Two adjusted adaptive comfort models of elderly in elderly facilities in shanghai

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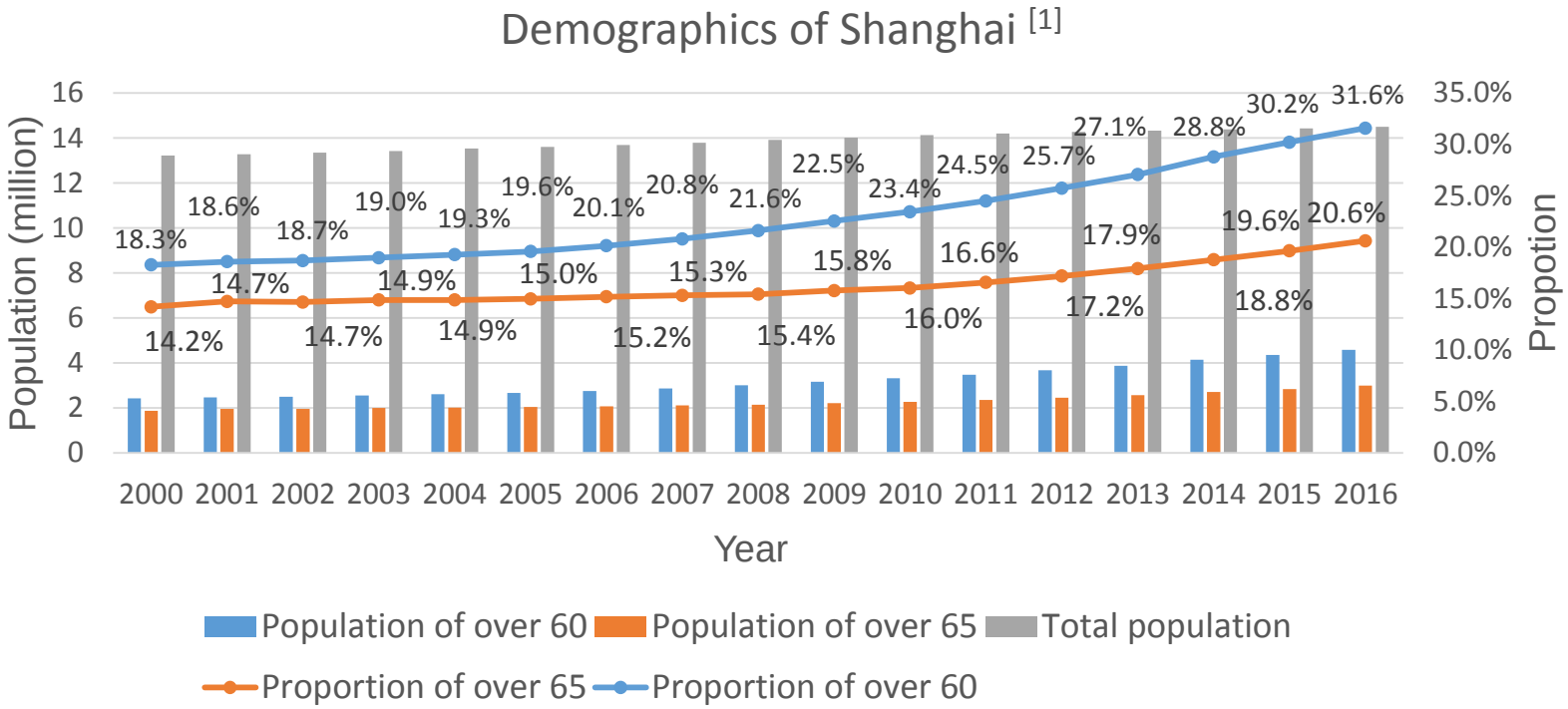
Background

Located in the Yangtze River Delta in East China, Shanghai has a humid subtropical climate and experiences four distinct seasons. Shanghai averages 4.2 °C (39.6 °F) in January and 27.9 °C (82.2 °F) in July, for an annual mean of 16.1°C (61.0 °F) [1].



