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Research Article

Changing relationship among clinic, home, and ambulatory blood pressure with increasing age

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Abstract

Studies in adults have shown similar levels of home (HBP) and daytime ambulatory blood pressure (dABP), which are lower than clinic blood pressure (CBP) measurements. This study investigated the impact of age on these differences. A total of 642 untreated children, adolescents, and adults referred to a hypertension clinic were evaluated with CBP, HBP, and dABP measurements within 4 weeks (mean age 38.6 ± 19.4 years; range 5–78 years; 61.1% males). In children, dABP was higher than both CBP and HBP. These differences were progressively eliminated with increasing age, and after the age of 30 years, dABP was similar to HBP, and both were lower than CBP. In subjects aged ≥60 years, dABP appeared to be lower than HBP. Age and hypertension appeared to be the main independent predictors of the differences among the three methods.These data suggest that the relationship between office and out–of–office blood pressure measurements is not the same across all age groups and should be taken into account in the evaluation of subjects with elevated blood pressure in clinical practice. J Am Soc Hypertens 2015;9(7):544–552.

Keywords: Adolescents; children; self-measurement; white coat hypertension.

Introduction

White coat and masked hypertension are known to be common among subjects referred for elevated blood pressure (BP).[1–3] For the detection of these phenomena and the optimal decision–making, current guidelines recommend the wide application of out–of–office BP evaluation using self–home measurements (HBP) or ambulatory monitoring (ABP).[1–3]

It is recognized that HBP and daytime ABP (dABP) monitoring give similar systolic and diastolic BP values, which are lower than the conventional clinic BP (CBP) measurements by about 5 mm Hg.[1–3] However, these data have been almost exclusively based on studies in adults aged >40 years, and there is evidence that in younger individuals and, particularly in children and adolescents, this relationship is not the same.[4–6] A meta–analysis of aggregated data from 33 studies demonstrated a progressive change in the relationship among the three BP measurement methods with increasing age, with a different pattern before compared with after the age of 50 years.[7] To date, no study has provided data from a direct comparison of all three BP measurement methods in the same individuals using a standard protocol according to current guidelines and including a wide range of participants from childhood to old age.

The objective of this study was to investigate the relationship among CBP, HBP, and dABP in a wide range of age from childhood to old age, who were referred to a hypertension clinic and therefore are candidates for office and out–of–office BP evaluation.

Methods

Subjects

This is a retrospective analysis of prospective data collected in the context of previous studies conducted

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Conflict of interest: None.

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from 1995 to 2012 in a university hospital hypertension clinic using a standard protocol for CBP, HBP, and ABP measurement.

Consecutive, fully ambulatory, untreated children, adolescents, adults, and elderly, referred for elevated BP who agreed to participate in trials involving CBP, HBP, and ABP measurements as described below, were included. Exclusion criteria were: severe cardiac, renal, or other systemic disease; sustained arrhythmia; evidence of secondary hypertension; any acute illness; use of drugs known to affect BP (excluding aspirin up to 300 mg/d and statins); pregnancy; inability to self–monitor HBP; and unwillingness to participate. In children and adolescents, diabetes mellitus was also a reason for exclusion. Each participant entered the database only once and only if he had complete CBP, HBP, and ABP measurements. The protocol of each one of the prospective studies was approved by the hospital scientific committee, and written informed consent was obtained from all participants and parents for children and adolescents.

BP Measurements

CBP, ABP, and HBP measurements were performed within 4 weeks. CBP was measured in a single study visit by trained physicians who fulfilled the British Hypertension Society Protocol criteria for observers' agreement in BP measurement.[8] Duplicate or triplicate measurements were taken at each visit after 5 minutes of sitting rest and with at least 1 minute between measurements. In the adults, a standard mercury sphygmomanometer was used (inflatable bladder size according to the individuals' arm circumference; Korotkov phase V for diastolic BP, or phase IV when sounds could be heard to 0 mm Hg), or a validated professional oscillometric arm device (Microlife WatchBP Office, Microlife AG, Widnau, Switzerland; inflatable bladder size according to the individuals' arm circumference).[9] In children and adolescents, CBP was taken only using a mercury sphygmomanometer. The average of the first and second reading (for duplicate measurements) or the second and third reading (for triplicate measurements) of the study visit was used in the analysis.

HBP was monitored on six routine work or school days within 2 weeks using validated fully automated electronic arm devices, Omron 705IT,[10] HEM-705CP[11] (Omron Healthcare Europe BV, Hoofddorp, The Netherlands) or Microlife WatchBP Home[12] (Microlife AG) with cuff size according to the individuals' arm circumference. In children and adolescents, the Omron devices 705IT,[13] 705CP,[14] and 711 IS[15] were used because they have been validated in this population. Participants, or their parents for children, were trained in the conditions of HBP measurement and the use of the devices and were instructed to perform duplicate morning (6–10 AM) and evening (6–10 PM) measurements after a 5–minute sitting rest and with 1 minute between measurements. In children, HBP measurements were taken by their parents. A form was supplied to all participants to report their HBP measurements. These data were verified against values downloaded or printed from the devices' automated memory. The average of at least 12 valid HBP readings per participant was used in the analysis.

ABP was monitored on a routine work or school day, before or after the HBP monitoring session, according to the devices' availability and participants' preference. Validated oscillometric devices, Spacelabs 90207[16] or 90217[17] (Spacelabs Inc., Redmond, Washington, USA), or Microlife WatchBP O3[18] (Microlife AG) were used with bladder size according to the individuals' arm circumference and measurements at 20–minute intervals for 24 hours. In children and adolescents, the Spacelabs ABP monitor was used because it has been validated in this population.[19] Subjects were instructed to undergo their usual daily activities, but to avoid strenuous exercise and remain still with their forearm extended during each reading. Daytime and nighttime ABP were defined according to the individual's reported sleeping times. Subjects with fewer than 20 valid awake and/or 7 asleep ABP readings were excluded.[2]

In each individual, before each ABP or HBP monitoring session, the accuracy of the oscillometric devices was tested against a mercury sphygmomanometer by manual activation to ensure that there was no consistent difference of >10 mm Hg in the measured BP (three successive readings; Y–tube connector).

Definition of Hypertension Phenotypes

Normotension was defined as low CBP (average systolic and diastolic $<140/90$ mm Hg for adults, or <95th percentile value by gender, age, and height for children and adolescents[20]) and low ABP (awake $<135/85$ mm Hg and asleep $<120/70$ mm Hg for adults, or <95th percentile by gender and height for children and adolescents[21]). White coat hypertension was defined as elevated CBP (systolic and/or diastolic) with normal ABP (awake and asleep, systolic and diastolic; thresholds as mentioned above). Masked hypertension was defined as normal systolic and diastolic CBP with elevated ABP (asleep and/or awake; systolic and/or diastolic). Sustained hypertension was defined as elevated CBP (systolic and/or diastolic) and elevated ABP (awake and/or asleep; systolic and/or diastolic).

Statistical Analysis

Subjects were divided into seven age subgroups (5–12, 13–17, 18–29, 30–39, 40–49, 50–59, and $\geq$60 years). The Kolmogorov–Smirnov test was used to assess whether the examined variables were normally distributed. In each age subgroup, CBP, HBP, and dABP measurements were compared using repeated measures analysis of variance