Short-term and long-term repeatability of the morning blood pressure in older patients with isolated systolic hypertension

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Objective **Using 24-h ambulatory blood pressure monitoring, we studied the repeatability of the morning blood pressure in older (≥60 years) patients with isolated systolic hypertension.**

Methods **The sleep-through morning surge was the morning blood pressure minus the lowest nighttime blood pressure. The preawake morning surge was the morning blood pressure minus the preawake blood pressure. In addition, we determined the cusum plot height of blood pressure from 04:00 to 10:00 h from a plot of cumulative sums.**

Results **In 173 patients with repeat recordings within 33 days (median), the short-term repeatability coefficients, expressed as percentages of maximal variation, ranged from 35 to 41% for the daytime and nighttime blood pressures and from 50 to 56% for the night-to-day blood pressure ratios. Short-term repeatability ranged from 52 to 75% for the sleep-through and the preawake morning surge, and from 51 to 62% for the cusum plot height. In 219 patients with repeat recordings within 10 months (median), the corresponding long-term estimates ranged from 45 to 64%, from 69 to 71%, from 76 to 83%, and from 50 to 78%, respectively. In categorical analyses of the short-term repeatability of the sleep-through morning surge and the preawake morning surge, using the 75th percentile as arbitrary cut-off, surging status changed in 28.0 and 26.8% of patients (κ-statistic ≤ 0.33). In the long-term interval, these proportions were 32.0 and 32.0%, respectively (κ-statistic ≤ 0.20). The κ-statistic threshold for moderate reproducibility is 0.4.**

Conclusion **The morning surge of blood pressure is poorly reproducible, irrespective of whether it is analysed as continuous or categorical variable. *J Hypertens* 26:1328–1335 © 2008 Wolters Kluwer Health | Lippincott Williams & Wilkins.**

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Keywords: ambulatory blood pressure monitoring, clinical trials, cumulative sums, morning surge, reproducibility

Abbreviations: BP, Blood Pressure; CI, Confidence Interval; CPH, Cusum Plot Height; MS, Morning Surge; RC, Repeatability Coefficient; SD, Standard Deviation

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Introduction

Blood pressure (BP) shows marked diurnal variation, reaching the highest level in the morning and then decreasing through the day to a trough level during the first hours of sleep at night. The morning surge is the rise in BP on awakening and might be a predictor of cardiovascular complications [1–5]. Japanese hypertensive patients with mean age of 72 years had a higher risk of multiple brain infarcts and stroke if the morning surge in systolic BP was above the 90th percentile [2], or if the difference of systolic BP between morning and evening was above the top quartile (>20 mmHg) [6].

In the Ohasama Study, a morning surge above the top quintile systolic (≥25 mmHg) predicted intracerebral haemorrhage [7]. The use of arbitrary thresholds to define the morning surge in BP limits the generalizability of previous studies. As highlighted by other researchers [8–13], the repeatability of the classification of subjects according to their BP is another important issue to be considered. In this article, we assessed the short-term and long-term repeatability of the morning surge, using continuous definitions [2,7] and previously published thresholds [3,6]. For this, we analysed the database of the substudy on ambulatory BP monitoring of the Systolic Hypertension in Europe (Syst-Eur) trial [14].

Methods

Study design and selection of patients

The Ethics Committee of the Faculty of Medicine at the University of Leuven as well as the Institutional Review Boards of all participating centres approved the protocol. Eligible patients were 60 years or older. On conventional measurement, they had a sitting systolic BP ranging from 160 to 219 mmHg with a diastolic BP of less than 95 mmHg. Standing systolic BP had to be 140 mmHg or more. These entry criteria rested on the mean of six BP readings obtained during the single-blind placebo run-in period (two readings in each position at three visits one month apart). Eligible patients were stratified by sex and the presence vs. absence of cardiovascular complications and were randomized to double-blind treatment with placebo or active medication.