Field survey

Aim

Explore the influence
physiology and psychol
in residential buildings

Methods

Conducting field survey

Time

Jan. 2013 to Apr. 2017

Sample size

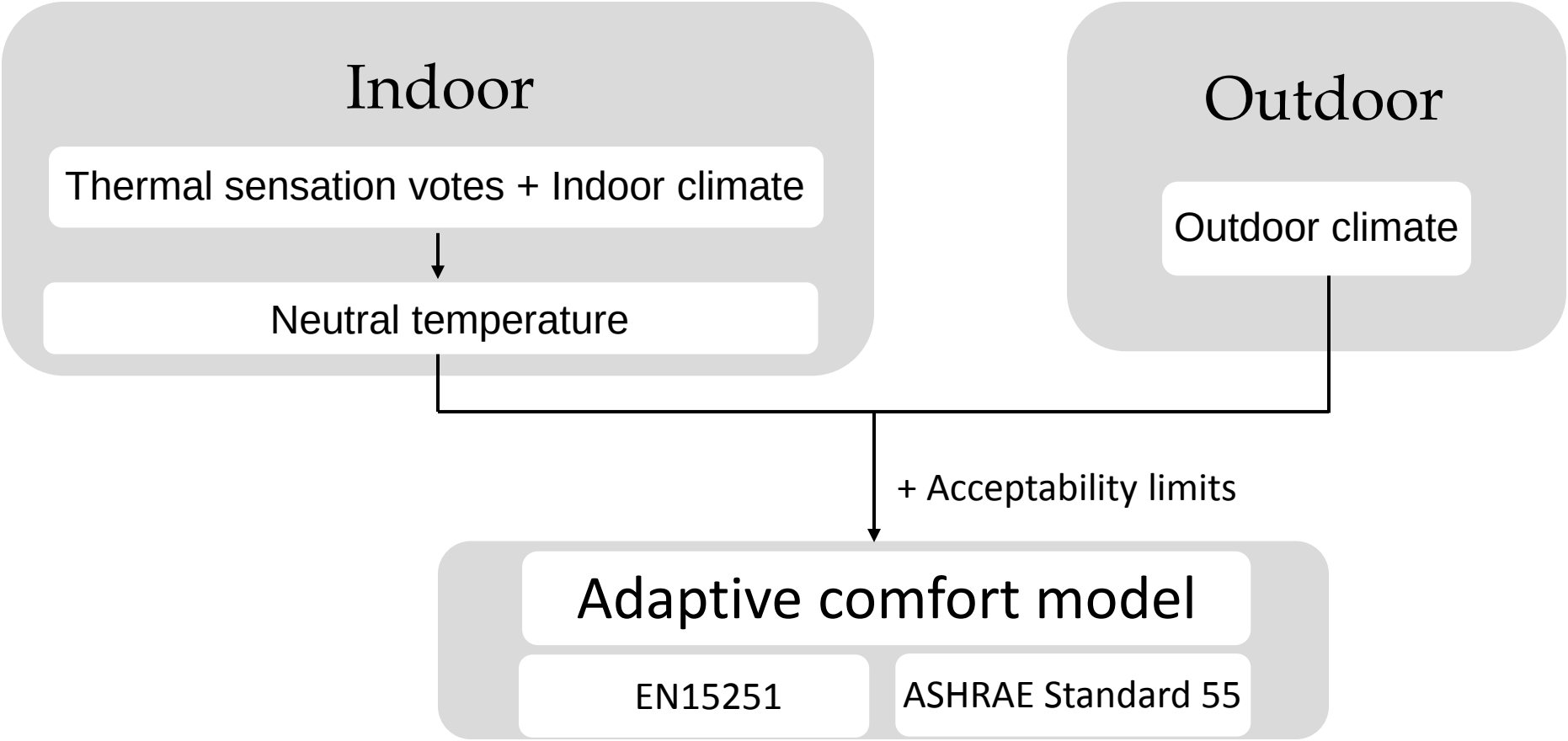
Year	Summer	Winter		
2013				
2014	330	165		
2015		149		
2016				
2017			120	120
Tatal	**330**	**314**	**385**	**1029**

