Nutrition, Metabolism & Cardiovascular Diseases (2014) **24**, 1052–1056

Available online at www.sciencedirect.com

Nutrition, Metabolism & Cardiovascular Diseases

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

VIEWPOINT

Ambulatory blood pressure monitoring in the elderly: Features and perspectives

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Received 24 February 2014; received in revised form 30 March 2014; accepted 7 April 2014
Available online 18 April 2014

KEYWORDS
Ambulatory blood pressure;
Elderly;
Treatment;
Weight control;
Aging

Abstract Aging leads to a multitude of changes in the cardiovascular system that include a rise in blood pressure. Age-related changes in blood pressure are mainly attributable to an increase in systolic blood pressure, generally associated with a slight decrease diastolic blood pressure. This leads to a widening in pulse pressure. Ambulatory blood pressure monitoring is a useful tool to understand these processes and to refine cardiovascular risk assessment. In the light of emerging data in this area, we reviewed the main features of ambulatory blood pressure in elderly and discussed the evidence showing that ambulatory blood pressure is superior to clinic blood pressure to reflect the true pattern of blood pressure over time. Furthermore, we discussed the role of weight control obtained by fitness programs to prevent an excessive rise in blood pressure with age.

A thorough understanding of these concepts is of paramount importance and has therapeutic implications in the growing population of elderly subjects with increased blood pressure.

Although the diagnosis and management of hypertension are traditionally based on blood pressure (BP) measurements in the clinic or physician's office, non-invasive ambulatory BP monitoring demonstrated a remarkable clinical value in assessing the extent of cardiovascular damage and prognosis [1,2].

A recent meta-analysis of 7030 subjects recruited in several longitudinal studies showed that ambulatory BP is superior to conventional office BP in predicting cardiovascular outcome [3]. Specifically, in multivariate-adjusted continuous analyses, both office and ambulatory BP predicted major cardiovascular events [3]. However, in fully-adjusted models that included both office and ambulatory BP, office BP lost its predictive value, whereas daytime systolic ambulatory BP retained their prognostic significance [3,4].

Moreover, several event-based cohort studies have shown that ambulatory BP refines cardiovascular risk stratification over and beyond other traditional risk factors, including age, sex, target organ damage and associated clinical conditions such as diabetes and kidney disease [1,5].

However, notwithstanding the growing evidence supporting the use of ambulatory BP monitoring for routine clinical practice, the published evidence on ambulatory BP monitoring in the elderly is limited. In this context, the analysis by Maselli and co-workers [6] published in the current issue of the *Journal* adds further data (Table 1) which need to be combined with the previous literature. Briefly, they recruited 80 active elderly subjects (age $\geq$ 65 years, range: 65–85 years) attending healthy fitness

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http://dx.doi.org/10.1016/j.numecd.2014.04.004

Table 1 Main features of the study by Maselli and co-workers [6].

Topic	Results
Ambulatory over office BP	At follow-up examination there were no significant variations in office BP from baseline. Conversely, significant increases in mean 24-h systolic (+5.3 mmHg, $p = 0.001$) and diastolic BP (+1.8 mmHg, $p = 0.018$) were detected.
Age and pulse pressure	Over the study period there was a significant increase in mean 24-h pulse pressure (57.0 ± 11.0 at baseline vs 60.4 ± 11.0 after 3.5 years, $p = 0.002$).
Relationships between weight control, age and BP	The role of weight control to prevent the rise in BP with advancing age was questioned.
Masked hypertension	The prevalence of this condition increased from 8.8% (baseline) to 16.3% (follow-up).

Legend: BP = blood pressure.

programs and analyzed the changes in office and ambulatory BP values over a time-frame of 3.5 years. The goal of analysis was to evaluate the association between age and BP and to explore the effect of weight control to prevent the rise in BP with age. The main hypothesis of the study was that BP increases over time even in active elders as a result of physiological aging processes.

Ambulatory over office BP

Ambulatory BP is intuitively superior to clinic BP to reflect the true pattern of BP during usual daily life [5,7,8]. Compared to office BP measurement, the main advantage of ambulatory BP monitoring is the number of readings obtained throughout a 24-h period [8]. Frequent readings during wakefulness and sleep enable clinicians to obtain a more precise estimation of a patient's BP, to asses BP levels in the outpatient setting, and to study BP variability and circadian BP profile [8].