Of 198 Syst-Eur centres, 46 opted to enrol their patients in the substudy on ambulatory BP monitoring. To be included in the present analysis, patients had to have had their ambulatory BP measured twice during the run-in period (short-term repeatability), or had to have had one baseline recording and one follow-up measurement of their ambulatory BP on double-blind placebo within 2 years of randomization (long-term repeatability). Of 837 randomized patients, 173 and 219 qualified for the analysis of short-term and long-term repeatability, respectively. The total number of patients statistically analysed was 320.

Of 173 patients with duplicate ambulatory BP recording during the run-in period, 72 also underwent a third recording after randomization to double-blind placebo treatment. In 62 of these patients, the quality of the recordings was sufficient to compute the morning surge on all three occasions.

Ambulatory blood pressure monitoring

We programmed properly validated portable monitors to obtain BP readings at intervals no longer than 30 min [14]. Editing criteria encoded in the monitor were disabled or set at limits as wide as possible. The cuff was secured to the nondominant arm. If on conventional sphygmomanometry the difference in systolic BP between both arms was 10 mmHg or more, the arm with highest readings was chosen. We used larger cuffs with a 33 cm × 15 cm bladder if arm circumference exceeded 31 cm.

We excluded the first hour of each recording from analysis (white-coat window) [15,16]. If the ambulatory recordings were longer than 1 day, we only analysed the first 24 h. We defined daytime and nighttime as the intervals ranging from 10:00 to 20:00 h and from midnight to 06:00 h, respectively. We weighted the within-subject means of the daytime and nighttime BPs for the interval between consecutive readings [14].

We limited the categorical analyses to systolic BP, because above 50 years it is a better predictor of cardiovascular complications than diastolic BP [17,18].

Morning surge of blood pressure

For analysis of the morning surge in BP, we determined the awake and asleep periods from the patients' diary cards. We defined the sleep-through morning surge (Fig. 1) as the difference between the morning pressure (the average BP during the 2 h after waking up) and the lowest nighttime BP (the average of the lowest pressure and the two readings immediately preceding and following the lowest value) [2]. We also studied the preawake morning surge (Fig. 1), as the difference between the morning BP (the average BP during the 2 h after waking up) and the preawake BP (the average BP during the 2 h before waking up) [2,7]. In categorical analyses, we applied the 75th percentile as the arbitrary threshold of exaggerated sleep-through (40 mmHg) and preawake (25 mmHg) morning surges.

In addition, we used cumulative sums (cusum) [19] for a continuous assessment of the BP changes in the morning from 04:00 to 10:00 h. We computed the cusum at time '*t*' and the cusum plot height according to the formula:

$$\text{Cusum}_{(t)} = \sum_{i=2}^{t}\left(\frac{\text{BP}_i + \text{BP}_{i-1}}{2} - \text{mean BP}\right)d_i$$

$$\text{Cusum plot height} = |\max(\text{cusum}_t) - \min(\text{cusum}_t)| \times (t = 2, \ldots, n)$$