Administration districts of Shanghai

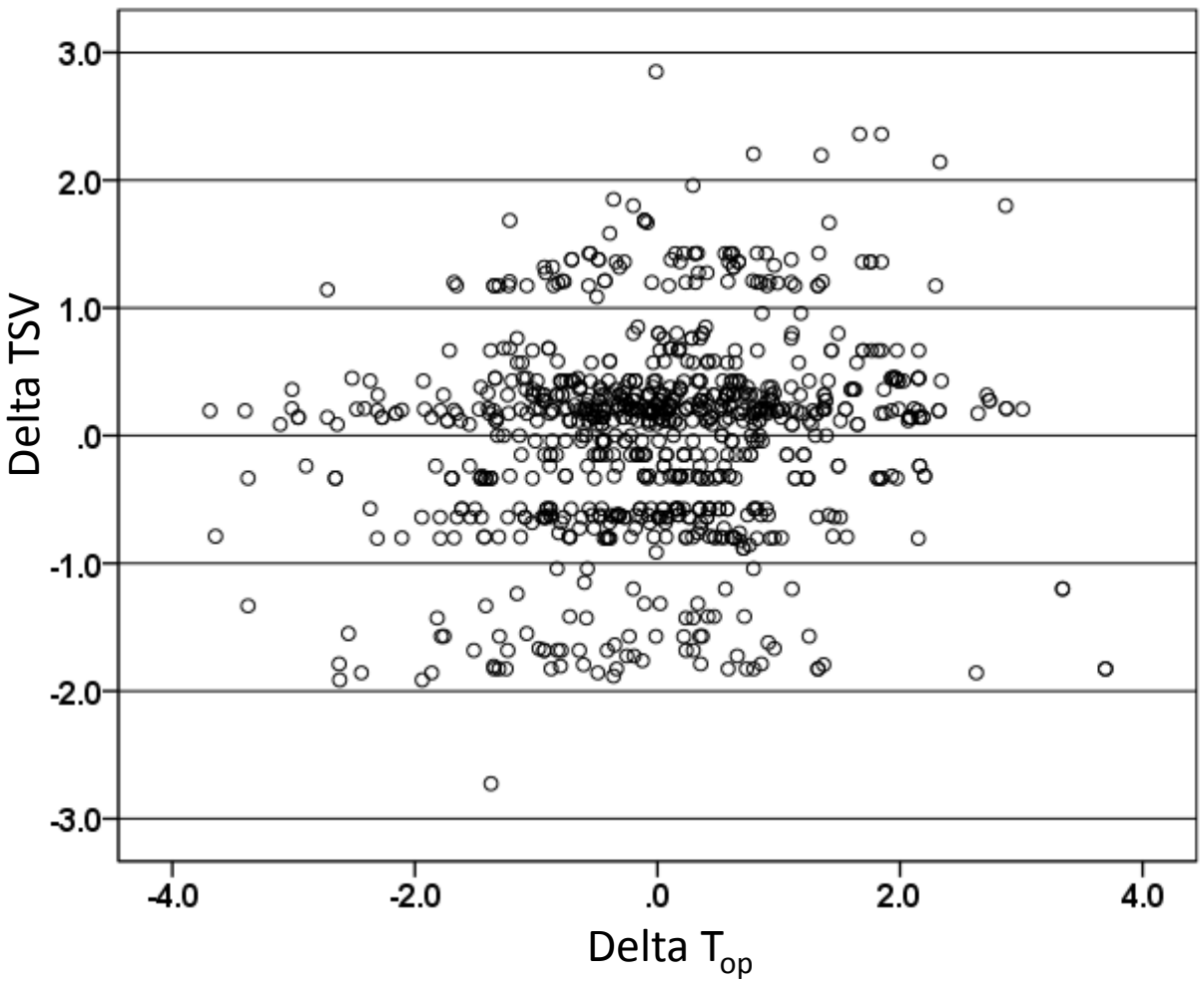
Field survey

- Survey
  - Measurement
    - Environmental
      - Indoor
        - Thermal environment
        - Illumination
        - Sound level
        - Carbon dioxide
      - Transition space
      - Outdoor
        - Air temperature
        - Relative humidity
        - Air velocity and direction
        - Illumination
    - Physiological
      - Heart rate
      - Respiratory rate
      - Blood pressure
      - Finger temperature
  - Questionnaire
    - Background information
    - Thermal comfort

Adaptive models



Adaptive models – Based on EN15251



- For each day-survey, the following equations were used to calculate two new variables(delta Top and delta TSV)

$$\mathrm{deltaT_{op}} = \mathrm{T_{op}} - \mathrm{avg}(\mathrm{T_{op}})$$

$$\mathrm{deltaTSV} = \mathrm{TSV} - \mathrm{avg}(\mathrm{TSV})$$

- Pooling all surveys and making a regression analysis between delta Top and delta TSV , the gradient b was **0.103**

- Adjusting the gradient by the following equation, and the adjusted gradient was 0.13.

$$b_{adj} = \frac{b\left(\sigma_{top}^2\right)}{\sigma_{top}^2 - \sigma_{err}^2}$$ [2]

σ_{top}^2 Variance of operative temperature

σ_{err}^2 Error variance of operative temperature

Adaptive models – Based on EN15251

- **Neutral temperature**
  Calculated based on Griffins method.

