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Reference values for the ambulatory blood pressure and the blood pressure measured at home: a population study

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Summary: **In order to determine reference values for the ambulatory blood pressure, a population sample of 328 subjects, aged 20–81 years, who reported themselves to be in good health, was investigated. The ambulatory blood pressure was recorded over 24 h, taking measurements at 20 min intervals from 8 am to 10 pm, and at 45 min intervals from 10 pm to 8 am. Blood pressure was also measured by trained observers on each of two separate home visits (5 readings per visit). The ambulatory blood pressure in the 328 subjects averaged 118/71 mmHg over 24 h, 124/76 mmHg during the day (10 am–8 pm), and 108/62 mmHg at night (0 am–6 am). Blood pressure measured by an observer at the occasion of the second home visit was 4/5 mmHg lower ($P<0.001$) than the daytime ambulatory blood pressure. The 95th centiles for the daytime ambulatory pressures were 144/95 mmHg in 85 men below age 50; 154/90 mmHg in 74 men aged ≥50 years; 132/85 mmHg in 96 women below age 50; and 151/91 mmHg in 73 women aged ≥50 years. The 95th centiles for the nighttime pressures in these four sex-age groups were 124/79, 140/83, 121/70, and 132/72 mmHg, respectively.**

Introduction

The use of ambulatory blood pressure measurements in clinical practice is hampered by the scarcity of studies reporting reference values in a representative sample of healthy subjects.[1] In an attempt to determine such reference values, healthy subjects were studied. They were drawn from the general population, and their ambulatory BP was compared with conventional BP measurements obtained at their homes by trained observers.

Methods

Field work

A random sample of the population of a small town was identified. The population of this town had been surveyed in previous population studies,[2–5] but had not yet been systematically screened for hypertension. The sample was stratified for gender and age in an attempt to provide equal numbers of men and women in 10 year age classes from 20 to 79 years inclusive.

The 849 subjects in the sample were visited at home by trained observers. Subjects were excluded from further participation, when they did not live at the indicated address ($n = 111$, of whom 7 had died), when they were taking antihypertensive drugs, diuretics or nitrates

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($n = 131$), or when they could not move about freely ($n = 4$). Of the remaining 603 subjects, 55% ($n = 330$) consented to participate. However, two subjects were removed from analysis, because more than 20% of their ambulatory BP readings were missing.

On each of two home visits, 1 to 2 weeks apart, the same observer measured systolic (SBP) and diastolic (DBP) (phase V) pressures five times consecutively with the subjects in the sitting position. The home BP readings were obtained between 8 am and 9 pm, using an anaeroid sphygmomanometer, calibrated against a mercury column, and a cuff with an inflatable bladder length of 22 cm and a width of 12 cm. In 10 obese subjects, a 54×15 cm cuff was employed. A self-administered questionnaire inquired about the participants' medical history, smoking habits, consumption of alcohol, and intake of medications.

The two observers involved in the study were tested for the accuracy of their BP measurements at six-monthly intervals, as previously described.[3] They had first to record the pressures from a film showing a falling mercury column with Korotkoff sounds (Measuring Blood Pressure, Production N° B-132, The Audio-Visual Centre, University of London, 11 Bedford Square, London WC1, 1973). Thereafter, they were tested using live subjects and stethoscopes with double ear-pieces. The BP readings of the observers were within 5 mmHg compared with those of experienced medical staff.

Ambulatory blood pressure

At the occasion of the first ($n = 155$) or second home visit ($n = 139$), or at a separate home visit ($n = 34$), as most convenient for the subjects, a 24 h ambulatory BP recording was started with the SpaceLabs 90202 monitor.[6] Except in the aforementioned obese men, an inflatable bladder of 22×12 cm was used. The recorders were programmed to obtain a measurement every 20 min from 8 am to 10 pm, and every 45 min for the remainder of the time (50 readings per 24 h).

