Reliable diagnosis for pulmonary diseases

Objective scoring of physiologically-induced dyspnea

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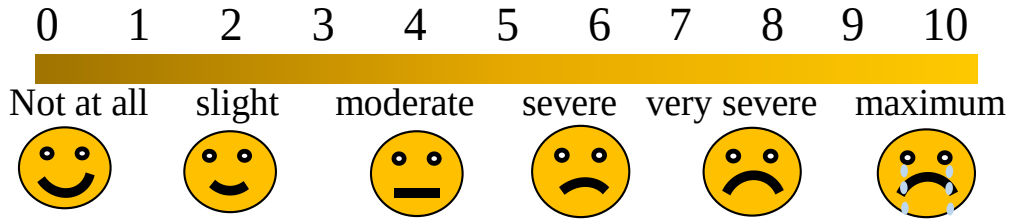
Objective scoring of physiologically-induced dyspnea

Dyspnea usually self-reported by Borg scale 0-10:



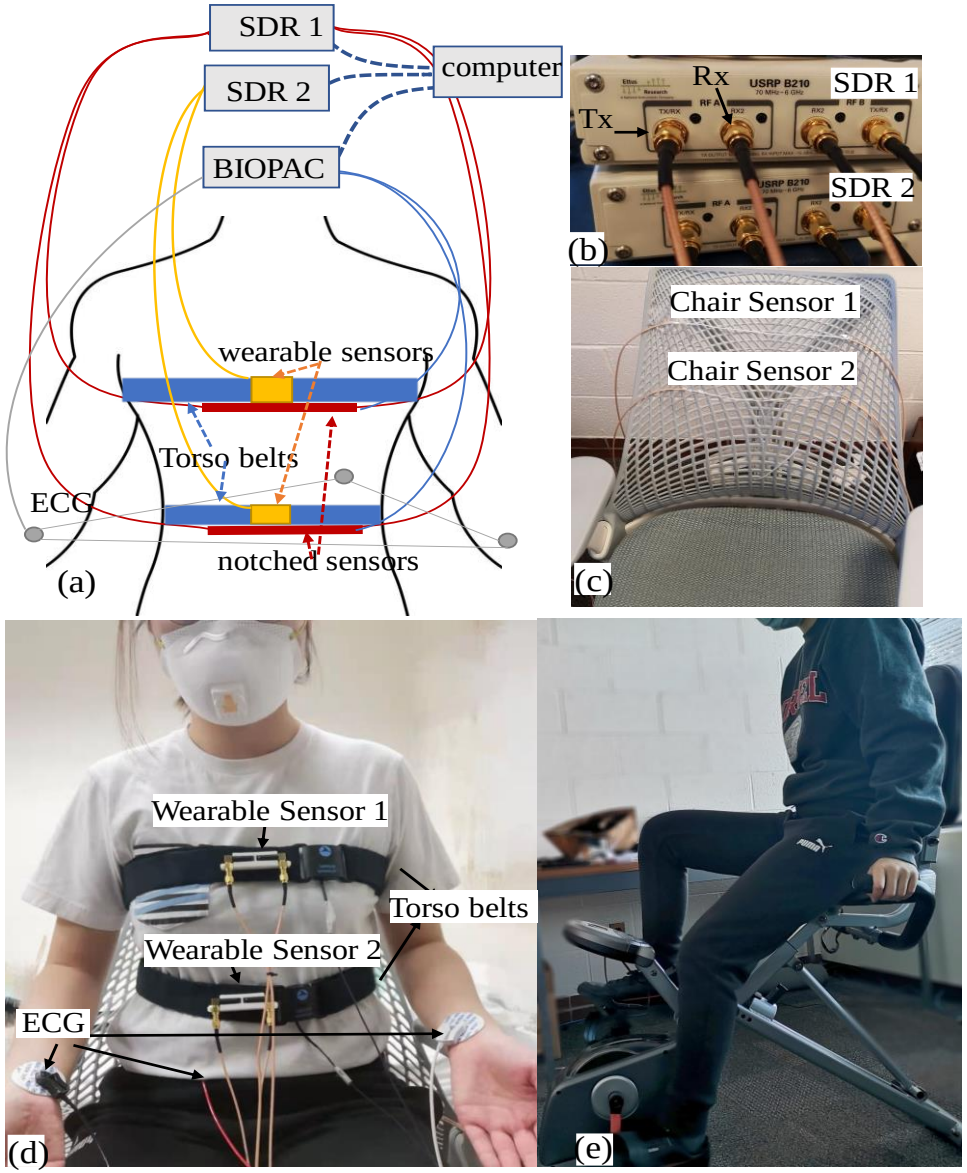
0: Relaxed as in sleeping or watching TV.
1-3: Can maintain for hours.
4-6: Can hold short conversation. But noticeable challenging.
7-9: Difficult to maintain exercise. Can barely speak a sentence.
10: Impossible to keep going. Unable to talk.