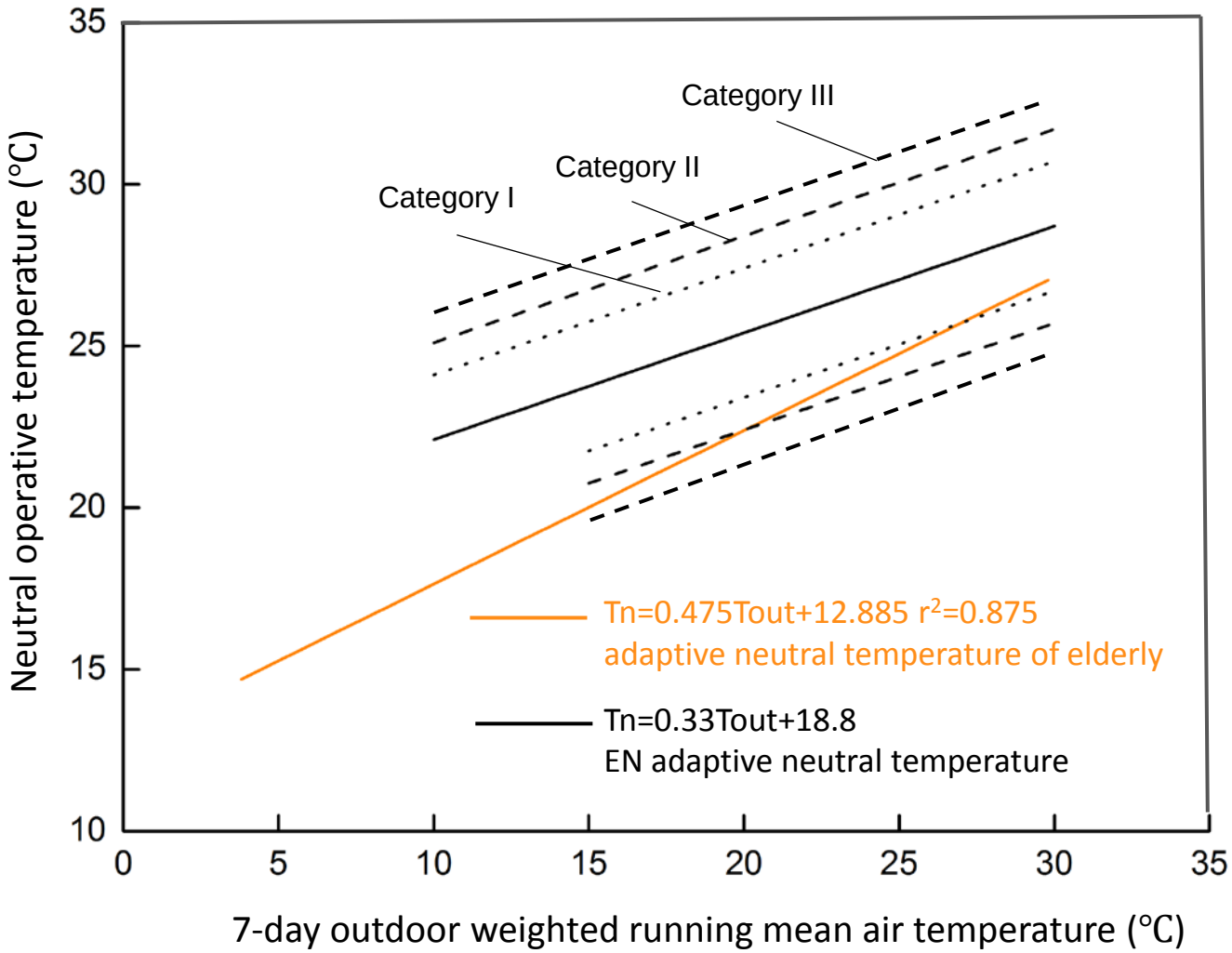
$$T_n = T_{op} - \frac{TSV}{b_{adj}}$$

- **Outdoor Climate**

$$T_{rm} = (t_{ed-1} + 0.8t_{ed-2} + 0.6t_{ed-3} + 0.5t_{ed-4} + 0.4t_{ed-5} + 0.3t_{ed-6} + 0.2t_{ed-7})/3.8$$

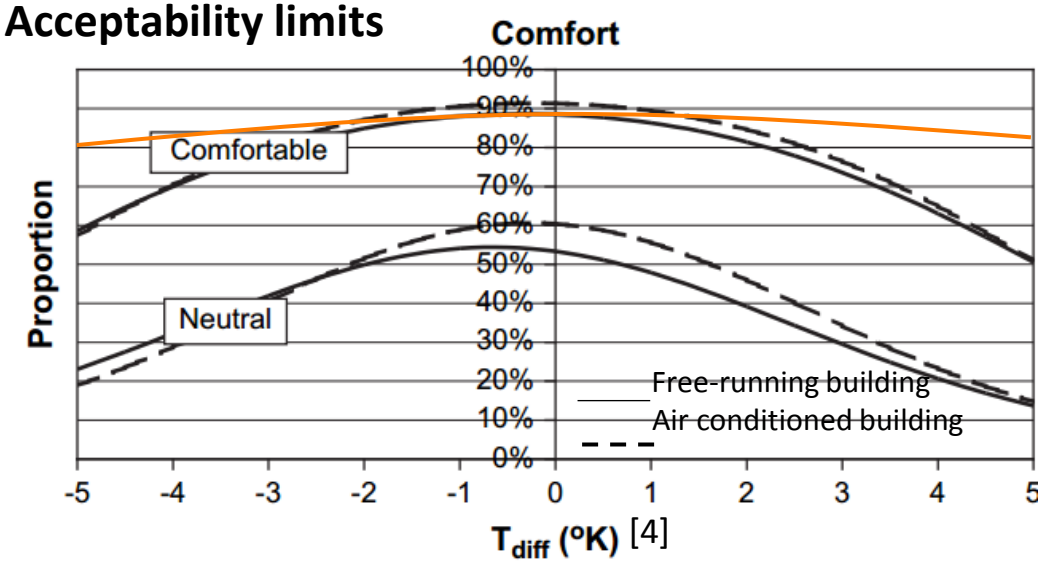
t_{ed-1} is the daily mean external temperature for the precious day

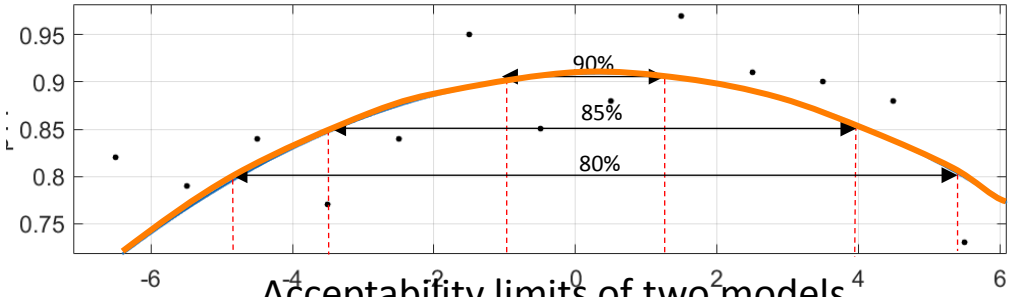
t_{ed-2} is the daily mean external temperature for the day before that.