Statistical Analysis

Unedited ambulatory recordings comprised all BP readings successfully completed by the software of the SpaceLabs recorders. The following exclusion criteria[7,8] were considered prior to analysis: (1) SBP<DBP, or >240 mmHg, or <50 mmHg; (2) DBP>140 mmHg, or <40 mmHg; (3) pulse pressure <10% of SBP; or (4) pulse rate higher >150 bpm, or <40 bpm.

Daytime was defined as the interval from 10 am to 8 pm, and nighttime from midnight to 6 am. These periods corresponded respectively with daytime activity and sleep in the vast majority of the subjects. Previous studies have demonstrated that these definitions of day- and nighttime eliminate the transition periods between activity and sleep, during which BP often changes markedly.[9]

The interval between the successive ambulatory BP readings had not been constant. The averages of the ambulatory BPs over 24 h and over the day- and nighttime periods were therefore calculated with weighting by the interval between successive BP readings.

Statistical methods included Student's *t*-test for pairwise comparisons and regression analysis. The agreement between the daytime ambulatory measurements and the pressure readings at the subjects' homes was investigated by the method proposed by Gould.[10]

Results

Characteristics of the participants

The subjects, 159 men and 169 women, were 49 ± 14 (mean $\pm$ standard deviation) years old, with a range from 20 to 81 years. The distribution of age was similar among men and women: 10% were 20–29 years old; 22% were 30–39; 23% were 40–49; 18% were 50–59; 20% were 60–69; and 7% were 70 years or older.

Body weight in the 328 subjects averaged 71.1 ± 12.5 kg, and body mass index 25.2 ± 3.5 kg/m^2. Circumference of the upper arm ranged from 21 to 36 cm, averaging 28 ± 3 cm. Ninety-six subjects were smokers (median 15 cigarettes per day; range 1–102), and 60 reported regular alcohol consumption (median 24 g/day; range 5–96). Thirty women took the contraceptive pill. Three subjects reported a history of myocardial infarction, three had experienced a transient ischaemic attack and one subject both conditions, but none of these seven subjects had complaints, when asked to participate.

Ambulatory measurements

Weekdays on which the ambulatory recordings took place had a similar distribution among men and women (10% of the recordings were performed on Mondays; 23% on Tuesdays; 19% on Wednesdays; 14% on Thursdays; 12% on

Fridays; 17% on Saturdays; 5% on Sundays). Seventy (0.4%) of the 16,870 ambulatory BP readings obtained in the 328 subjects met the exclusion criteria for DBP, 84 (0.5%) met the exclusion criteria for pulse rate and 13 (0.1%) exceeded the limits for pulse rate. However, none of the measurements fell outside the limits defined for SBP. Because editing did not materially alter the shape of the circadian BP curves, nor the means of the day- and nighttime BPs, only analyses based on unedited recordings are presented.

In the 328 subjects the 24 h ambulatory BPs averaged 118/71 mmHg (95% confidence intervals: 117–120/70–72 mmHg). The daytime BPs averaged 124/76 mmHg (123–125/75–77 mmHg), and the nighttime pressures 108/62 mmHg (106–109/61–63 mmHg). The 5th, 50th (median) and 95th centiles of the ambulatory BPs are presented for men and women and two age classes (20–49 and ≥50 years) separately in Table I, and the average ambulatory BPs and corresponding 95% confidence intervals for any hour during the day in Figure 1.

The night/day BP ratio in all 328 subjects averaged 0.87 systolic and 0.81 diastolic. The 5th and 95th centiles were respectively 0.78 and 0.98 for SBP, and 0.69 and 0.96 for DBP. The night/day ratio of SBP was not correlated with age ($r = -0.02$), but there was a weak positive correlation between the night/day ratio of DBP and age ($r = 0.13$; $P = 0.02$).

Home measurements

A total of 3,280 systolic and diastolic BP readings were obtained at the homes of the participants. Thirty-one per cent of these BP readings ended in 0, 21% in 2, 18% in 4, 14% in 6 and 16% in 8.

