

The independent association of overweight and obesity with breathlessness in adults. A cross-sectional, population-based study.

Authors

David C Currow, Eleonora Dal Grande, Calvin Sidhu, Magnus Ekström, Miriam J. Johnson

David C Currow*

- ImPACCT, Faculty of Health, University of Technology Sydney, Ultimo. New South Wales. Australia. 2007
- Wolfson Palliative Care Research Centre, University of Hull, Hull. England. HU6 7RX
- david.currow@uts.edu.au

Eleonora Dal Grande

- Population Research and Outcomes Studies Unit, Discipline of Medicine, Health Sciences Faculty, The University of Adelaide. Australia.
- eleonora.dalgrande@adelaide.edu.au

Calvin Sidhu

- Concord Repatriation General Hospital, New South Wales, Australia
- caljitsid@gmail.com

Magnus Ekström

- Department of Respiratory Medicine and Allergology, Institution for Clinical Sciences, Lund University, Sweden
- pmekestrom@gmail.com

Miriam J. Johnson

- Hull York Medical School, University of Hull, Hull. England
- Miriam.Johnson@hyms.ac.uk

*corresponding author

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Introduction

Obesity and overweight are significant worldwide health problems with a rapidly rising prevalence. [1] Obesity and overweight have serious consequences: higher rates of metabolic syndrome, diabetes, cardiovascular and cerebrovascular diseases; joint disorders; and sleep problems.

Breathlessness is common in the general adult population with one study showing that nearly one in ten had experienced breathlessness sufficient to limit exertion for at least three out of the previous six months. [2] Factors contributing to the subjective sensation include respiratory, cardiovascular, and neuromuscular disorders. The most frequently attributed underlying aetiology is respiratory disease secondary to smoking. [3]

Obesity / overweight and breathlessness share important features: life-style factors, prevalence; and cycles of decreasing function leading to deconditioning creating synergistic detriment. While the physiological mechanisms of breathlessness in overweight / obese adults are unclear, the combination of changes in ventilatory drive and pulmonary mechanics are likely contributory. [4]

Understanding the relationship between breathlessness and obesity / overweight is the first step to improving people's clinical management. The aim of this study was to determine whether obesity / overweight were independently associated with breathlessness in community-dwelling adults. The null hypothesis was that there was no relationship between body mass index (BMI) and breathlessness.

Methods

Sample

Data were collected using two years of the South Australian Health Omnibus Survey (HOS), [5] a multi-stage, systematic, clustered area sample of households conducted face-to-face annually in Spring in participants' homes. Australian Bureau of Statistics (ABS) census collector districts (CCDs) were randomly selected from Adelaide and country towns >1,000 people. Within each CCD, a random starting point was selected and 10 properties identified using a fixed skip interval.

One person in each household was interviewed by trained interviewers after an introductory letter was sent. Each respondent was asked if he/she had “experienced breathlessness most days for more than three months in the last six months”. The survey used the modified Medical Research Council Scale (mMRC) [6] to assess the level of exertion needed to induce breathlessness, a tool suitable for assessing breathlessness in obese people. [7, 8] Existing evidence also establishes a correlation between mMRC and expiratory reserve volume (ERV), forced expiratory volume in 1 second (FEV₁) and 6 minute walking test (6MWT) distances. [7]

Body mass index (BMI) used self-reported height and weight, coded into four World Health Organisation (WHO) categories (normal weight (BMI 20-25kg/m²); overweight (>25-30kg/m²); obese (>30-35kg/m²; and severe (>35-40kg/m²) /morbid obesity (>40kg/m²)). [9] Adults with a BMI <20 were excluded, given the greater likelihood that other pathologies account for these levels.

Statistical analyses

Data were analysed using Statistical Package for Social Sciences (SPSS) Version 23.0 and Stata Version 13. Data were weighted for population estimates (five year age group; sex; rurality (metropolitan / non-metropolitan); household size) to the ABS’ 2005 Estimated Residential Population for South Australia.

Univariable analyses compared the proportion of respondents by socio-demographic factors in three breathlessness groups (mMRC 0; 1; ≥2) and the four WHO weight ranges. No data were imputed. Multinomial logistic regression models had mMRC group as the dependent variable exploring BMI groups, and adjusting for age group, sex and smoking status. None of the interaction terms considered (age/sex, BMI/sex and BMI/smoking) was significant and therefore not included.