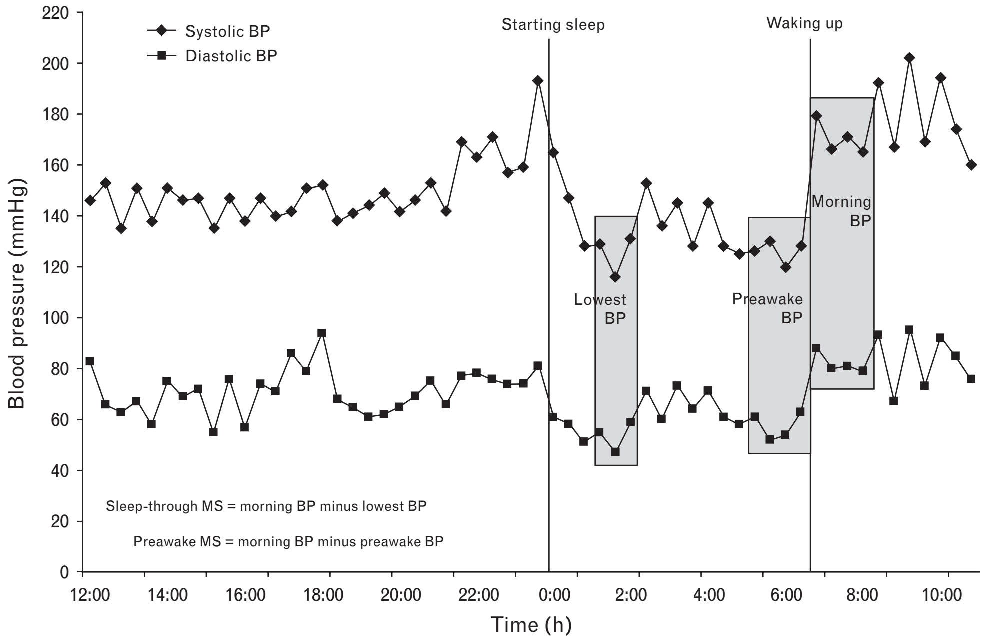
where

$$\text{mean BP} = \frac{\sum_{i=2}^{n}(\text{BP}_i + \text{BP}_{i-1}/2)d_i}{\sum_{i=2}^{n} d_i}$$

and n is the number of BP measurements between 04:00 and 10:00 h, BP_i is the ith BP measurement between 04:00 and 10:00 h, d_i is the time interval in hours between (BP_i and BP_{i-1}).

To be eligible for the cumulative sums analysis, the ambulatory recordings had to include at least one reading per hour during the time interval from 04:00 to 10:00 h. If BP was not measured at 04:00 h, an estimated value was generated by mean interpolation from the measurements immediately before and after 04:00 h. Similarly, if BP

Fig. 1



Derivation of the sleep-through and preawake morning surge from the 24-h ambulatory blood pressure recording of a representative patient. BP, blood pressure; MS, morning surge.

was not measured at 10:00 h, an estimated value was generated from the measurements immediately before and after 10:00 h. The cusum plot height was the difference between the maximum and the minimum of the cusum curve (Fig. 2). The cusum plot height measures both the extent and steepness of the BP increase in the morning hours.

Statistical methods

For database management and statistical analysis, we used SAS software, version 9.1.3 (SAS Institute Inc, Cary, North Carolina, USA). We compared means and proportions by Student's *t*-test for paired and unpaired observations, as appropriate, and the χ^2-statistic, respectively. We assessed the agreement between paired ambulatory recordings by Bland and Altman's method [20,21]. We used the repeatability coefficient for the evaluation of the short-term and long-term repeatability [22]. It was twice the standard deviation of the within-subject differences between repeat recordings (repeat minus first). We expressed the repeatability coefficient as a percentage of the mean of the repeat measurements, as well as the percentage of close to maximal variation (four times the standard deviation of the average of the repeat measurements). In categorical analyses, we applied McNemar's test and we computed the κ-statistic [23] as a measurement of agreement. Finally, we used simple regression analysis to correlate differences between repeated measures of the changes in the morning pressure with difference in the time of awakening between consecutive recordings.