BP (measured by the same observer) was 2/1 mmHg lower ($P<0.001$) at the second than at the first home visit. BP at the repeat home visit (5 readings) averaged 120/71 mmHg in the 328 subjects (95% confidence interval: 118–122/70–72 mmHg). The 95% confidence intervals for the average BPs obtained at the second home visit in the four subgroups by gender and age are shown in Figure 1 (hatched area), and the 5th, 50th (median) and 95th centiles in Table I.

Agreement between home and day-time ambulatory measurements

The correlation coefficients between the daytime ambulatory BP and the BP measurements obtained at the repeat home visit (average of 5 readings) were 0.72 for SBP and 0.60 for DBP (Figure 2).

Blood pressure measured at home was on average 4/5 mmHg lower ($P<0.001$) than the daytime ambulatory BP (mean ±2 standard deviation interval from −18 to 26 mmHg for SBP, and from −11 to 21 mmHg for DBP). When systolic and diastolic pressures were

Table I Fifth, 50th and 95th centiles of systolic/diastolic pressure (mmHg)

	Men		*Women*	
Age range	*20–49*	*≥50*	*20–49*	*≥50*
n	85	74	96	73
Pressure at home				
P5	102/58	106/60	97/54	102/60
P50	119/73	121/72	110/67	124/72
P95	150/93	157/90	132/82	152/87
Ambulatory pressure				
Day (10 am–8 pm)				
P5	111/68	112/66	105/64	109/67
P50	126/77	124/78	118/73	122/74
P95	144/95	154/90	132/85	151/91
Night (0 am–6 am)				
P5	95/53	93/52	90/49	90/50
P50	110/62	107/62	104/58	106/62
P95	124/79	140/83	121/70	132/72
Whole day (24 h)				
P5	106/62	108/64	101/59	104/62
P50	121/72	119/73	114/67	120/70
P95	134/87	147/87	125/80	150/83

