

# Reference Values for Clinic Pulse Pressure in a Nonselected Population

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A wide pulse pressure (PP) may constitute an independent predictor of cardiovascular morbidity and mortality. We assessed the reference values of brachial clinic PP, according to age and gender in a nonselected population (61,724 subjects) who were undergoing a routine systematic health examination. According to mean values, 50 mm Hg is likely the reference value for clinic PP in both men and women. Diagnostic thresholds for clinic PP ( $\geq 65$  mm Hg) determined either by adding 2 SD to the means or from the

95th percentiles are in close agreement with clinic PP values previously reported to be associated with increased cardiovascular morbidity and mortality. Am J Hypertens 2001;14:415–418 © 2001 American Journal of Hypertension, Ltd.

**Key Words:** Blood pressure, men, women, pulse pressure, reference values.

**A**ccumulating data support the hypothesis that pulse pressure (PP) may be related to cardiovascular morbid events and thus, may constitute a cardiovascular risk factor, independently of systolic (SBP), diastolic (DBP), and mean (MBP) blood pressures. A wide PP was shown to be a marker of increased conduit vessel stiffness<sup>1–3</sup> and studies have suggested its close association with carotid intima–media thickness, carotid atherosclerosis,<sup>2,4,5</sup> and left ventricular mass.<sup>6</sup> Clinic brachial PP may also be an independent predictor of myocardial infarction<sup>7,8</sup> or congestive heart failure,<sup>9</sup> and appears to be a more accurate predictor of cardiovascular mortality than either SBP or MBP alone in some populations.<sup>10–12</sup>

In these studies, subjects were grouped according to tertiles,<sup>8</sup> quartiles,<sup>10</sup> or quintiles<sup>13</sup> of PP and some of these studies were performed mainly in men<sup>10</sup> or in women,<sup>14</sup> with data suggesting differences in the results between men and women. To our knowledge, normal reference values of PP have not been determined. Therefore, the goal of the present large-scale study was to assess reference values of brachial clinic PP in a general population, according to gender and age.

## Methods

The study population consisted of 61,724 consecutive subjects, 51% men, between 16 and 90 years old, who visited health care centers of the Institut inter Régional pour la Santé (IRSA) in the western center of France,

between February 1995 and September 1996 for a free systematic check-up proposed every 5 years by the French Public Health System (Sécurité Sociale) to its affiliates.

Each subject went through the standard procedure of IRSA and filled in a standardized self-administered questionnaire, which provided data about educational and professional status, smoking habits, and alcohol and drugs consumption. Clinical examination included the anthropometric measurements, weight, height, and waist and hip circumferences. The waist-to-hip ratio (WHR) and the body mass index (BMI) were calculated. Blood pressure and heart rate were obtained in all participants during the medical examination. Blood pressure was recorded using a standardized protocol, according to the World Health Organization recommendations. All the measurements were performed by a trained physician. Blood pressure was measured using a mercury sphygmomanometer with a cuff adapted to the arm circumference with the subject in a supine position, at rest. The cuff was deflated at the rate of 2 mm Hg/sec. Systolic blood pressure was defined as the first regular Korotkoff sound heard and DBP as the last regular sound heard (Korotkoff phase V).

PP was calculated for each subject as the arithmetic difference between SBP and DBP. On arrival, a fasting blood sample was drawn and all measurements were performed on serum at the same central laboratory (Direction Départementale des Affaires Sanitaires et Sociales) agreement number 3221 and validated according to International Standards Organization (ISO) 9001 and ISO 9002

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**Table 1.** Means and percentiles of the clinic PP and means of SBP and DBP according to age in men

