Validation of Structured Light Plethysmography (SLP) Generated Respiratory Rate (RR) Against Clinician Over-Scored Capnography

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Abstract

Structured Light Plethysmography (SLP) is a novel non-contact technology for measuring tidal breathing through monitoring the movements of the thoraco-abdominal (TA) wall. In this study we have compared respiratory rate (RR) measured using SLP with that of a gold standard (clinician over-scored capnography) in cohort of 35 adult subjects with various respiratory conditions. RR was found to agree very well between the two methods (±0.75 brpm). Agreement was not significantly influenced by gender, height, weight, BMI, respiratory status.

Aims

- To validate SLP derived respiratory rate (RR) against a gold standard (clinician over-scored capnography)

INTRODUCTION

Structured Light Plethysmography (SLP) is a non-contact, non-invasive tidal breathing measurement technology that utilises the movement of the thoraco-abdominal (TA) wall to generate a 1-dimensional trace from which a number of tidal breathing parameters including respiratory rate (RR) can be calculated.

We have previously demonstrated a RR agreement of within ±2 breaths per minute (brpm) with respiratory inductance plethysmography (RIP) bands [1] and a breath-by-breath agreement of within ±1.4 brpm with pneumotachography [2].

Demonstrating equivalence between RR generated from SLP and clinician over-scored capnography (considered a gold standard) in a varied range of participants and operators would confirm the accuracy of SLP in measuring RR and the influence of factors such as body size, age, respiratory condition and operator dependency.

Participants

35 adult subjects (21M, 14F) between the ages of 19 and 77 years including healthy volunteers (N=11) and those with a recognised respiratory disease or impairment (N=24) were recruited by two research nurses on at a GP practice and the other at a general hospital.

Experimental procedure

Subjects were seated comfortably in a high-backed chair and were advised to breathe naturally and limit their movement.

A 14 x 10 grid size was used for all participants and the distance of the device from the patient was adjusted to achieve appropriate grid coverage of the TA region. The cross point was centred on the xiphisternum. Displacement of the TA wall and continuous nasal CO2 were measured simultaneously for 5 minutes by Thora-3Di (PneumaCare Ltd, Cambridge, UK) and BCI Capnocheck 9004 (Smiths Medical) respectively. For clarity, Figure 1 shows the working principle of SLP.

Respiratory rate (RR) calculation

For each subject, RR was calculated for a randomly selected 1 minute epoch of the 5 minute trace.

RR calculation was performed using the PneumaView-3D software (PneumaCare Ltd, Cambridge, UK) for SLP and by an independent anaesthesiologist scoring and manually counting the breaths on the nasal CO2 traces for the capnograph.

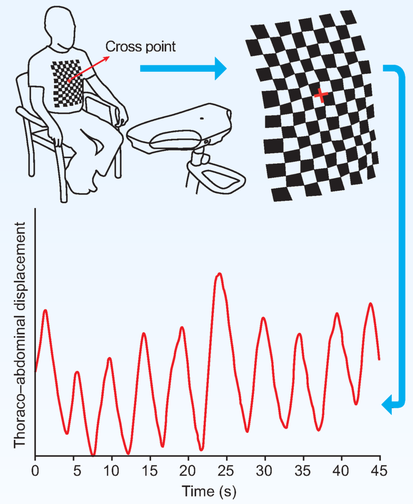

Figure 1. Working principle of SLP. Axial displacement of every intersection point on the projected grid is measured by two cameras at 30 frames per second as the thoraco-abdominal (TA) wall moves back and forth. By averaging this displacement across all intersection point at any one point in time (i.e. for each frame), a one-dimensional displacement over time trace can be produced which corresponds to the overall movement of the chest and abdomen over time.

Statistical analysis

Bland and Altman method was used to assess the agreement. A series of subgroup analyses were carried out to assess the effect of operator/site, age, gender, weight, height, BMI and respiratory disease/health condition on the agreement. T-tests were used for the subgroup analyses.

RESULTS

The 95% limits of agreement were (-0.72, 0.75 brpm) which are much narrower than the commonly accepted limits of agreement of (-2, 2 brpm). Furthermore, no significant differences were found in RR between various different subgroups. Details of the subgroup analyses can be found in Table 1. For age, height and weight, the median value of the sample was used to split each group in two.

Table 1. Subgroup analyses

Subgroups	Sample Size	Mean difference (SD) in RR Thora-3Di (–) Capnography	p-value
Site			
Hospital	18	-0.08 (0.39)	0.27
GP Practice	17	0.06 (0.35)	
Gender			
Male	21	0 (0.39)	0.79
Female	14	-0.04 (0.37)	
Age (yr) at consent			
Age < 54	17	-0.12 (0.28)	0.11
Age ≥ 54	18	0.08 (0.43)	
Disease			
Normal	11	-0.09 (0.30)	0.42
Respiratory disease	24	0.02 (0.40)	
Height (cm)			
Height < 172.5	17	0 (0.43)	0.83
Height ≥ 172.5	18	-0.03 (0.32)	
Weight (kg)			
Weight < 74.5	17	-0.06 (0.35)	0.50
Weight ≥ 74.5	18	0.03 (0.40)	
BMI (kg/m²)			
BMI < 25	17	-0.12 (0.28)	0.11
BMI ≥ 25	18	0.08 (0.43)	

CONCLUSIONS

Respiratory rate measured by SLP was found to be equivalent to that derived from clinician over-scored capnography (FDA gold standard for RR measurement). Additionally, the agreement between the two devices is not affected by site/operator, age, gender, height, weight, BMI or the respiratory status of the subject.

REFERENCES

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