Adaptive models – Based on EN15251

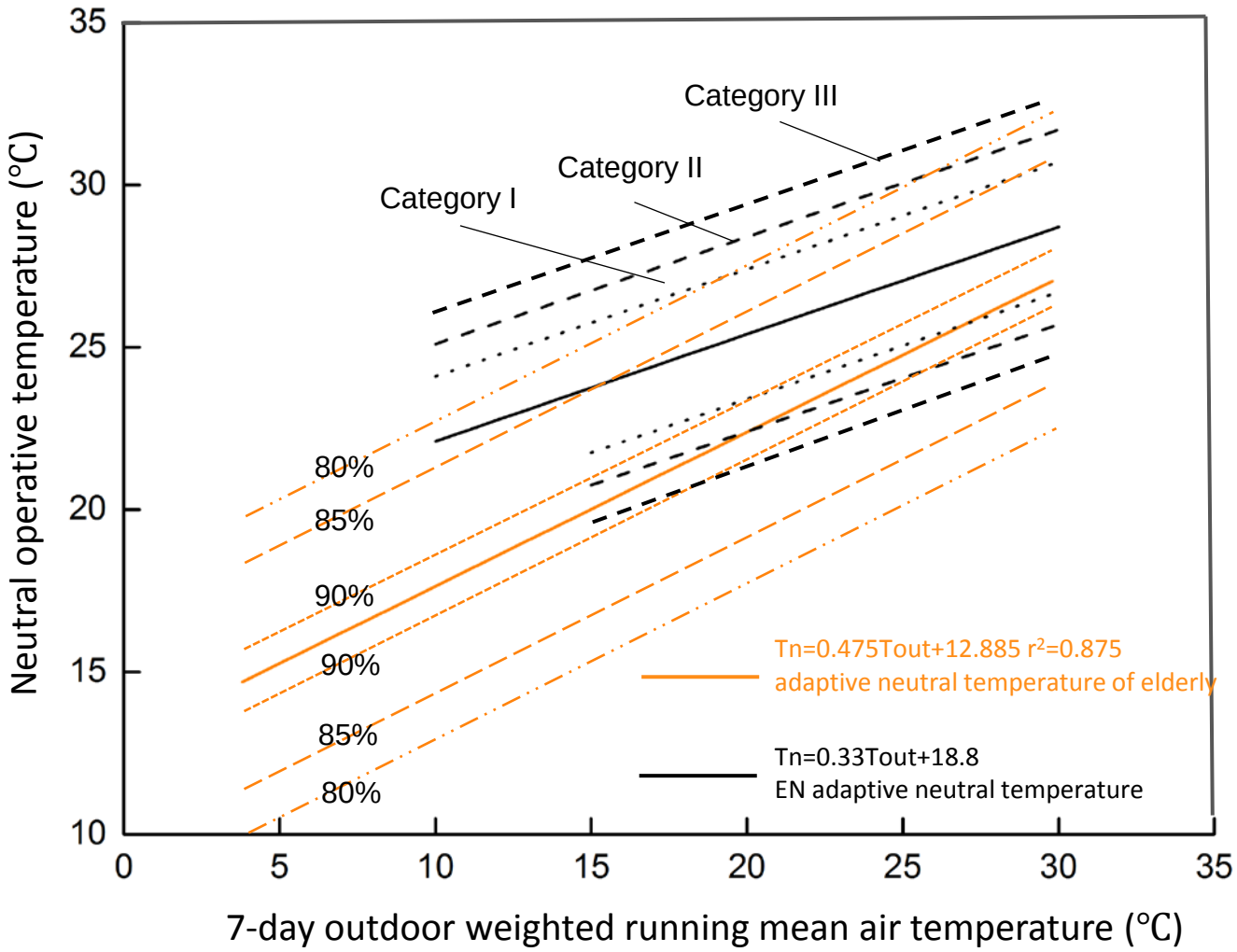
➢ **Acceptability limits**





Acceptability limits of two models

	EN15251	Our model
Category	I- ±2K II-±3K III-±4K	90% - ±1K 85% - ±4K 80% - ±5K



Adaptive models – Based on ASHRAE

- **Neutral temperature**

  Regressions of mean thermal sensation votes(mTSV) on indoor operative temperature (4 of 34 reached P<0.05); solving these 4 regression models for the mTSV=0.

