Respiratory Medicine 131 (2017) 199–204

Contents lists available at ScienceDirect

Respiratory Medicine

journal homepage: www.elsevier.com/locate/rmed

The association between anthropometric measures and lung function in a population-based study of Canadian adults

A. Rowe [a], P. Hernandez [b], S. Kuhle [c], S. Kirkland [d, *]

[a] Dept. of Community Health and Epidemiology, Dalhousie University, Canada
[b] Dept. of Medicine, Dalhousie University, Canada
[c] Dept. of Pediatrics and Obstetrics & Gynaecology, Dalhousie University, Canada
[d] Dept. of Community Health and Epidemiology, Dalhousie University, Centre for Clinical Research, Room 423, 5790 University Ave, Halifax, Nova Scotia B3H 1V7, Canada

A R T I C L E I N F O

Article history:
Received 21 February 2017
Received in revised form
27 August 2017
Accepted 30 August 2017
Available online 1 September 2017

Keywords:
Pulmonary function
Epidemiology
Population-based
Body composition
Spirometry

A B S T R A C T

Background: Decreased lung function has health impacts beyond diagnosable lung disease. It is therefore important to understand the factors that may influence even small changes in lung function including obesity, physical fitness and physical activity. The aim of this study was to determine the anthropometric measure most useful in examining the association with lung function and to determine how physical activity and physical fitness influence this association.
Methods: The current study used cross-sectional data on 4662 adults aged 40–79 years from the Canadian Health Measures Survey Cycles 1 and 2. Linear regression models were used to examine the association between the anthropometric and lung function measures (forced expiratory volume in 1 s [FEV_1] and forced vital capacity [FVC]); R^2 values were compared among models. Physical fitness and physical activity terms were added to the models and potential confounding was assessed.
Results: Models using sum of 5 skinfolds and waist circumference consistently had the highest R^2 values for FEV_1 and FVC, while models using body mass index consistently had among the lowest R^2 values for FEV_1 and FVC and for men and women. Physical activity and physical fitness were confounders of the relationships between waist circumference and the lung function measures. Waist circumference remained a significant predictor of FVC but not FEV_1 after adjustment for physical activity or physical fitness.
Conclusions: Waist circumference is an important predictor of lung function. Physical activity and physical fitness should be considered as potential confounders of the relationship between anthropometric measures and lung function.

1. Background

Decreased lung function is a predictor of mortality independent of diagnosed lung disease [1]. There are several known risk factors for decreased lung function such as genetic predisposition, tobacco smoke exposure, environmental or occupational exposure to pollutants, and lack of physical activity [2]. From a clinical and public health standpoint, it is important to understand how these risk factors interrelate to affect lung function, especially those that are potentially modifiable. Obesity is another risk factor for decreased lung function but is less well understood. One way that obesity may affect lung function is through changes in mechanical properties of the respiratory system related to an excess of fat surrounding the rib cage and abdomen, thereby reducing the available volume for the lungs to expand [3]. Body mass index (BMI) is the most commonly used clinical measure of obesity but does not distinguish the distribution of body mass or between fat mass and fat-free mass [4]. Given the mechanism by which obesity is proposed to affect lung function [5,6], body composition measures that assess visceral fat mass such as waist circumference, may be superior to BMI in this context; there is evidence to support this hypothesis [5,7–9]. Also, obesity is inversely related to physical fitness [10], which in turn is positively associated with lung function [11]. Very little is known about the role of physical fitness in the relationship between the obesity and lung function. Therefore, the objective of the current

* Corresponding author.
E-mail address: Susan.kirkland@dal.ca (S. Kirkland).

http://dx.doi.org/10.1016/j.rmed.2017.08.030
0954-6111/© 2017 Published by Elsevier Ltd.

Abbreviation list

BMI	Body Mass Index
CHMS	Canadian Health Measures Survey
COPD	Chronic Obstructive Pulmonary Disease
CPAFLA	Canadian Physical Activity, Fitness, Lifestyle Approach
CV	Coefficient of Variation
FEV_1	Forced Expiratory Volume in the First Second
FVC	Forced Vital Capacity
mCAFT	Modified Canadian Aerobic Fitness Test
MEC	Mobile Examination Centre
R^2	Coefficient of Determination (measure of goodness of fit for a regression line to the data)
SD	Standard Deviation
SF5	Sum of 5 Skinfold Measurements
WC	Waist Circumference

study was to examine the association between anthropometric measures and lung function in a population-based sample of Canadian adults, and to determine if the relationship is independent of physical fitness and physical activity.