Age Range (y)	No. of men	PP (mm Hg)					SBP (mm Hg) (mean $\pm$ SD)	DBP (mm Hg) (mean $\pm$ SD)
		Mean $\pm$ SD	Percentiles					
			25th	50th	75th	95th		
16-20	1894	53 $\pm$ 10	50	60	60	70	127 $\pm$ 11	73 $\pm$ 8
21-25	1838	53 $\pm$ 10	50	50	60	70	128 $\pm$ 11	75 $\pm$ 9
26-30	3267	52 $\pm$ 9	50	50	60	70	128 $\pm$ 11	77 $\pm$ 8
31-35	3934	51 $\pm$ 9	45	50	60	70	128 $\pm$ 12	77 $\pm$ 9
36-40	4277	51 $\pm$ 9	45	50	60	70	129 $\pm$ 12	79 $\pm$ 9
41-45	4393	51 $\pm$ 9	45	50	60	70	132 $\pm$ 13	80 $\pm$ 10
46-50	3989	52 $\pm$ 10	45	50	60	70	134 $\pm$ 14	82 $\pm$ 10
51-55	2452	54 $\pm$ 10	50	50	60	70	137 $\pm$ 14	83 $\pm$ 10
56-60	2005	56 $\pm$ 11	50	55	60	75	139 $\pm$ 16	84 $\pm$ 10
61-65	1142	57 $\pm$ 11	50	55	60	80	142 $\pm$ 17	84 $\pm$ 10
66-70	329	60 $\pm$ 13	50	60	70	80	144 $\pm$ 18	84 $\pm$ 11
>70	172	63 $\pm$ 12	55	60	70	85	148 $\pm$ 15	85 $\pm$ 9
Total	29692	52 $\pm$ 10	45	50	60	70	132 $\pm$ 14	79 $\pm$ 10

PP = pulse pressure; SBP = systolic blood pressure; DBP = diastolic blood pressure.

norms. Serum total cholesterol, triglycerides, and fasting glucose were measured by enzymatic methods adapted to a Dax 24 Technicon (Puteaux, France). The procedures followed were in accordance with institutional guidelines.

### Statistical Analysis

All statistical analyses were run on NCSS 6.0 (Number Cruncher Statistical System, Kaysville, UT). Data are presented as mean  $\pm$  SD and mean values for the 95th percentiles on an age range of 5 years.

### Results

The main characteristics of the subjects (men and women, respectively) enrolled in this study were as follows: age (40.2  $\pm$  12.4 and 39.9  $\pm$  12.8 years), weight (74.3  $\pm$  11.2

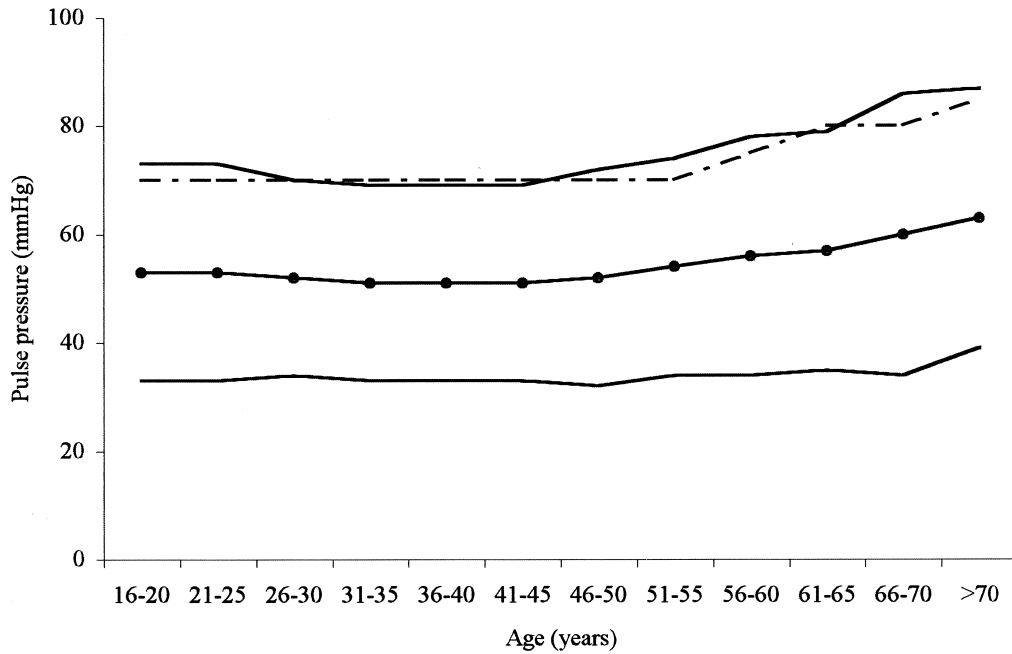
and 60.4  $\pm$  11.0 kg), height (173  $\pm$  7 and 161  $\pm$  6 cm), BMI (24.8  $\pm$  3.5 and 23.4  $\pm$  4.2 kg/m<sup>2</sup>), WHR (0.905  $\pm$  0.072 and 0.779  $\pm$  0.072), heart rate (68  $\pm$  11 and 70  $\pm$  10 beats/min), SBP (132  $\pm$  14 and 125  $\pm$  14 mm Hg), DBP (79  $\pm$  10 and 75  $\pm$  10 mm Hg), MBP (97  $\pm$  10 and 92  $\pm$  10 mm Hg), total cholesterol (2.17  $\pm$  0.42 and 2.09  $\pm$  0.38 g/L), fasting glucose (0.99  $\pm$  0.15 and 0.93  $\pm$  0.13 g/L), triglycerides (1.15  $\pm$  0.97 and 0.83  $\pm$  0.49 g/L), and smokers (30.4% and 20.1%). The age distribution of the population was similar in men and women.