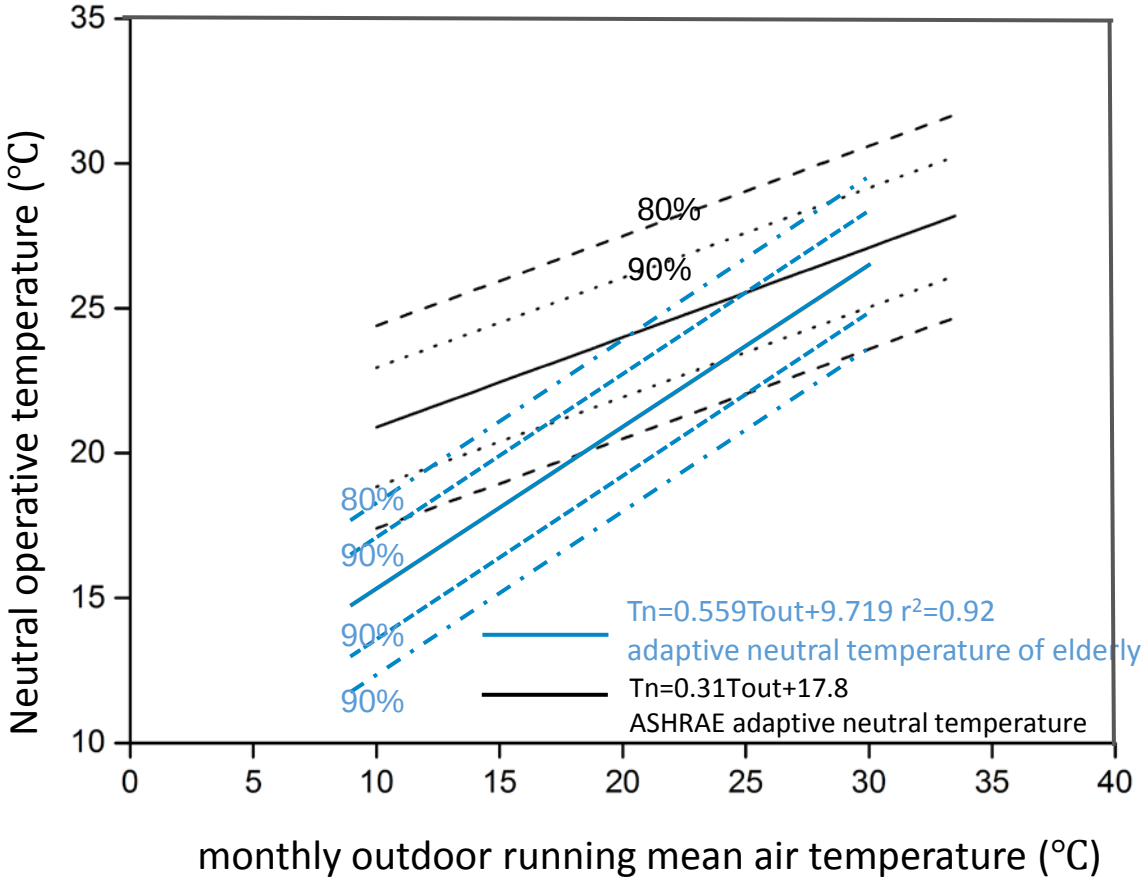
	Winter	Summer	Mid-season
Number of building	11	10	13
Number of buildings with regression models achieving 95% significance	1	2	1

- **Outdoor climate**

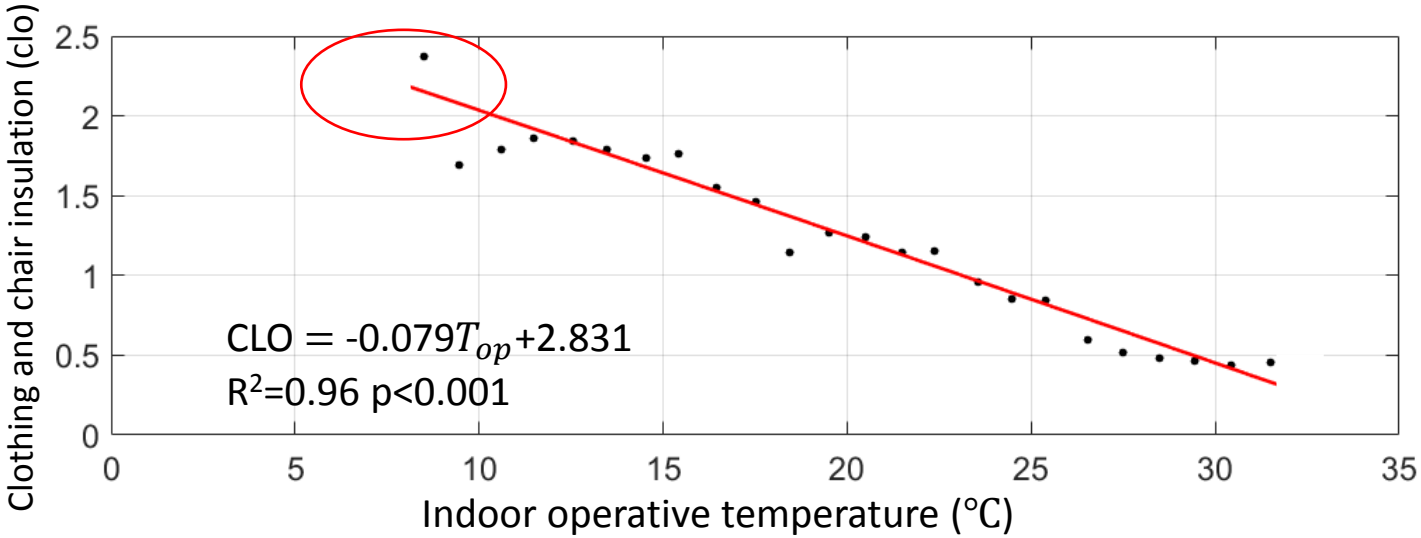
  Defined as monthly arithmetic running mean temperature.