Dyspnea : shortness or difficulty of breathing

Chronic dyspnea due to COPD, asthma, lung diseases.

Subjective and Problematic ??

Experimental Setup

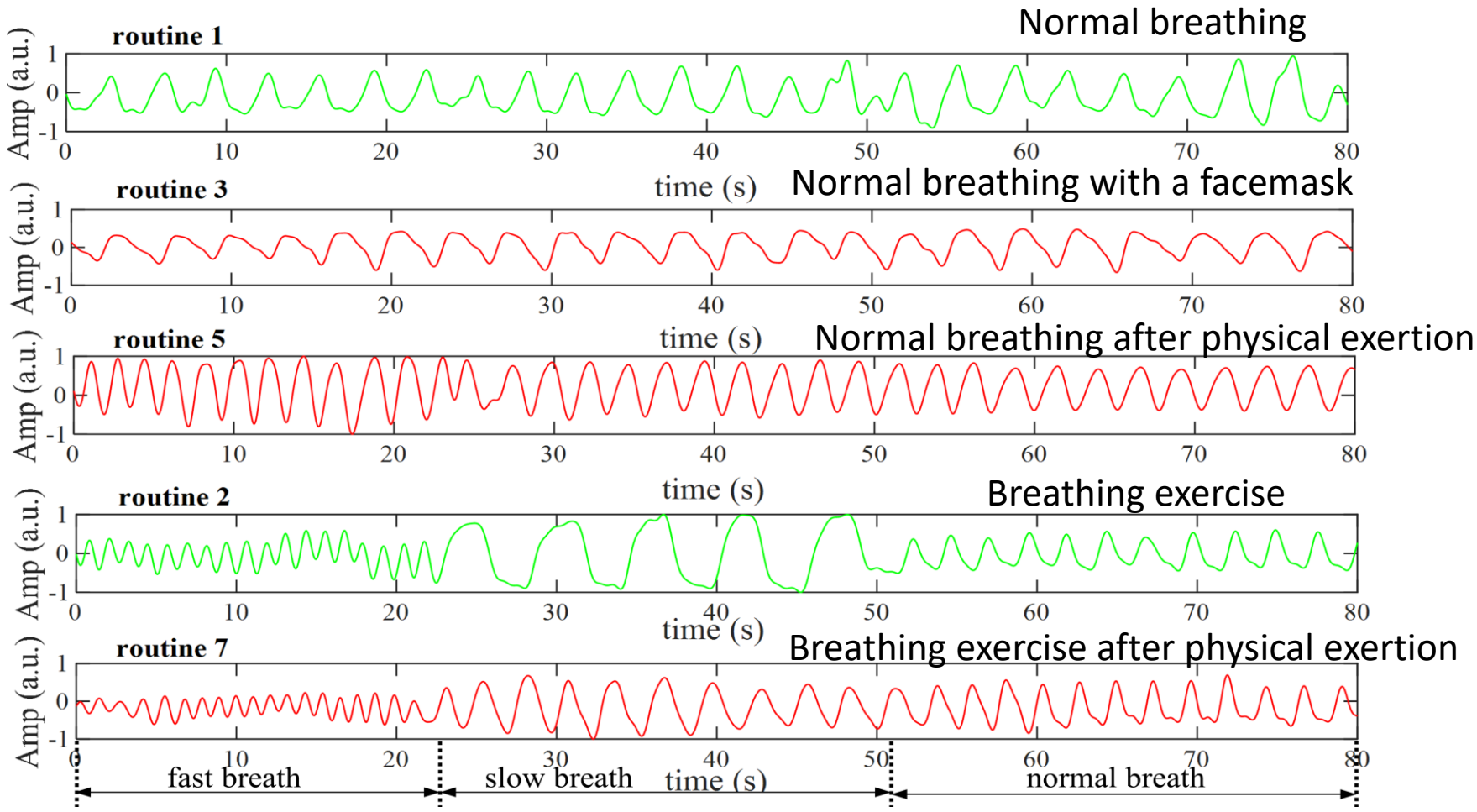


2 wearable RF sensors &
2 invisible RF sensors integrated to chair
On thorax and abdomen position

Simulate dyspnea on healthy subject (N=32) by:

1. 10 mins exercise
