PneumaCare

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Comparison of Tidal Breathing Indices Measured Simultaneously Using Pneumotachography and Structured Light Plethysmography (SLP)

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INTRODUCTION

A change in respiratory rate (RR) or respiratory pattern can be indicative of a disease state and as such, assessment of these may result in a diagnosis.

In their simplest form, tidal breathing timing indices such as RR, inspiratory time (Ti), expiratory time (Te), total breath time (Ttot), and their ratios Ti/Te and Ti/Ttot (duty cycle), provide an estimate of breathing frequency and asymmetry in tidal breaths.

Tidal breathing is often measured using a pneumotachograph (PNT). PNT directly measures pressure change at the mouth from which flow may be estimated and, using numerical integration, a volume signal over time can be obtained.

Tidal breathing can also be measured from movement of the thoraco-abdominal (TA) wall.

Structured light plethysmography (SLP) is a recently developed respiratory measurement device that measures TA wall movements during tidal breathing,

SUBJECTS AND METHODS

This was a non-randomized study in a cohort of 22 participants. The cohort represented participants with a physician diagnosed respiratory condition, and participants with no previous or current respiratory diagnosis.

Ages ranged from 6 to 78 years (Mean ± SD = 52 ± 23.5).

This diversity of participants was included to provide a wide range of tidal breathing rates and patterns.

Participants were excluded if they had a cold or any other viral infection, chest surgery within the past month or an acute disease process likely to interfere with data acquisition.

The study protocol was approved by the United Kingdom Health Research Authority National Research Ethics Service.

Tidal breathing was recorded simultaneously using PNT (Viasys Masterscope CT, Viasys healthcare GmbH) and SLP (PneumaScan, PneumaCare Ltd.). The PNT used had a sampling rate of 100Hz, flow range of 0 to ±20L/S and flow accuracy of ±2%.

SLP projects a grid of light onto the TA wall of a participant. Changes in the grid pattern are recorded using two cameras (located in the scanning head) and then translated into a virtual surface corresponding to the shape of TA wall of the subject. Average axial displacement of the virtual grid provides a 1 dimensional movement over time trace from which tidal breathing timing indices can be calculated. SLP samples at 30Hz.

Figure 1 illustrates the working principle of SLP.

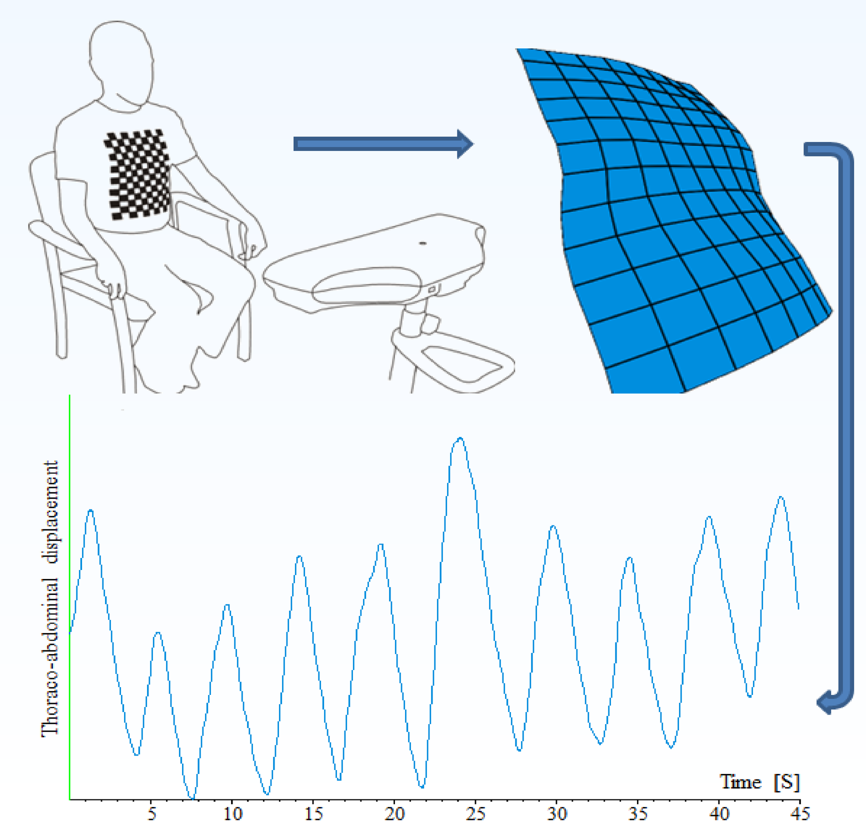

Figure 1. Working principle of SLP.