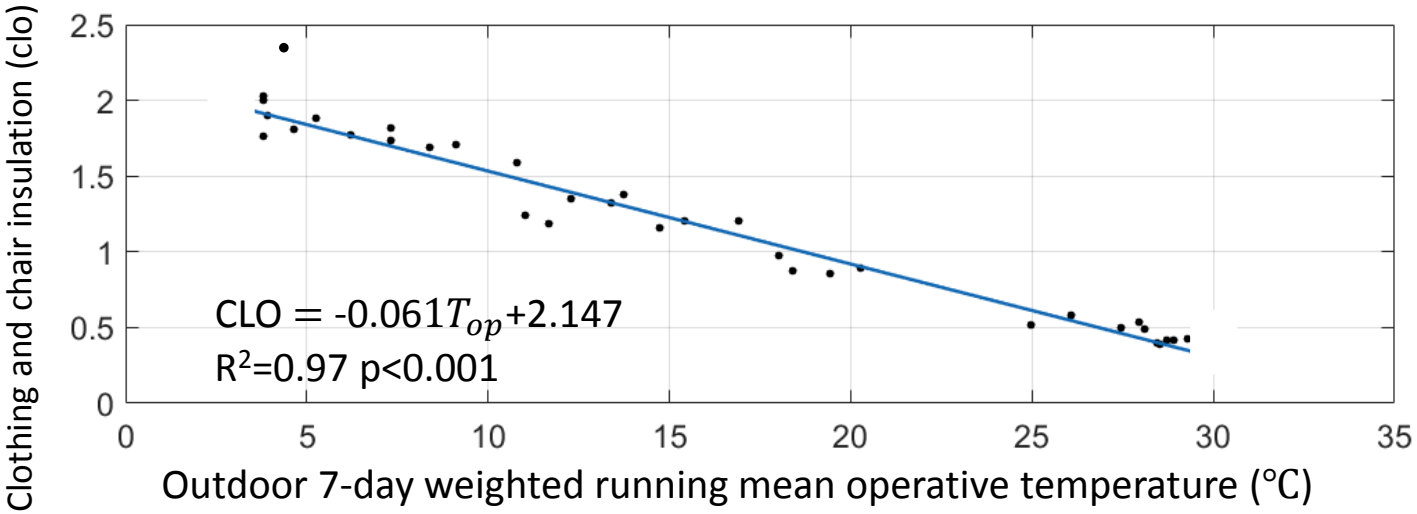
- **Acceptability limits**

  90%(ΔATSV=±0.5) and 80%(Δ ATSV =±0.85) acceptability limits were adopted and the corresponding range were ±1.73K and±2.94K.