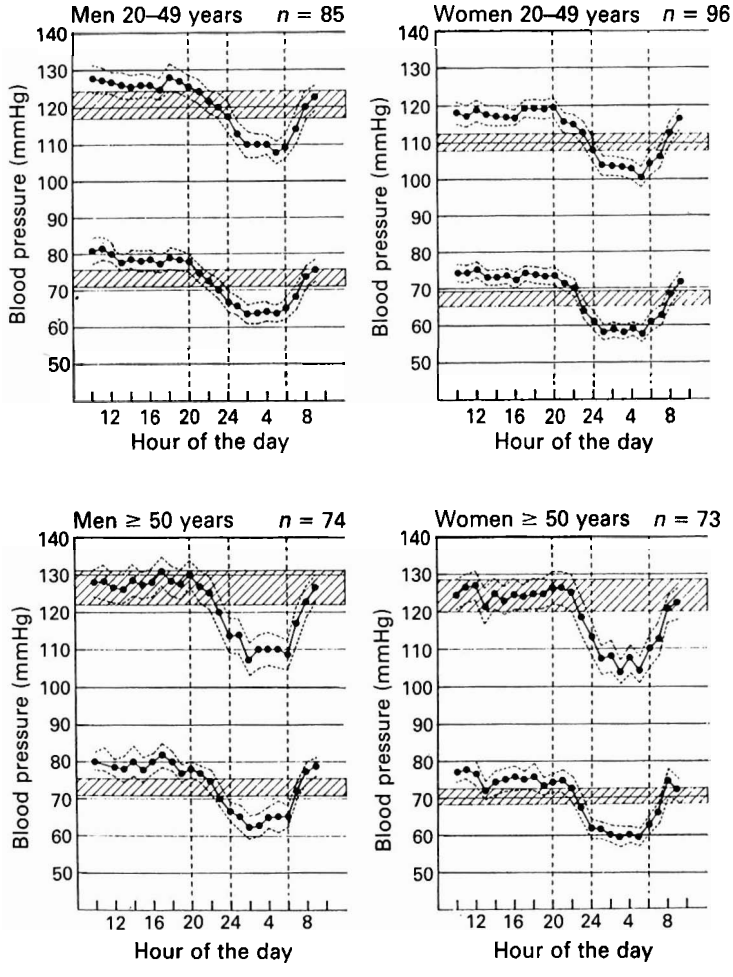

Figure 1 Ambulatory systolic and diastolic blood pressures in men and women and in two age categories (20–49 and ≥50 years). The hourly means (with 95% confidence interval) are presented. The shaded bands indicate the 95% confidence interval for the BP measured by a nurse at home (average of 5 readings obtained at a second visit).

combined, 84% of the subjects had mean daytime pressures that differed less than 20/15 mmHg from the pressures measured at home.

Discussion

In the present study a random sample of the subjects, who reported themselves to be in good health at the time of the examination, was investigated. The participation rate was 55%. Subjects taking drugs with hypotensive action were not eligible for inclusion into the sample, but by contrast to many previous studies,[11–24] nobody was excluded from participation and analysis on the basis of an elevated BP as measured by an observer.

The ambulatory BP in all subjects combined averaged 118/71 mmHg over 24 h, 124/76 mmHg during the day, and 108/62 mmHg at night. Previous studies[11–24] recruited mainly selected healthy subjects, or patients referred to specialised clinics to exclude the diagnosis of hypertension. In these reports[11–24] the mean ambulatory SBP ranged from 111 to 122 mmHg for a full 24 h period, from 115 to 128 mmHg during the day, and from 99 to 111 mmHg at night; the ranges for the mean DBP in these

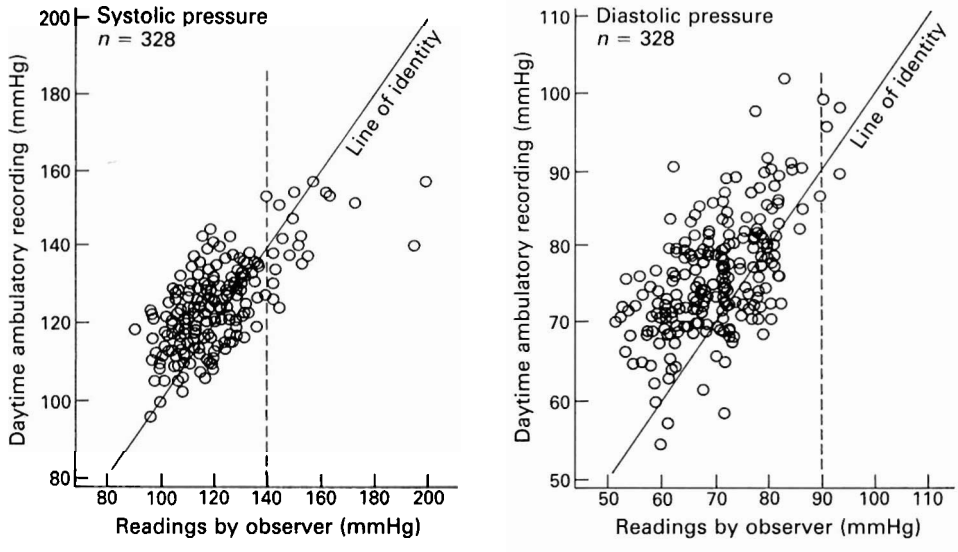

Figure 2 Scatterplot (n = 328) of the daytime ambulatory BP on the BP measured by a nurse at home (average of 5 readings obtained at second visit).

studies[11–24] were 59–79 mmHg, 63–85 mmHg, and 51–70 mmHg, respectively. In addition, the present BP means are almost identical to those observed in a recent study in 815 Irish bank employees (24 h BP: 118/72 mmHg; daytime BP: 124/78 mmHg; nighttime BP: 106/61 mmHg).[25]