Ethical approval was obtained from the South Australian Department of Health’s Ethics Committee. Respondents gave verbal informed consent. This paper uses Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. [10]

Results

Participation was 5480/8377 (65.4%) of people contactable: 314 people were <18 years; 552 did not report height or weight; 291 had a BMI <20; 2 did not have a breathlessness score, leaving 4321 respondents: 2214/4321 (52.3%) were male; mean age 47.9 years (SD 17.4; median 47.0; range 18-95; 19.9% of respondents were smokers. mMRC grades 2-4 were reported by 109 respondents (2.5%; grade 2 (n=58), 3 (n=41) and 4 (n=10)); and BMI 20-25 (n=1708); >25-30 (n=1587); >30-35 (n=1028); and >35 (n=301 (of whom 101 were morbidly obese)). Respondents aged 18 years and over who did not report their height or weight (n=552) were more likely to be female, in the youngest and oldest age strata, and have moderate to severe levels of breathlessness.

Mean BMI was 27.2 kg/m² (SD 5.1; median 26.1; range 20.0-65.4): for respondents with an mMRC 0, mean BMI was 27.1 (SD 5.0); mMRC 1, mean BMI was 28.6 (SD 5.5) and mMRC 2-4, the mean BMI was 29.2 (SD 7.4). As BMI increases, so does the prevalence and severity of breathlessness (mMRC ≥1, BMI > 25; normal weight 6.8%; overweight 11.2%; obese 12.4% and severe/morbid obesity 16.6%; p<0.0001; Figure 1).

In the adjusted multi-variable analysis, people with obesity, severe or morbid obesity were twice as likely as respondents with a normal BMI to have an mMRC score of 2-4 (OR 2.05 (95%CI 1.22, 3.43; p <0.0001)) and for severe/morbid obesity, this rose to OR 3.53 (95%CI 1.87, 6.63; p<0.0001).

Discussion

This population-based study of community-dwelling adults establishes a strong and significant association between increasing BMI and breathlessness related to exertion, and builds on methodologies that have explored this association. [11, 12, 13] Rising rates of obesity / overweight may lead to increased absolute numbers of people with breathlessness and an increasing proportion of people with breathlessness will have obesity / overweight as a contributing factor.

The improvements in breathlessness, lung volumes, inspiratory and expiratory muscle strength, and decreased respiratory drive often observed following weight loss confirm the role of obesity / overweight in breathlessness. [4, 14] Uniquely, this study uses a description of breathlessness over a defined time-frame, and includes the whole adult population rather than sub-groups limited by age or diagnosis.

Obesity has multiple detrimental effects on the respiratory system which contribute to breathlessness:

- decreased expiratory reserve volume (ERV);
- decreased functional residual capacity (FRC);
- greater reliance on intercostal muscles rather than diaphragm;
- decreased diffusion capacity;
- reduced lung compliance;
- a higher likelihood of sleep disordered breathing;
- decreased total lung capacity (TLC); and
- increased residual volume (RV). [15, 16, 17, 18]

Importantly, weight loss in this setting has led to improved ERV, RV, FRC and TLC, making weight loss a specific therapeutic goal in this setting. [15]

Breathlessness, persisting despite optimal treatment of the underlying pathophysiology and resulting in disability, has recently been suggested as a clinical syndrome in its own right: *chronic breathlessness syndrome*. [19] Any relationship between *chronic breathlessness syndrome* and obesity-related breathlessness needs to be debated.

Overweight / obesity is an independent risk factor only for the other factors included in the current model. These data likely under-estimate the magnitude of the association given that people with more severe breathlessness were less likely to provide height and weight when surveyed.

Future research

Given the impact of overweight and obesity on other clinical factors such as heart failure which were not available in this community survey and which will contribute to breathlessness, further modelling needs to include physician-diagnosed clinical factors. For some people, breathlessness may lead to less exertion and weight gain; for others weight gain leads to increasing breathlessness and less exertion; or for some people, both factors may be at play from the outset.

Given evidence that breathlessness can be lessened with weight loss in the setting of obesity / overweight, further studies to explore how breathlessness changes with weight loss with and

without cardiac conditioning would enhance our understanding of the relationship between obesity / overweight and breathlessness.

