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Determinants of the components of arterial pressure among older adults — The role of anthropometric and clinical factors: A multi-continent study

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Objective: The aim of this study was to evaluate the factors associated with different components of arterial blood pressure in nine nationally-representative samples of people aged ≥50 years. **Methods**: Data were available for 53,289 people aged ≥18 years who participated in the SAGE (WHO Study on global AGEing and adult health) study conducted in China, Ghana, India, Mexico, Russia, and South Africa, and the COURAGE (Collaborative Research on Ageing in Europe) study conducted in Finland, Poland, and Spain, between 2007 and 2012. Standard procedures were used to obtain diastolic and systolic blood pressure (DBP, SBP) measurements to identify hypertensive participants, and to determine mean arterial blood pressure (MAP) and pulse pressure (PP). **Results**: The analytical sample consisted of 42,116 people aged 50 years or older. South Africa had the highest prevalence of hypertension (78.3%), and the highest measurements of MAP ± SD (113.6 ± 36.4 mmHg), SBP ± SD (146.4 ± 49.5 mmHg), and DBP ± SD (97.2 ± 33.9 mmHg). In the adjusted models, dose-dependent positive associations between Body Mass Index (BMI) and MAP or PP were observed in most countries ($p < 0.05$). Diabetes was positively associated with PP in most countries but the association between diabetes and MAP was less consistent. Stroke was associated with both higher MAP and PP in China, Ghana, and South Africa ($p < 0.05$). **Conclusions**: Obesity and diabetes remain important modifiable risk factors for arterial peripheral resistance and stiffness as reflected by MAP and PP respectively. Controlling arterial pressure abnormalities after stroke events may be important for secondary prevention, particularly in developing countries.

1. Introduction

The world is ageing at an unprecedented speed with a parallel increase in non-communicable diseases [1]. Arterial hypertension is an important risk factor for coronary heart disease, cerebrovascular disease, and heart failure. Despite the fact that treating increased arterial pressure leads to a lower risk for cardiovascular diseases

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(CVDs), hypertension remains insufficiently managed in a large proportion of the worldwide population, especially among the elderly [2,3]. In 2009, the World Health Organization (WHO) attributed 13% of all deaths globally to high blood pressure making it an area of prime importance for public health in both developing and developed nations [4]. To date, there have been large variations in the reported prevalence of hypertension, both between and within countries, which may be a reflection of the differences in access to treatment, or health care management policies [4,5], or alternatively due to the variations in study design and methods of measurement.

Most previous studies have focused on the classic definition of hypertension [Diastolic Blood Pressure (DBP), Systolic Blood Pressure (SBP)], without taking into account the complexity of the cardiovascular system [3]. Recently, it has been reported that the use of components of arterial blood pressure measurement [Mean arterial pressure (MAP), pulse pressure (PP)], which differ from the traditional measures (SBP and DBP), provides a broader image in the CVD risk prediction [7]. MAP is a cardiac output and peripheral resistance indicator [7,8], whereas PP reflects the large artery's stiffness, which increases with ageing, particular among individuals over the age of 50, because of the opposing trends in SBP and DBP [9–12]. Data from the U.S. has shown that obesity and diabetes are associated not only with hypertension but also with PP. Moreover, a 10 mmHg increase in PP in adults over 45 years old was associated with a 12% increased risk for CVD death in the NHANES study [13].

Despite evidence regarding the effect of overweight, obesity, and diabetes, on the progression of hypertension [3,14,15] and higher levels of SBP and DBP [16], information about their role in the wider spectrum of arterial blood pressure such as MAP and PP is sparse, particularly for the older population in general, and in the developing country setting. Given the rapid ageing of the global population, the alarming increase in hypertension among adults ≥50 years old both in developing and developed country settings, the complexity of arterial blood pressure, and the lack of global MAP and PP data, the aim of the present study was to evaluate the role of various determinants on different components of arterial blood pressure in nine countries using nationally-representative data from Africa, Asia, Latin America, and Europe. Population data on the components of blood pressure are needed to better understand the effects of various bio-clinical and socio-demographic determinants in vascular health, to set intervention priorities, and to evaluate national health care programmes.