Some studies have suggested that the level of the ambulatory BP may be useful in the diagnosis of hypertension and in guiding antihypertensive treatment.[26,27] The present study, based on a representative population sample of 328 subjects, reports the 95th centile for the daytime, nighttime and 24 h ambulatory BPs in four subgroups by age and sex (Table I). If these 95th centiles can be considered as the upper limit of normal, the daytime values are close to the 140/90 mmHg boundary often used in clinical practice for conventional BP measurements. However, the relevance of these 95th centiles in relation to the incidence of cardiovascular morbidity and mortality remains to be further elucidated.[28,29] In addition, one should keep in mind that ambulatory BP recordings provide information that is usually not available, when the BP is measured by an observer, e.g. the level of BP during habitual daily activities, and the amount of BP fall at night. Thus, normality of the ambulatory BP must be related not only to the height of the BP, but also to the BP pattern over 24 hours. In the present study the 5th and 95th centiles for the night/day BP ratio ranged from 0.78 to 0.98 for the systolic pressure, and from 0.69 to 0.96 for the diastolicpressure, but these findings need independent confirmation by other reports.

It is unlikely that the present measurements at the subjects' homes were substantially influenced by an alerting reaction to the observer, as is usually the case in clinics.[30,31] Nonetheless, it remains possible that the 4/5 mmHg difference between the daytime ambulatory BP and the BP at home would have been greater, had the latter been self-determined. On the other hand, the muscular activity required for cuff inflation has recently been demonstrated to cause a transient rise in pressure.[32]

As opposed to the auscultatory measurements at home, an oscillometric method was used to record the ambulatory BP in the present study. However, the 90202 SpaceLabs recorder fulfils the criteria of the Association for the Advancement of Medical Instrumentation (AAMI)[33] and is accurate within 4 ± 8 mmHg for both SBP and DBP, compared with auscultatory readings by two blinded clinicians. In addition, the oscillometric technique is practical for population studies, since it does not require the use of a microphone. The interval between the readings was 20 min during the day and 45 min at night. However, di Rienzo *et al.*[34] have shown that, compared with continuous intra-arterial recordings, noninvasive ambulatory BP measurement can achieve an accurate assessment of the true BP level, even when consecutive BP readings are as far as 30 to 60 min apart.