Moreover, the measurement of BP in the physician's office may trigger an alerting reaction and rise in BP [9]. The transient rise in BP from before to during the visit is usually defined as 'white-coat effect' and a reliable estimate of this phenomenon may be carried out through non-invasive ambulatory BP [10].

Average ambulatory BP levels generally show a weak association with office BP values taken by a doctor or a nurse. For example, if we plot office BP versus the average daytime ambulatory BP, we show that for any given value of office BP, the observed ambulatory BP may vary considerably in either direction from predicted [10].

In this context, the new data provided by Maselli and co-workers [6] indirectly support this notion by showing that office measurements were unable to detect significant changes in BP from baseline to follow-up. Conversely, significant increases in systolic (+5.3 mmHg, $p = 0.001$) and diastolic (+1.8 mmHg, $p = 0.018$) BP could be detected over the subsequent 3.5 years through the use of 24-h ambulatory BP monitoring [6].

Age and pulse pressure

As discussed above, Maselli and co-workers [6] highlighted the point that age is a major determinant of BP. They confirmed that age-related increases in BP are mainly attributable to an increase in systolic BP with a parallel steadiness, or slight decrease, in diastolic BP [11]. This leads to a widening in pulse pressure [11,12] (Fig. 1).

Stiffening of large arteries and decreased arterial compliance are key features of aging which largely account for the changes in pulse pressure that occur from 50 years of age onwards [11,12].

Although the Authors of this analysis [6] documented a significant rise in pulse pressure (change in mean 24-h pulse pressure over the study period: +3.4 ± 9.7 mmHg, $p = 0.002$), such age-related increase was less than expected. Notably, after exclusion of individuals with dementia, serious states of malnutrition, pulmonary disease, malignancies in an active phase and uncontrolled metabolic diseases, this age-related process would be expected to be most prominent in active elderly people who are not subject to the confounding influence of co-morbid illness on BP [13].

These observations suggest that healthy fitness programs may reduce the increase in pulse pressure with increasing age, thus exerting a net cardiovascular benefit.

Although a recent analysis of the International Database of Ambulatory Blood Pressure in Relation to Cardiovascular Outcome (IDACO) [14] involving 9938 participants randomly recruited from general populations (47.3% women) showed that ambulatory pulse pressure is a weak risk factor for cardiovascular complications in elderly, other prospective studies in hypertension clearly demonstrated a significant association between pulse pressure and subsequent rate of cardiovascular morbid events (independently of age) [15–17].

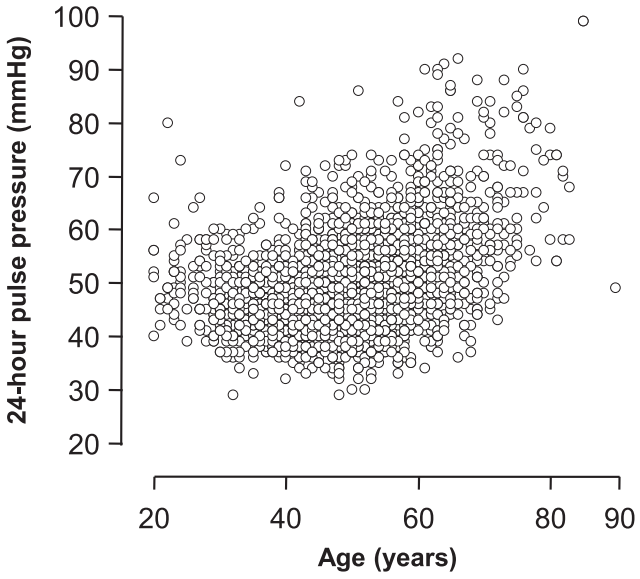

Figure 1 Association between age and ambulatory pulse pressure in 2747 untreated hypertensive patients enrolled in the Progetto Ipertensione Umbria Monitoraggio Ambulatoriale (PIUMA) study. Unpublished data.