2. Materials and methods

2.1. The SAGE and COURAGE sample

Data from the SAGE (WHO Study on global AGEing and adult health) survey conducted between 2007 and 2010 in China, Ghana, India, Mexico, Russia, and South Africa, and the COURAGE (Collaborative Research on Ageing in Europe) survey conducted between 2011 and 2012 in Finland, Poland, and Spain were analysed. The sample consisted of adults ≥18 years of age with oversampling of those aged ≥50 years. The response rate ranged from 51% (Mexico) to 93% (China). Briefly, the two surveys followed the same protocol and used standardized questionnaires to collect information on health and well-being among adult non-institutionalized populations [3,17]. Nationally-representative samples were generated by multistage clustered sampling. Further details of the two surveys may be found elsewhere [3,17].

All data were collected through face-to-face interviews by trained interviewers, and informed consent was obtained from all participants. If the participant was unable to participate in the survey due to limited cognitive function, information on the participant was obtained through a proxy respondent using a shorter questionnaire. Individuals whose information were collected through a proxy questionnaire were excluded from this analysis as blood pressure measurement was not conducted, and because information on these individuals were not included in the publically available SAGE dataset. The sample size after the exclusion of these individuals was 52,946 (China 14,813; Finland 1934; Ghana 5110; India 11,230; Mexico 2756; Poland 3940; Russia 4355; South Africa 4225; Spain 4583). Sampling weights were generated to adjust for the population structure reported by the United Nations Statistical Division and the census of the National Institute of Statistics for the SAGE and COURAGE respectively. The research review board of each location and the WHO Ethical Review Committee provided ethical approval to conduct the study.

2.2. Evaluation of clinical characteristics

Height and weight were measured with the use of a stadiometre and a routinely calibrated electronic weighting scale respectively. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. BMI was categorized as the following: <18.5 kg/m^2 (underweight), 18.5–24.9 kg/m^2 (normal weight), 25.0–29.9 kg/m^2 (overweight), 30.0–34.9 kg/m^2 (obesity class I), and ≥35.0 kg/m^2 (obesity class II+). Blood pressure was measured 2 and 3 times in the COURAGE and SAGE surveys respectively with a less than one-minute interval using standard protocols. Mean systolic and diastolic pressure were obtained by calculating the mean of all the available measurements. Hypertension was a dichotomous variable and was defined as at least either one of the following: mean systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, and self-reported diagnosis of hypertension. MAP was calculated with the following formula: [(2*diastolic pressure)+systolic pressure]/3. PP was calculated by subtracting the systolic pressure from the diastolic pressure [8,18]. Presence of diabetes and stroke was based on self-report as to whether the participant was ever diagnosed with the conditions.

2.3. Evaluation of dietary habits, socio-demographic and other lifestyle characteristics

Alcohol drinking, fruit and vegetable consumption, physical activity, smoking habit, age, sex, education, marital status, and wealth were evaluated. Alcohol consumption was assessed with the question "Have you ever consumed a drink that contains alcohol (such as beer, wine, spirits, etc.)?" with answer options 'yes' and 'no'. Those who answered 'no' were categorized as 'never' drinkers. A separate question asked about how many drinks of any alcohol beverage the participant had consumed each day of the past week. Those who consumed at least 4 (females) or 5 drinks (males) of any alcoholic beverage per day on at least one day in the past week were considered 'heavy' drinkers. Those who had ever consumed alcohol but were not heavy drinkers were categorized as 'non-heavy' drinkers. Fruit and vegetable consumption were assessed with two separate questions that asked about how many servings of fruit or vegetable the participant consumes on a typical day, and answers were categorized into 0–1, 2–4, ≥5 servings per day. Level of physical activity was assessed with the Global Physical Activity Questionnaire using conventional cut-offs and categorized as low, moderate, and high (http://www.who.int/chp/steps/GPAQ/en/). Information on smoking habits was obtained with two questions: "Have you ever smoked tobacco or used smokeless tobacco?" and "Do you currently use (smoke, sniff or chew) any tobacco products such as cigarettes, cigars, pipes, chewing tobacco or snuff?" Those who answered 'no' to the first question were considered 'never' smokers, and those who answered 'yes' to both