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References

1. Mancia, G. Ambulatory blood pressure monitoring in hypertension research and clinical practice. In: *1986 Hypertension Yearbook. Critical Reviews for the Clinician.* Ed: International Society of Hypertension. Gower Academic Journals, London, 1986, pp 93–115.
2. Staessen, J., Bulpitt, C., Fagard, R., Joossens, J.V., Lijnen, P. & Amery, A. Four urinary cations and blood pressure: a population study in two Belgian towns. *Am J Epidemiol* 1983, **117:** 676–687.
3. Staessen, J., Bulpitt, C.J., Fagard, R., Joossens, J.V., Lijnen, P. & Amery, A. Familial aggregation of blood pressure, anthropometric characteristics and urinary excretion of sodium and potassium. A population study in two Belgian towns. *J Chron Dis* 1985, **38:** 397–407.
4. Staessen, J., Bulpitt, C.J., Fagard, R. Joossens, J.V., Lijnen, P. & Amery, A. Salt intake and blood pressure in the general population: a controlled intervention trial in two towns. *J Hypertens* 1988, **6:** 965–973.
5. Staessen, J., Amery, A., Bernard, A. *et al.* Blood pressure, the prevalence of cardiovascular diseases and exposure to cadmium: a population study. *Am J Epidemiol* 1991, (in press.)
6. O'Brien, E., Sheridan, J., Browne, T., Conroy, R. & O'Malley, K. Validation of the SpaceLabs 90202 ambulatory blood pressure recorder. *J Hypertens* 1989, 7 (Suppl. 6): S388–S389.
7. Kennedy, H.L., Padgett, N.E. & Horan, M.J. Performance reliability of the Del Mar Avionics non-invasive ambulatory blood pressure instrument in clinical use. *Amb Electrocardiol* 1979, **1:** 13–17.
8. Casadei, R., Parati, G., Pomidossi, G. *et al.* 24-hour blood pressure monitoring: evaluation of Spacelabs 5300 monitor in comparison with intra-arterial blood pressure recording in ambulant subjects. *J Hypertens* 1988, **6:** 797–803.
9. Van Hoof, R., Hespel, P., Fagard, R., Lijnen, P., Staessen, J. & Amery, A. Effect of endurance training on blood pressure at rest, during exercise, and during 24 hours in sedentary men. *Am J Cardiol* 1989, **63:** 945–949.
10. Gould, B.A. An assessment of the accuracy and role of self-recorded blood pressures in the management of hypertension. Thesis submitted for the Doctorate of Medicine, University of London, 1983.
11. Horan, M.J., Kennedy, H.L. & Padgett, N.E. Do borderline hypertensive patients have labile blood pressure? *Ann Intern Med* 1981, **94:** 466–468.
12. Pickering, T.G., Harshfield, G.A., Klienert, H.D., Blank, S. & Laragh, J.H. Blood pressure during normal daily activities, sleep and exercise. Comparison of values in normal and hypertensive subjects. *JAMA* 1982, **247:** 992–996.
13. Kennedy, H.L., Horan, M.J., Sprague, M.K., Padgett, N.E. & Shriver, K.K. Ambulatory blood pressure in normotensive males. *Am Heart J* 1983, **10:** 717–722.
14. Drayer, J.I.M., Weber, M.A. & Hoeger, W.J. Whole-day BP monitoring in ambulatory normotensive men. *Arch Intern Med* 1985, **145:** 271–274.
15. Sundberg, S. Noninvasive, automatic 24-h ambulatory blood pressure monitoring in normotensive subjects. *Eur J Appl Physiol* 1987, **56:** 381–383.
16. Pomidossi, G., Parati, G., Casadei, R., Villani, A., Groppelli, A. & Mancia, G. Twenty-four hour ambulatory blood pressure in normotensive and borderline hypertensive subjects. *J Hypertens* 1988, **6** (Suppl. 4): S67–S69.
17. Warling, X., Carlier, P.G., Krzesinski, J.M. & Rorive, G.L. La mesure de la pression arterielle permet d'ameliorer le definition de l'hypertension arterielle. *Arch Mal Coeur* 1988, **81** (Suppl. HTA): 225–230.
18. Battistella, P., De Gaudemaris, R., Francois, G. *et al.* Valeurs de reference de la tension arterielle ambulatoire d'activite et de nuit. *Arch Mal Coeur* 1989, **82:** 1019–1022.
19. De Gaudemaris, R., Mallion, J.M., Battistella, P. *et al.* Ambulatory blood pressure and variability by age and sex in 200 normotensive subjects: reference population values. *J Hypertens* 1987, **5** (Suppl. 5): S429–S430.
20. Pickering, T.G., James, G.D., Boddie, C., Harshfield, G.A., Blank, S. & Laragh, J.H. How common is white coat hypertension? *JAMA* 1988, **259:** 225–228.
21. Chanudet, X., Chau, N.P. & Larroque, P. Evaluation de l'hypertension arterielle limite de l'adulte jeune par mesure ambulatoire de la pression arterielle. *Arch Mal Coeur* 1989, **82:** 365–372.
22. Chau, N.P., Mallion, J.M., de Gaudemaris, R. *et al.* Twenty-four-hour ambulatory blood pressure in shift workers. *Circulation* 1989, **80:** 341–347.
23. James, G.D., Cates, E.M., Pickering, T.G. & Laragh, J.H. Parity and perceived job stress elevate blood pressure in young normotensive working women. *Am J Hypertens* 1989, **2:** 637–639.
24. Broadhurst, P., Brigden, G., Dasgupta, P., Lahiri, A. & Raftery, E.B. Ambulatory intra-arterial blood