The mean values and the 25, 50, 75, and 95th percentiles of PP, and the mean values of SBP and DBP, according to age and gender are presented in Tables 1 and 2. Mean clinic PP was 52  $\pm$  10 and 49  $\pm$  10 mm Hg in men and women, respectively. In both sexes, the mean clinic PP widened with advancing age, but with an apparent plateau between 16 and

**Table 2.** Means and percentiles of the clinic PP and means of SBP and DBP according to age, in women

Age Range (y)	No. of women	PP (mm Hg)					SBP (mm Hg) (mean $\pm$ SD)	DBP (mm Hg) (mean $\pm$ SD)
		Mean $\pm$ SD	Percentiles					
			25th	50th	75th	95th		
16-20	2502	49 $\pm$ 9	40	50	50	60	120 $\pm$ 10	71 $\pm$ 8
21-25	2475	48 $\pm$ 8	40	50	50	60	120 $\pm$ 10	72 $\pm$ 9
26-30	2874	47 $\pm$ 8	40	50	50	60	119 $\pm$ 11	73 $\pm$ 9
31-35	3789	47 $\pm$ 8	40	50	50	60	120 $\pm$ 11	73 $\pm$ 9
36-40	4340	47 $\pm$ 9	40	50	50	60	121 $\pm$ 12	74 $\pm$ 9
41-45	4818	48 $\pm$ 9	40	50	50	60	124 $\pm$ 13	76 $\pm$ 9
46-50	4229	50 $\pm$ 9	40	50	55	65	128 $\pm$ 14	78 $\pm$ 10
51-55	2494	52 $\pm$ 10	45	50	60	70	131 $\pm$ 15	79 $\pm$ 9
56-60	2025	54 $\pm$ 11	50	50	60	70	134 $\pm$ 15	80 $\pm$ 9
61-65	1218	55 $\pm$ 11	50	55	60	75	137 $\pm$ 16	81 $\pm$ 9
66-70	419	58 $\pm$ 12	50	60	65	80	141 $\pm$ 16	82 $\pm$ 10
>70	233	64 $\pm$ 15	55	60	70	90	146 $\pm$ 19	82 $\pm$ 11
Total	31416	49 $\pm$ 10	40	50	55	65	125 $\pm$ 14	75 $\pm$ 10

Abbreviations as in Table 1.