2. Wear thick facemask

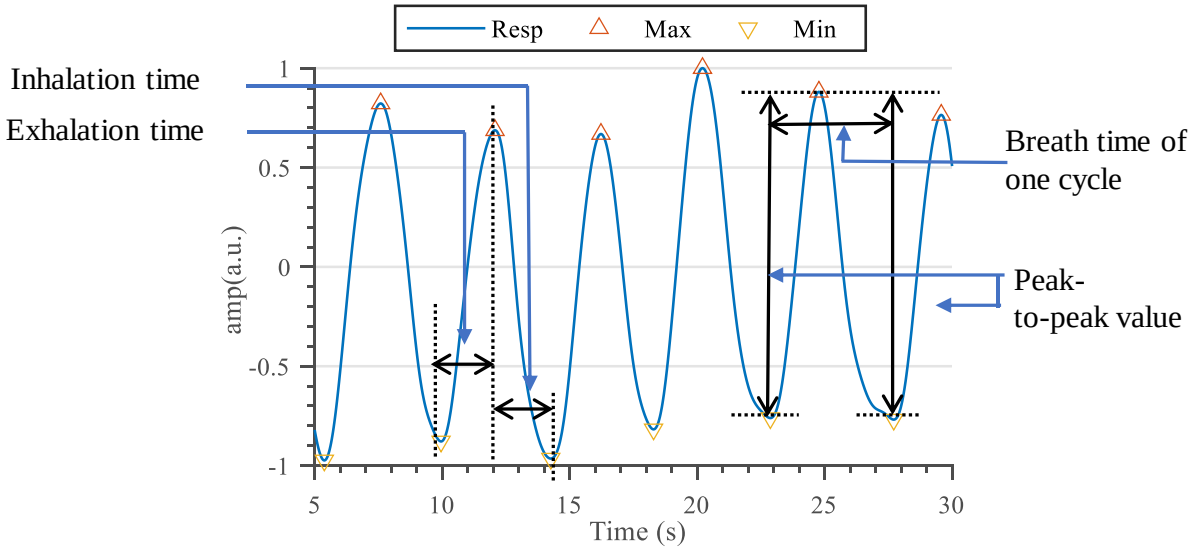
Self reported dyspnea score for each routine is collected.



An example of NCS respiratory waveforms during the study protocol. The illustration period is truncated from 10 to 90 s of each routine. Green curves indicate absence of dyspnea, and red curves indicate some degrees of dyspnea.