RESULTS

A total of 224 breaths were detected across all participants for each device. Both breath-by-breath and averaged indices including RR, inspiratory time (Ti), expiratory time (Te), total breath time (Ttot), ratio of inspiratory to expiratory time (Ti/Te) and duty cycle (Ti/Ttot) were calculated for each individual.

Bland-Altman plots were used to assess the agreement between each pair of parameter.

Although different in principle, traces are similar in morphology. A typical comparison between PNT and SLP traces is shown in Figure 2.

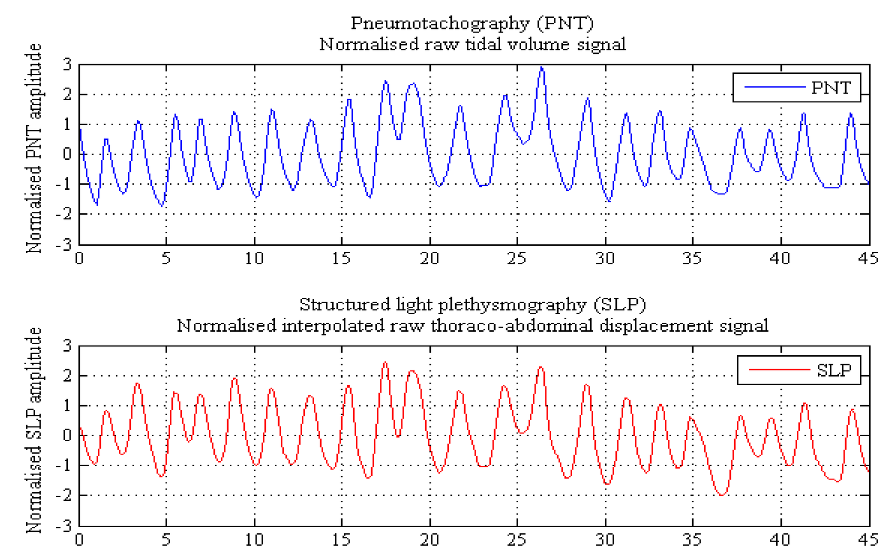

Figure 2. A typical comparison of SLP and PNT traces.

Both traces are normalised (zero mean, unit standard deviation) for ease of visual comparison.

Breath-by-breath RR between the two devices agreed to within ±1.39 brpm. Agreement for breath-by-breath Ti, Te, Ttot, Ti/Te and Ti/Ttot were within ±0.22, ±0.29, ±0.31, ±0.16 and ±0.05 seconds respectively.

Mean RR over 45 seconds agreed to within ±0.18brpm between the two devices. Agreement for mean Ti, Te, Ttot, Ti/Te and Ti/Ttot were within ±0.16, ±0.16, ±0.06, 0.09 and ±0.03 seconds respectively. Table 1 (in abstract) summarises the results.

Statistical analysis. Breath-by-breath differences between the calculated timing indices were plotted in a Bland and Altman setting.

Note that although a breath-by-breath comparison gives a deeper insight into how the two devices compare, in practice, clinicians often average these parameters over a clinically appropriate interval (e.g. between 15 to 60 seconds). We have therefore also provided a similar (Bland-Altman) comparison between the parameters averaged over 45 seconds.

