Heart, Lung and Circulation (2015) **24,** 573–582
1443-9506/04/$36.00
http://dx.doi.org/10.1016/j.hlc.2014.12.005

ORIGINAL ARTICLE

South African and International Reference Values for Lung Function and its Relationship with Blood Pressure in Africans

Yolandi van Rooyen, MSc [a], Hugo W. Huisman, PhD [a], Aletta E. Schutte, PhD [a], Fritz C. Eloff, DSc [b], Johan L. Du Plessis, PhD [b], Annamarie Kruger, PhD [b], Johannes M. Van Rooyen, DSc [a*]

[a]Hypertension in Africa Research Team (HART), North-West University, Potchefstroom, South Africa
[b]Occupational Hygiene and Health Research Initiative (OHHRI), North-West University, Potchefstroom, South Africa

Received 27 August 2014; accepted 2 December 2014; online published-ahead-of-print 27 December 2014

Background In South Africa respiratory diseases are highly prevalent, with cardiovascular disease being a manifestation. However, international reference values for lung function are commonly used, which may not be appropriate to correctly identify reduced lung function. An inverse relationship exists between lung function and blood pressure (BP) but is not investigated extensively in black South Africans.

Methods We included 2010 Africans from the PURE (Prospective Urban Rural Epidemiology) study (aged > 35 years) in the North West Province. Spirometry was performed and predicted values for forced expiratory volume in one second (FEV_1) and forced vital capacity (FVC) were calculated from South African, European and United States prediction equations.

Results With the exception of the European predicted values, all other predicted mean FEV_1 and FVC were above 80%. South African reference values displayed the highest percentages of the predicted values for FEV_1 and FVC (87.9 and 99.7%, respectively.) BP increased from quintiles five to one for both FEV_1 and FVC, (p for trend <0.001). After adjustment the differences remained ($p<0.05$).

Conclusions South African reference values yielded higher percentages of predicted FEV_1 and FVC values than European and US equations suggesting that South African prediction equations may be more useful when investigating lung function in black South Africans. Elevated BP is related to reduced lung function, highlighting the importance in managing both respiratory- and cardiovascular disease.

Keywords Cardiovascular disease • Ethnicity • Respiratory diseases • Hypertension • Lung function

Introduction

The prevalence of non-communicable diseases (NCDs) including cardiovascular disease (CVD) and respiratory diseases in South Africa is high and accounts for 11% and 3% respectively, of the total NCD mortality in South Africa [1]. The burden of NCDs is also predicted to increase in South Africa if preventive measures are not taken [2].

There are several challenges in estimating the respiratory disease burden in South Africa. Appropriate reference data is

*Corresponding author at: Hypertension in Africa Research Team (HART), North-West University (Potchefstroom Campus), Private Bag X6001, Potchefstroom, 2520, South Africa. Tel.: +27 18 299 2440; fax: +27 18 299 1053, Email: johannes.vanrooyen@nwu.ac.za

vital and unsuitable reference equations as well as inaccurate interpretation may lead to over- or under diagnosis [3]. In South Africa where the mining industry is prominent and a large number of the population still use open fires for food preparation and as a heating source, the accurate assessment and prediction of lung function should be highlighted. South African prediction equations are available [4,5] but are seldom used since it is not included in the software packages of commercial spirometers. Instead, European reference equations have largely been used in South Africa. However, it has been described that populations from southern Africa display a lower forced vital capacity (FVC) as well as forced expiratory volume (FEV_1) when compared to Europeans [6] and a recent study conducted by Quanjer et al., [7] confirmed these findings. To account for this, the South African Thoracic Society (SATS) proposed that a correction factor of 0.9 be utilised for black South Africans when European prediction equations are being used [8].

Reduced lung function poses significant extra pulmonary effects, with one of the best recognised manifestations being accompanying cardiovascular disease [9]. This is especially notable in patients with chronic obstructive pulmonary disease (COPD) where it has been shown that even moderate reductions in expiratory flow volumes elevate the risk for CVD two- to three-fold [10–13]. An inverse relationship between lung function and blood pressure has been reported in several studies [14–17]. Although the mechanism underlying this relationship remains unclear, it has been shown that individuals with reduced lung function have higher levels of C-reactive protein, fibrinogen and other systemic inflammatory markers when compared to those with normal lung function [18,19]. Since low-grade systemic inflammation is associated with vascular dysfunction, reduced lung function poses as a risk factor for cardiovascular morbidity and mortality [20].

We therefore aimed firstly to compare the prediction values from three different reference populations namely European, US and South Africa, in a large sample of black South Africans (n=2010); and secondly to establish whether lung function is associated with blood pressure in these participants.

Material and Methods

Study Design and Subject Selection

This study is embedded in the South African leg of the Prospective Urban and Rural Epidemiology (PURE) study, taking place in the North West Province. This is a prospective study of which baseline data was collected in 2005. PURE was designed to investigate lifestyle changes and health status of populations from numerous developing countries [21,22].

In the North-West province of South Africa, a total of 2010 volunteers aged $\geq$ 35 years were included from 6000 randomly selected households – equal numbers from rural and urban settings.

Approval was obtained from the Ethics Committee of the North-West University, Potchefstroom, South Africa. Permission to conduct the study in the above-mentioned communities was granted by the Provincial Department of Health, community leaders, tribal chiefs, and mayors. The protocol was explained to the subjects in their home language by field workers and they were given the opportunity to ask questions. Confidentiality and anonymity of all the results were assured by making use of anonymised numbers. Participants received remuneration for travelling expenses during the study and were referred to clinics if any pathology was noticed.

Questionnaires

The subjects were interviewed by extensively trained field workers using structured demographic, socio-economic, lifestyle and physical activity questionnaires, developed and standardised for the international PURE study and adjusted for each country [21]. Lifestyle data included tobacco use, alcohol intake, health history, and medication use.

Anthropometric and Cardiovascular Measurements

Anthropometric measurements were done under the supervision of a level three anthropometrist and included height (Invicta Stadiometer, IP 1465, Invicta, London, UK) and weight (Precision Health Scale, A&D Company, Tokyo, Japan). The body mass index (BMI = weight (kg) / height $(m)^2$ was also calculated [23].

Cardiovascular Measurements

Brachial blood pressure (BP) was taken by cardiovascular physiologists on the right arm using an automated digital BP monitor (OMRON HEM-757, Omron Healthcare, Kyoto, Japan) after a 10 minute resting period. The subject was sitting in a comfortable position with the right arm rested on a stable surface. The BP measurement was repeated after a five minute resting interval and the mean BP was used for statistical analyses.

Spirometry

Lung function was assessed using a mobile Micro GP Spirometer (Micro Medical Ltd, Kent, UK) according to the American Thoracic Society recommendations [24]. The protocol was explained to participants prior to the assessment. A minimum of three acceptable recordings and a maximum of five were obtained from each participant while in the standing position and with at least 1 minute between repeat measurements. The variables that were analysed were FEV_1 (Forced Expiratory Volume in 1 sec) and FVC (Forced Vital Capacity). Analysis was based on the best measurement for both FEV_1 and FVC out of all measurements obtained from each participant. Published prediction equations from European [7], American [25], and South African [8] populations were used to calculate predicted FEV_1 and FVC values for each participant.