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References

1. Mancia, G. Ambulatory blood pressure monitoring in hypertension research and clinical practice. In: *1986 Hypertension Yearbook. Critical Reviews for the Clinician.* Ed: International Society of Hypertension. Gower Academic Journals, London, 1986, pp 93–115.
2. Staessen, J., Bulpitt, C., Fagard, R., Joossens, J.V., Lijnen, P. & Amery, A. Four urinary cations and blood pressure: a population study in two Belgian towns. *Am J Epidemiol* 1983, **117:** 676–687.
3. Staessen, J., Bulpitt, C.J., Fagard, R., Joossens, J.V., Lijnen, P. & Amery, A. Familial aggregation of blood pressure, anthropometric characteristics and urinary excretion of sodium and potassium. A population study in two Belgian towns. *J Chron Dis* 1985, **38:** 397–407.
4. Staessen, J., Bulpitt, C.J., Fagard, R. Joossens, J.V., Lijnen, P. & Amery, A. Salt intake and blood pressure in the general population: a controlled intervention trial in two towns. *J Hypertens* 1988, **6:** 965–973.
5. Staessen, J., Amery, A., Bernard, A. *et al.* Blood pressure, the prevalence of cardiovascular diseases and exposure to cadmium: a population study. *Am J Epidemiol* 1991, (in press.)
6. O'Brien, E., Sheridan, J., Browne, T., Conroy, R. & O'Malley, K. Validation of the SpaceLabs 90202 ambulatory blood pressure recorder. *J Hypertens* 1989, 7 (Suppl. 6): S388–S389.
7. Kennedy, H.L., Padgett, N.E. & Horan, M.J. Performance reliability of the Del Mar Avionics non-invasive ambulatory blood pressure instrument in clinical use. *Amb Electrocardiol* 1979, **1:** 13–17.
8. Casadei, R., Parati, G., Pomidossi, G. *et al.* 24-hour blood pressure monitoring: evaluation of Spacelabs 5300 monitor in comparison with intra-arterial blood pressure recording in ambulant subjects. *J Hypertens* 1988, **6:** 797–803.
9. Van Hoof, R., Hespel, P., Fagard, R., Lijnen, P., Staessen, J. & Amery, A. Effect of endurance training on blood pressure at rest, during exercise, and during 24 hours in sedentary men. *Am J Cardiol* 1989, **63:** 945–949.
10. Gould, B.A. An assessment of the accuracy and role of self-recorded blood pressures in the management of hypertension. Thesis submitted for the Doctorate of Medicine, University of London, 1983.
11. Horan, M.J., Kennedy, H.L. & Padgett, N.E. Do borderline hypertensive patients have labile blood pressure? *Ann Intern Med* 1981, **94:** 466–468.
12. Pickering, T.G., Harshfield, G.A., Klienert, H.D., Blank, S. & Laragh, J.H. Blood pressure during normal daily activities, sleep and exercise. Comparison of values in normal and hypertensive subjects. *JAMA* 1982, **247:** 992–996.
13. Kennedy, H.L., Horan, M.J., Sprague, M.K., Padgett, N.E. & Shriver, K.K. Ambulatory blood pressure in normotensive males. *Am Heart J* 1983, **10:** 717–722.
14. Drayer, J.I.M., Weber, M.A. & Hoeger, W.J. Whole-day BP monitoring in ambulatory normotensive men. *Arch Intern Med* 1985, **145:** 271–274.
15. Sundberg, S. Noninvasive, automatic 24-h ambulatory blood pressure monitoring in normotensive subjects. *Eur J Appl Physiol* 1987, **56:** 381–383.
16. Pomidossi, G., Parati, G., Casadei, R., Villani, A., Groppelli, A. & Mancia, G. Twenty-four hour ambulatory blood pressure in normotensive and borderline hypertensive subjects. *J Hypertens* 1988, **6** (Suppl. 4): S67–S69.
17. Warling, X., Carlier, P.G., Krzesinski, J.M. & Rorive, G.L. La mesure de la pression arterielle permet d'ameliorer le definition de l'hypertension arterielle. *Arch Mal Coeur* 1988, **81** (Suppl. HTA): 225–230.
18. Battistella, P., De Gaudemaris, R., Francois, G. *et al.* Valeurs de reference de la tension arterielle ambulatoire d'activite et de nuit. *Arch Mal Coeur* 1989, **82:** 1019–1022.
19. De Gaudemaris, R., Mallion, J.M., Battistella, P. *et al.* Ambulatory blood pressure and variability by age and sex in 200 normotensive subjects: reference population values. *J Hypertens* 1987, **5** (Suppl. 5): S429–S430.
20. Pickering, T.G., James, G.D., Boddie, C., Harshfield, G.A., Blank, S. & Laragh, J.H. How common is white coat hypertension? *JAMA* 1988, **259:** 225–228.
21. Chanudet, X., Chau, N.P. & Larroque, P. Evaluation de l'hypertension arterielle limite de l'adulte jeune par mesure ambulatoire de la pression arterielle. *Arch Mal Coeur* 1989, **82:** 365–372.
22. Chau, N.P., Mallion, J.M., de Gaudemaris, R. *et al.* Twenty-four-hour ambulatory blood pressure in shift workers. *Circulation* 1989, **80:** 341–347.
23. James, G.D., Cates, E.M., Pickering, T.G. & Laragh, J.H. Parity and perceived job stress elevate blood pressure in young normotensive working women. *Am J Hypertens* 1989, **2:** 637–639.
24. Broadhurst, P., Brigden, G., Dasgupta, P., Lahiri, A. & Raftery, E.B. Ambulatory intra-arterial blood