Signal processing and Machine Learning model

1. Extract respiratory parameters from waveforms



2. Respiratory features (n=15) from respiratory parameters.

	Breath rate (BPM)	Peak-to-peak (a.u.)	Inhalation interval (s)	Exhalation interval (s)
Coefficient of variation	CoV_{BR}	CoV_{PP}	CoV_{IN}	CoV_{EX}
Mean	μ_{BR}		μ_{IN}	μ_{EX}
Autocorrelation	$R1_{BR}$	$R1_{PP}$	$R1_{IN}$	$R1_{EX}$
Successive differences	$R2_{BR}$	$R2_{PP}$	$R2_{IN}$	$R2_{EX}$

3. ML Model for dyspnea scoring

Input features: Respiratory features

Ground truth Label: Self-reported dyspnea score D_{self}

Model: Random forest regressor

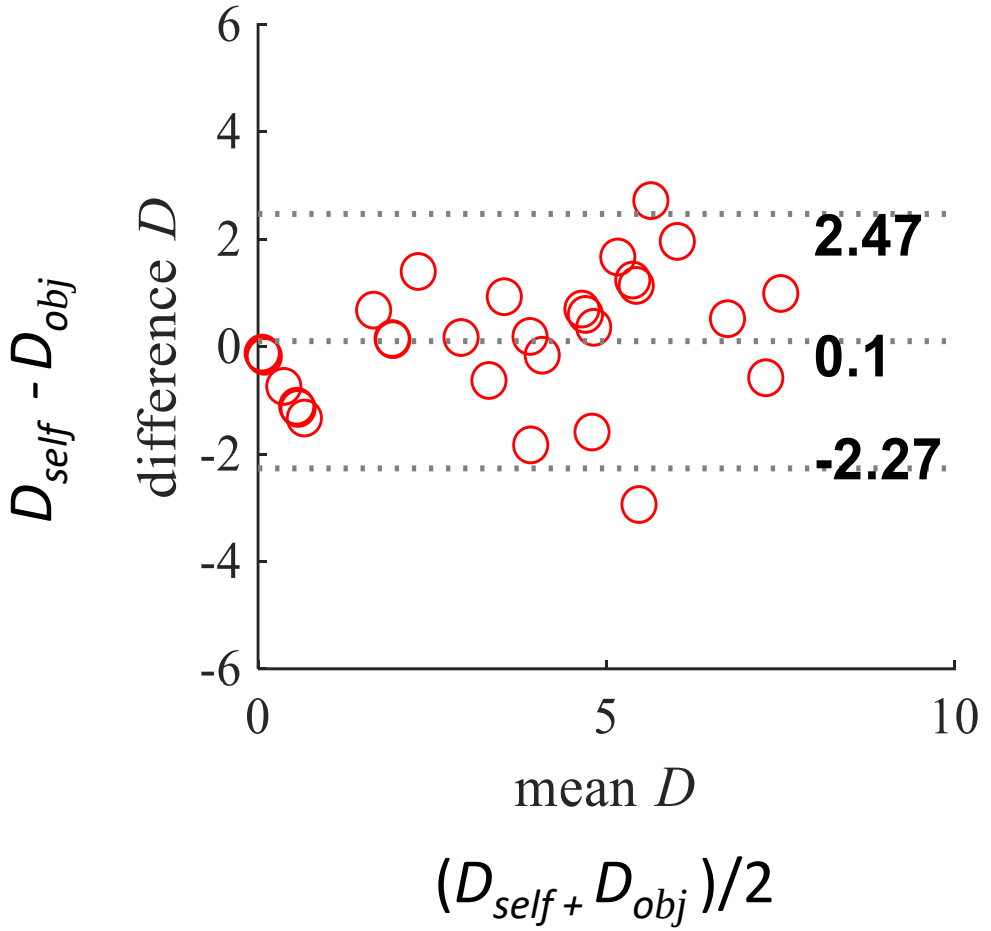
Output: predicted objective dyspnea score D_{obj}

$$\text{Accuracy: } \eta = 1 - \frac{|D_{obj} - D_{self}|}{9}$$

Prediction accuracy for dyspnea score

Data set	NCS
Model	Random forest
Feature importance	μ_{BR}=40.2% $R2_{BR}$=15.1% $R2_{EX}$=7.5%
Mean η by k-fold cross-validation	0.866
Mean η by leave-one-participant-out cross-validation	0.881
η for testing data	0.907

B&A plots between D_{self} and D_{obj}



The method formulates a baseline for clinical dyspnea assessment.