Adaptive adjustments – Clothing insulation

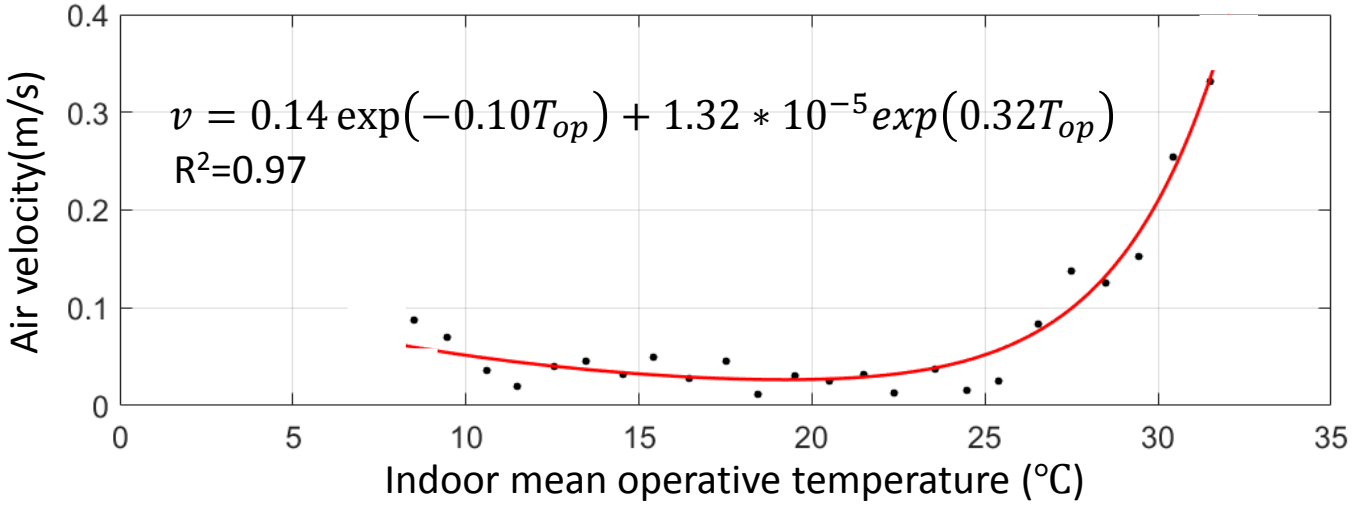


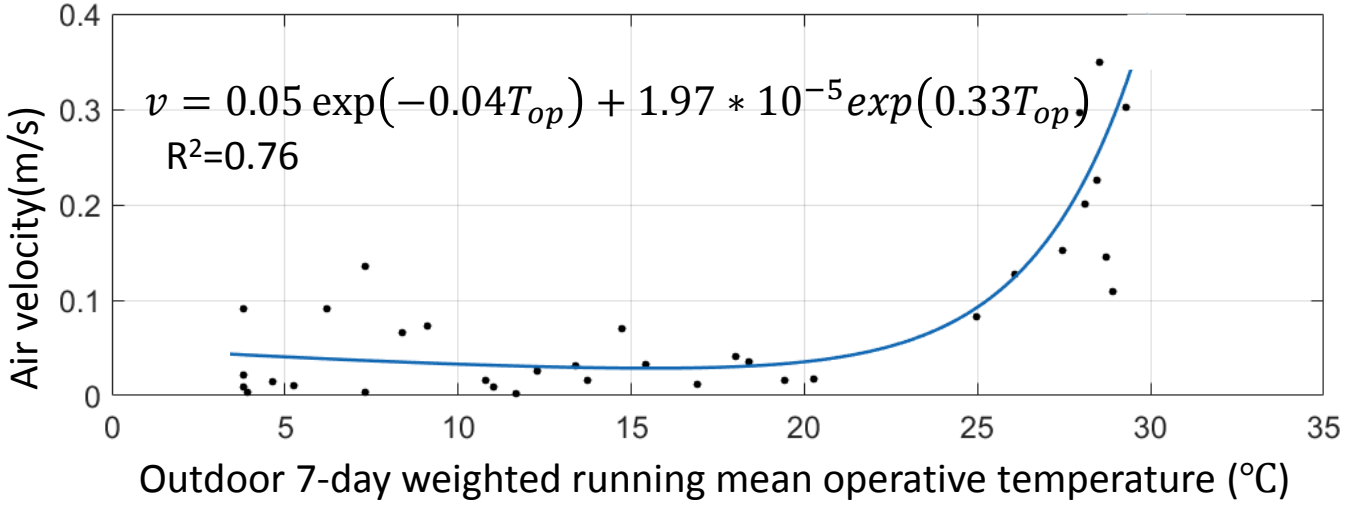


- Clothing and chairs insulation were recorded during surveys and converted into clo units according to ASHRAE standard 55.
- Weighted trend lines for clothing in relation to the indoor operative temperature and outdoor weighted running mean operative temperature were calculated.
- Average values of insulation in each season were significantly different (P<0.05) , and the values are listed in the following table.

	Winter	Summer	Mid-season
Mean (clo)	1.83	0.48	1.19
S D	0.32	0.13	0.31

Adaptive adjustments – Air velocity





- Using air speeds to quantify elderly's adaptive behaviors of opening windows and usage of fans.
- Weighted exponential trend lines for air velocity in relation to the indoor operative temperature and outdoor weighted running mean operative temperature were calculated.
- Average values of air speed in each season are significantly different (P<0.05) , and the values are listed in the following table.

	Winter	Summer	Mid-season
Mean (m/s)	0.046	0.202	0.024
S D	0.05	0.17	0.045

Conclusions

(1) Two adjusted adaptive thermal comfort models were proposed ,based on EN15251 and ASHRAE Standard 55.However,for the elderly in shanghai, it is more suitable to built a adaptive comfort model following EN 15251.

(2) A new Griffins constant (0.12) is derived from our data, which is smaller than the value (0.5) EN15251 suggested . It indicates elderly in shanghai have less thermal sensitivity than the subjects of EN adaptive model.

(3) Under the same range of outdoor climates, elderly always show lower neutral temperatures and wider acceptability range than the values derived from EN15251, which indicates elderly in shanghai are more tolerant of the local environment and more adaptive to cold and mild climate.

References

[1] Shanghai Research Center On Aging, 2005-2016 Report on the development of shanghai old age program.

[2] M.A. Humphreys, H.B. Rijal, J.F. Nicol, Updating the adaptive relation between climate and comfort indoors; new insights and an extended database, Build.Environ. 63 (2013) 40-55

[3] "中国地面国际交换站气候标准值月值数据集" (in Chinese). China Meteorological Administration. Retrieved 2014-06-11

[4] Fergus Nicol ,Michael Humphreys. Derivation of the adaptive equations for thermal comfort in free-running buildings in European standard EN15251 .Build.Environ. 45 (2010) 11-17

Thanks for your attention!

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