pressure in normal subjects. *Am Heart J* 1990, **120:** 160–166
25. O'Brien, E.T., Murphy, J., Tyndall, A. *et al.* Twenty-four-hour ambulatory blood pressure in men and women aged 17 to 80 years: the Allied Irish Bank Study. *J Hypertens* 1991, **9:** 355–360.
26. Waeber, B., Jacot Des Combes, B., Porchet, M., Biollaz, J., Schaller, M.D. & Brunner, H.R. Ambulatory blood pressure recording to identify hypertensive patients who truly need therapy. *J Chron Dis* 1984, **37:** 55–57.
27. Waeber, B., Scherrer, U., Petrillo, A. *et al.* Are some hypertensive patients overtreated? *Lancet* 1987, **ii:** 732–734.
28. Perloff, D., Sokolow, M. & Cowan, R. The prognostic value of ambulatory blood pressures. *JAMA* 1983, **249:** 2792–2798.
29. Mann, S., Craig, M.W.M. & Raftery, E.B. Superiority of 24-hour measurement of blood pressure over clinic values in determining prognosis in hypertension. *Clin Exp Hypertens* 1985, **A7:** 279–281.
30. Mancia, G., Bertinieri, G., Grassi, G. *et al.* Effects of blood pressure measurement by the doctor on patient's blood pressure and heart rate. *Lancet* 1983, **ii:** 695–698.
31. Padfield, P.L., Lindsay, B.A., McLaren, J.A., Pirie, A. & Rademaker, M. Changing relation between home and clinic blood pressure measurements: do home measurements predict clinic hypertension? *Lancet* 1987, **ii:** 322–324.
32. Veerman, D.P., van Montfrans, G.A. & Wieling, W. Effects of cuff inflation on self-recorded blood pressure. *Lancet* 1990, **335:** 451–453.
33. Hope, S.L., Alun-Jones, E. & Sleight, P. Validation of the accuracy of the Medilog ABP non-invasive blood pressure monitor. *J. Amb Monitoring* 1988, **1:** 39–51.
34. Di Rienzo, M., Grassi, G., Pedotti, A. & Mancia, G. Continuous vs. intermittent blood pressure measurements in estimating 24-hour average blood pressure. *Hypertension* 1983, **5:** 264–269.