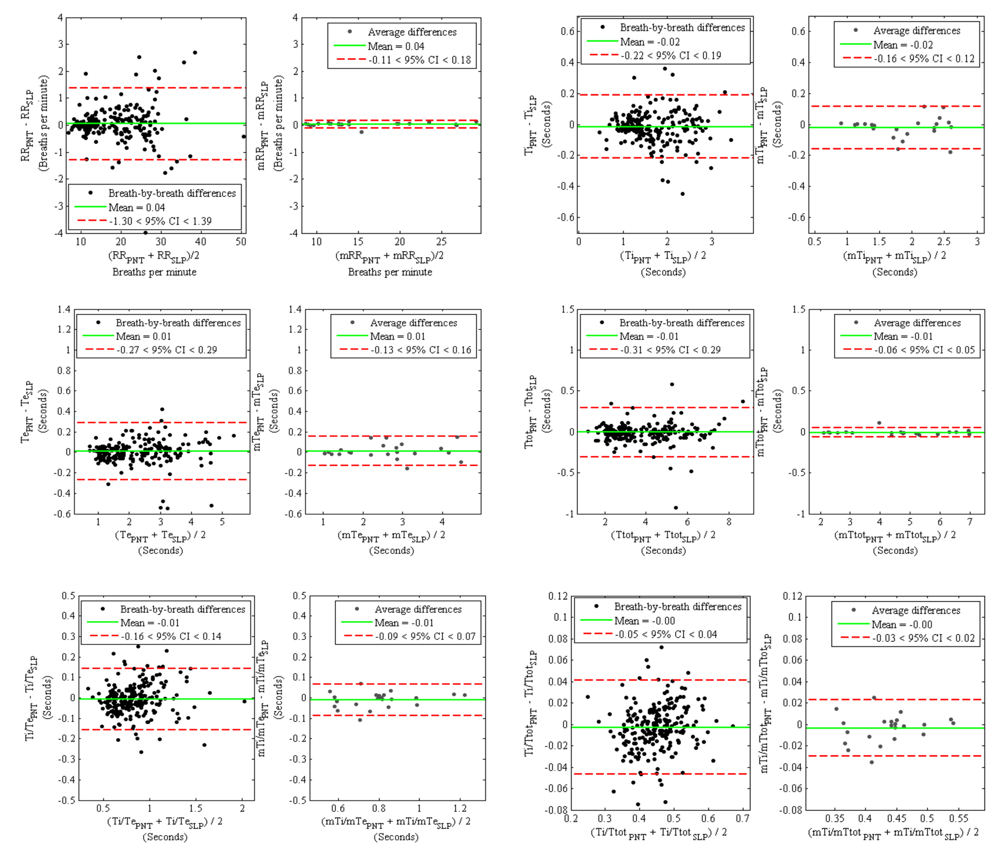

Figure 3. depicts the Bland Altman agreement between PNT and SLP in measuring tidal breathing parameters, on both breath-by-breath and averaged levels.

Timing index	Difference between PNT and SLP (PNT - SLP) Breath-by-breath Mean [Limits of Agreement]	Averaged (over 45 seconds) Mean [Limits of Agreement]
RR (brpm)	0.04 [-1.30, 1.39]	0.04 [-0.11, 0.18]
Ti (Second)	-0.02 [-0.22, 0.19]	-0.02 [-0.16, 0.12]
Te (Second)	0.01 [-0.27, 0.29]	0.01 [-0.13, 0.16]
Ttot (Second)	-0.01 [-0.31, 0.29]	-0.01 [-0.06, 0.05]
Ti/Te	-0.01 [-0.16, 0.14]	-0.01 [-0.09, 0.07]
Ti/Ttot	0 [-0.05, 0.04]	0 [-0.03, 0.02]

Table 1. Agreement of tidal breathing timing indices between PNT and SLP.

CONCLUSIONS

In this study breath-by-breath and averaged tidal breathing timing indices (RR, Ti, Te, Ttot, Ti/Te, Ti/Ttot) measured simultaneously by pneumotachography and structured light plethysmography (SLP) were compared.

RR was found to agree very well between the two devices. There are strong indications that the Ti, Te, Ttot and Ti/Ttot may also be judged to agree between PNT and SLP, not only when averaged but also on a breath-by-breath level.

Agreement in these fundamental parameters indicates that, despite the difference in technologies, SLP can be used to measure tidal breathing timing indices with equivalent precision to the gold standard pneumotachograph.

REFERENCES

1. De Boer, W. et al., 2010. SLP: A Zero-Contact Non-Invasive Method for Pulmonary Function Testing. *Proceedings of the British Machine Vision Conference 2010*, pp.85.1–85.12.

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