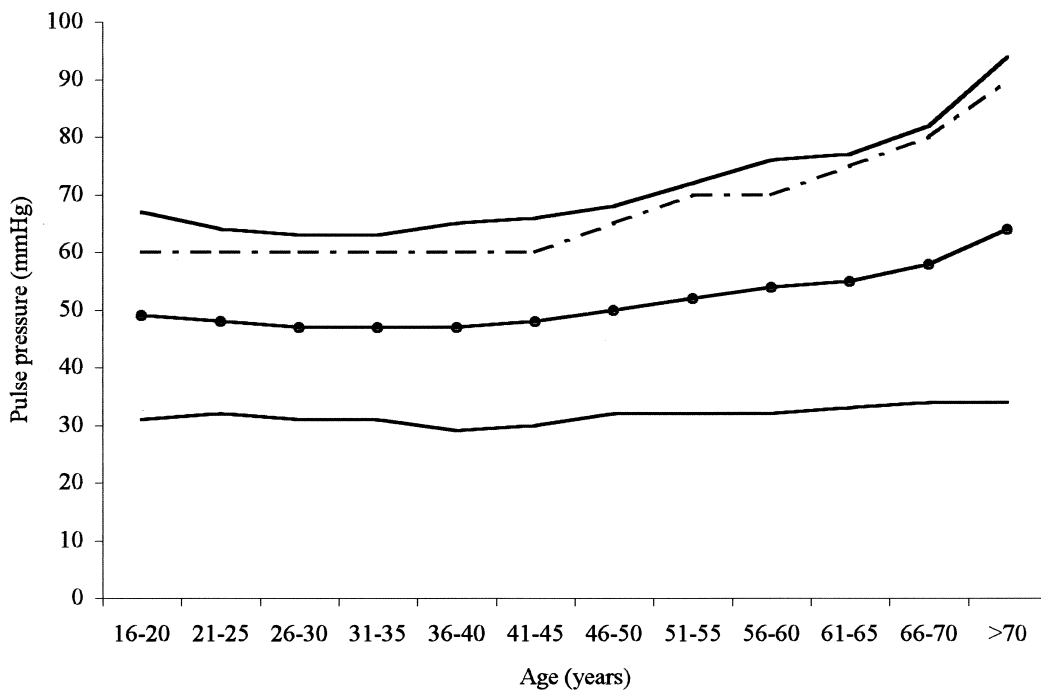
**FIG. 1.** Means, means  $\pm$  2 SD limits, and 95th percentiles (dotted line) of the clinic pulse pressure in men.

50 years of age. This plateau was apparent in men and in women where PP remained stable ( $\Delta \approx 1$  to 2 mm Hg) between 16 and 50 years of age versus an increase of 4 mm Hg per decade in subjects more than 50 years old. Clinic PP was higher in men than in women in the youngest group (<45-year-old). After 45 years of age, the difference between men and women was reduced. The thresholds for clinic PP determined from the 95th percentile (70 and 65 mm Hg in

men and women, respectively) and by adding 2 SD to the means (72 and 69 mm Hg, respectively) were concordant to within 2/4 mm Hg (Tables 1 and 2 and Figs. 1 and 2).

### Discussion

The results of this epidemiologic study showed that clinic PP in a nonselected population averaged 49 and 52 mm Hg, in



**FIG. 2.** Means, means  $\pm$  2 SD limits, and 95th percentiles (dotted lines) of the clinic pulse pressure in women.

women and men, respectively. Because the difference between men and women are within  $\pm 3$  mm Hg, these data suggest that 50 mm Hg may be considered as the normal value of clinic PP. The nonlinear age-dependent increase in brachial clinic PP could be explained by age-dependent differences in amplification of the PP between the aorta and the brachial artery. In younger subjects, there is considerable amplification of the arterial pressure wave between the ascending aorta and the brachial artery, which decreases with age as the arteries stiffen. This phenomenon of decreasing pressure wave amplification in the upper limb has been proposed to explain a steady increase in central aortic PP with age from childhood, but is only apparent in brachial artery recordings from age 40 to 50 onward. Diagnostic thresholds for clinic PP determined either by adding 2 SD to the means or from the 95th percentile of the distribution of the PP were concordant. This threshold ( $\geq 65$  mm Hg) determined in both men and women is in close agreement with clinic PP values ( $\geq 63$  mm Hg,  $\geq 65$  mm Hg,<sup>10</sup> or  $\geq 68$  mm Hg<sup>13</sup>) previously reported to be associated with increased cardiovascular morbidity and mortality. These values, described in the literature and found in the present study, are valid when casual measurement of blood pressure (BP) in clinic is concerned. In fact, using ambulatory BP measurements, lower threshold values have been reported.<sup>1,15</sup> A different hypothesis may be proposed to explain the difference observed between clinic and ambulatory PP values. Among them, the white coat effect may play an important role as values, in our study, were recorded on one visit only. As previously proposed,<sup>15,16</sup> office PP measurement may overestimate the usual levels of PP. In conclusion, until all the prospective evidence becomes available, these preliminary results suggest that 50 mm Hg could be considered as the normal value of clinic PP in both men and women.

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