2. Methods

2.1. Study design

The study used data from Canadian Health Measures Survey (CHMS) Cycles 1 and 2, a representative, cross-sectional survey assessing indicators of health and wellness in Canadians aged between 6-79 years and 3–79 years for Cycles 1 and 2, respectively [12]. The CHMS consists of questionnaires completed during a household visit as well as a visit to the mobile examination center (MEC). The household questionnaires cover socio-demographic and health information, while at the MEC participants undergo a number of physical measurements (including spirometry, body measurements, and a fitness test). Collection sites for Cycles 1 and 2 were identified through the sampling frame of the Canadian Labour Force Survey and were used as MEC locations. Households were selected within each collection site, using the 2006 Census as a sampling frame. A detailed description of the sampling strategy is included in the survey documentation [12]. Interviews and examinations for Cycles 1 and 2 of the CHMS were performed between 2007-2009 and 2009–2011, respectively. The overall response rates for Cycles 1 and 2 were 51.7% and 55.5%, respectively. Approximately 11,000 persons in total participated in the two cycles of the survey. The present analysis uses data from 4662 individuals who were between the ages of 40–79 years.

As this study is a secondary analysis of data from Statistics Canada, additional research approval was not necessary. The application process, procedures for accessing/analyzing and reporting of Statistics Canada data ensures the privacy and protection of all subjects who participate in the survey. Internationally recognized standards for research involving humans were met and maintained by Statistics Canada through completion of the survey and approval was received from the Health Canada Research Ethics Board.

2.2. Primary outcomes and exposures of interest

The primary outcome was lung function, as measured by forced expiratory volume in the first second (FEV_1) and forced vital capacity (FVC). These values were obtained from spirometry completed at the MEC using Koko spirometers (nSpire Health, Longmont, CO, USA). The largest value of three trials for each measure was included in the data set. No medications were withheld prior to testing. Spirometry was performed according to ATS/ERS standards; further details on the administration of spirometry testing as part of CHMS can be found elsewhere [12,13]. No bronchodilation tests or further lung function measures were obtained in CHMS.

The exposure of interest was anthropometric measures, as estimated by BMI, waist circumference (WC), hip circumference, waist-to-hip ratio, waist-to-height ratio, and sum of 5 skinfolds thickness measurements (SF5). Trained health professionals collected all anthropometric measurements at the MEC. BMI was calculated from measured weight and height. Weight was measured using a calibrated digital scale (Mettler Toledo, Mississauga, ON, Canada) to the nearest 0.1 kg. Standing height was measured using a fixed stadiometer, to the nearest 0.01 cm. The WC measurement was performed based on the Canadian Physical Activity, Fitness, and Lifestyle Approach (CPAFLA) protocol [14] at the mid-point between the bottom of the rib cage and the top of the iliac crest at the end of a normal expiration to the nearest 0.1 cm, while participants were standing and relaxed. Waist-to-height ratio was calculated as WC over height. The SF5 was determined using the five-site method of the CPAFLA protocol [14] with a Harpenden skinfold caliper to the nearest 0.2 mm. Each SF was measured twice and the mean was recorded, provided the measurements were within 0.4 mm. Triceps SF was measured on the midline of the back of the arm at the mid-point level between the acromium process and the tip of the olecranon process. Biceps SF was measured over the biceps at the same level as the midpoint for the triceps. Subscapular SF was measured below the inferior angle of the scapula at an angle of 45° to the spine. Iliac crest SF was measured in the midaxillary line above the crest of the ilium. Medial calf SF was measured at the medial side of the calf at the point of the largest circumference. Body mass index and WC were not measured in pregnant women, and SF measurements were not done on individuals with a BMI $\geq$30 kg/m^2. BMI measurements were categorized into the following groups: underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (>30 kg/m^2) [15]. Waist circumference measurements were categorized into normal, increased risk and substantially increased risk ($\leq$94 cm, >94 cm, >102 cm for males and $\leq$80 cm, >80 cm, >88 cm for females) as per the WHO recommendations for risk of metabolic complications [16]. Hip circumference and SF5 were categorized into tertiles by sex. Waist-to-hip ratio was categorized as above or below/equal 0.9 for males and 0.85 for females, based on WHO recommendations [16]. Waist-to-height ratio was categorized as above or below/equal to the cut-off of 0.5 for both men and women [17].

Physical fitness variables were collected via the Modified Canadian Aerobic Fitness Test (mCAFT) and handgrip strength measurements. The protocol for the mCAFT was extracted from the Canadian Physical Activity, Fitness & Lifestyle Approach Edition 3 [18] and is validated for the measurement of maximum oxygen uptake (VO2 max). mCAFT involved participants repeatedly stepping up and down from a single step, at an increasing rate until their maximal rate/time was achieved, from which their VO2 max was calculated, and this value was used in the analysis. Total handgrip strength was measured using a Smedley III handgrip dynamometer (Takei Scientific Instruments, Japan) and the maximal grip strength of each hand was recorded to the nearest kg. Physical activity was assessed in each participant who was given an Actical activity monitor (Phillips Respironics, The Netherlands) to