Implications for practice

The rapid rise in the prevalence and disease burden of obesity is concerning. [20] These data on breathlessness provide another reason to reverse urgently these population trends. Obesity / overweight are independently associated with more severe self-reported physical activity-related breathlessness, building on previous population-based evidence. [11, 12, 13] For people with breathlessness, assessment of BMI should be part of good clinical care. Given evidence that weight loss can improve a range of respiratory parameters, weight loss should be considered a therapy for breathlessness in relevant patients and exertion-induced breathlessness addressed as part of exercise and lifestyle programmes. [15]

References

1. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study. *Lancet* 2013; 384(9945):766-81.
2. Currow DC, Plummer JL, Crockett A, Abernethy AP. A community population survey of prevalence and severity of dyspnea in adults. *J Pain Symptom Manage* 2009;38(4):533-45.
3. Johnson M, Bowden J, Abernethy AP, Currow DC. To what causes do people attribute their chronic breathlessness? A population survey. *J Palliat Med* 2012; 15(7):744-750.4.
4. Parameswaran K, Todd DC, Soth M. Altered respiratory physiology in obesity. *Can Respir J* 2012; 13 (4): 203-210.
5. Taylor AW, Dal Grande E, Wilson DH. The South Australian Omnibus Survey 15 years on: has public health benefited? *Public Health Bulletin* 2006; 3:30-2
6. Bestall JC, E A Paul, R Garrod, R Garnham, P W Jones, J A Wedzicha. Usefulness of the Medical Research Council (MRC) dyspnoea scale as a measure of disability in patients with chronic obstructive pulmonary disease. *Thorax* 1999; 54:7 581-586
7. Launois C, Barbe C, Bertin E et al. The modified Medical Research Council scale for the assessment of dyspnea in daily living of obesity: a pilot study. *BMC Pulm Med* 2012; 12: 61.
8. Gerlach Y, Williams MT, Coates AM. Weighing up the evidence – a systematic review of measures used for the sensation of breathlessness in obesity. *Int Jour Obes* 2013; 37: 341-349.
9. World Health Organisation. Obesity: Preventing and managing the global epidemic. Report of a WHO Consultation (WHO Technical Report Series 894) 2000;

http://www.who.int/nutrition/publications/obesity/WHO_TRS_894/en/ (accessed 24 March 2016)

10. Von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. Strengthening of Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Prev Med* 2007; 45(4):247-51.
11. Zutler M, Singer JP, Omachi TA, Eisner M, Iribarren C, Katz P. Relationship of obesity with respiratory symptoms and decreased functional capacity in adults without established COPD. *Prim Care Respir J* 2012; 21(2):194-201
12. Sin DD, Jones RL, Man SF. Obesity is a risk factor for dyspnea but not for airflow obstruction. *Arch Intern Med* 2002;162(13):1477-81.
13. Bowden JA, To T, Abernethy AP, Currow DC. Predictors of chronic breathlessness: a large population study. *BMC Public Health* 2011;11(1):33.
14. Littleton S. Impact of obesity on respiratory function. *Respir* 2012; 17: 43-49.
15. El-Gammal H, Khayat A, Shikora S. Relationship of dyspnea to respiratory drive and pulmonary function tests in obese patients before and after weight loss. *Chest* 2005; 128 (Dec): 3870-3874.
16. Costa D, Barbalho MC, Miguel GPS et al. The impact of obesity on pulmonary function in women. *Clinics (Sao Paulo)* 2008; 63: 719-724.
17. Jensen D, Ofir D, O'Donnell D. Effects of pregnancy, obesity and aging on the intensity perceived breathlessness during exercise in healthy humans. *Resp Physio and Neurobio* 2009; 167: 87-100.
18. Lin CK, Lin CC. Work and breathing and respiratory drive in obesity. *Respir* 2012; 17: 402-411.

19. Johnson MJ, Yorke J, Hansen-Flaschen J, Lansing R, Ekström M, Similowski T, Currow DC. Towards an expert consensus to delineate a clinical syndrome of chronic breathlessness. *Eur Resp J* 2017 49: 1602277; DOI: 10.1183/13993003.02277-2016
20. The GBD Obesity Collaborators. Health Effects of Overweight and Obesity in 195 Countries over 25 Years. *N Engl J Med*; DOI: 10.1056/NEJMoa1614362.

