	80.0%
Specificity	80.5%
Accuracy	80.3%
Area under the curve	0.85

Table 1: The Linear discriminant classifier overall accuracy, sensitivity, specificity and Area under the receiver operating characteristic curve (AUROC).

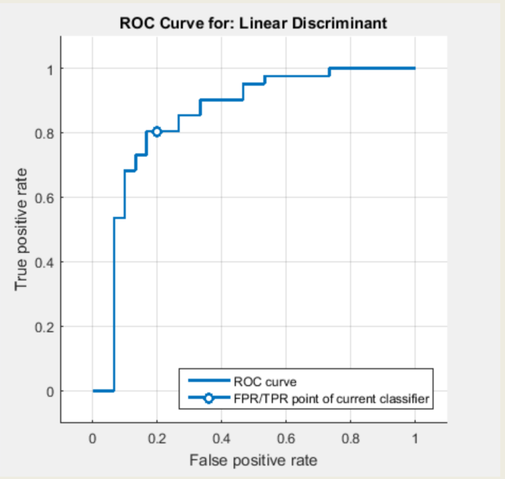

Figure 3: The performance of the model based on the receiver operating characteristic curve (ROC).

CONCLUSIONS

- Sensitivity, specificity and AUROC all suggest there is potential in exploring tidal breathing for diagnostic purposes. Given that all the information required for the classification are parameters extracted from five minutes of quiet tidal breathing using a non-contact device. It may be useful to explore the use of SLP to assist in diagnosing children with asthma.

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