Results

Baseline characteristics

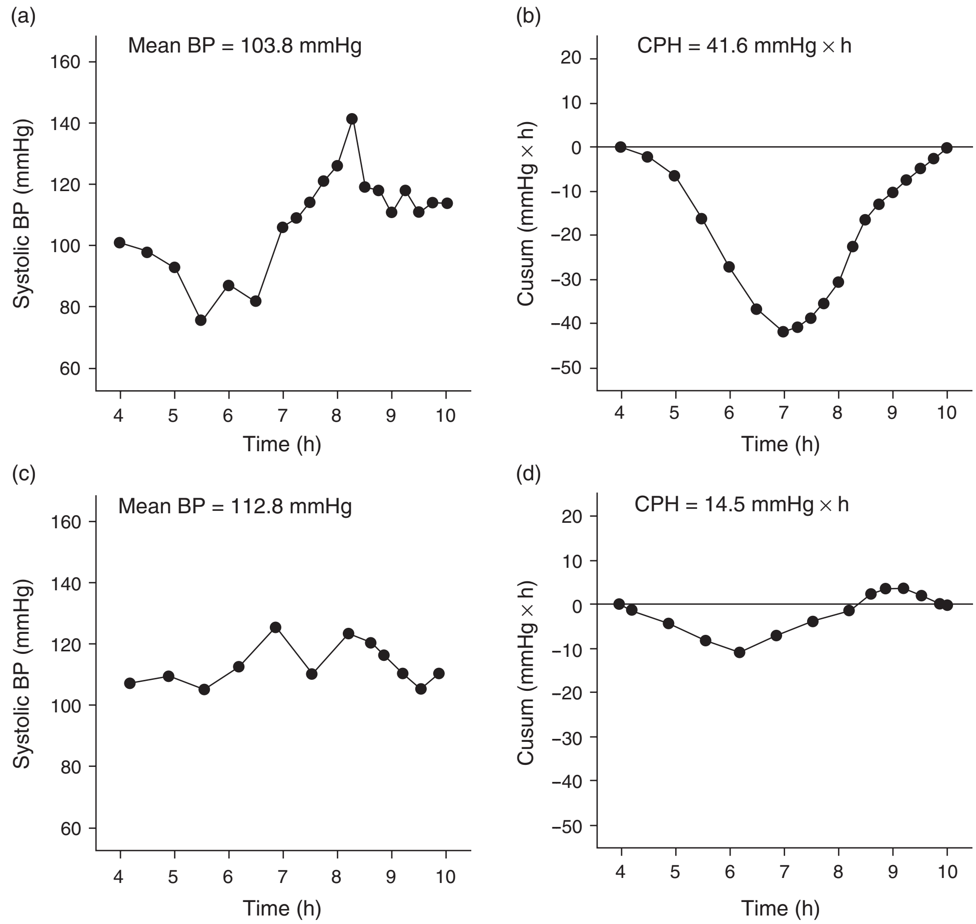
Of the 320 patients, 195 (60.9%) were female and 86 (26.9%) had a history of previous cardiovascular complications. Mean age (±SD) was 70.5 ± 6.0 years (range, 60–88 years). Body mass index averaged 26.7 ± 4.3 kg/m^2 in women and 26.0 ± 3.5 kg/m^2 in men. The prevalence of smoking was 5.1% in women and 19.2% in men ($P < 0.001$). The number of patients drinking alcohol amounted to 27.7 and 64.8% ($P < 0.001$), respectively. There were no statistical differences in the characteristics of the patients included in the analysis of short-term and long-term repeatability. Figure 3 shows the distributions of the sleep-through and preawake morning surge, the cusum plot height and night-to-day ratio in 320 patients whose BP was recorded during the placebo run-in period.

Short-term repeatability

In the 173 patients available for the study of the short-term repeatability, the median time-interval between the duplicate measurements was 33 days (interquartile range, 28–46 days; range, 2–127 days). The technique of ambulatory BP recording was consistently oscillometric in 137 patients (79.2%) and consistently auscultatory in 20 patients (11.6%).

During the run-in period, there were no significant differences between the repeat recordings in the mean values for the daytime and nighttime BPs, the night-to-day BP ratios, the sleep-through and preawake morning

Fig. 2



Plots of ambulatory blood pressure (panels a and c), and cusum plot height (b and d) in a patient with (a and b) and a patient without (c and d) morning surge in systolic blood pressure. CPH, cusum plot height.

surges in BP or the cusum plot height (Table 1). The repeatability coefficients expressed as percentages of the mean ranged from 14 to 24% for the BP levels and the night-to-day BP ratios, and from 90 to 272% for the morning surge in BP and the cusum plot height (Table 1). These estimates, expressed as percentages of the maximal variation ranged from 35 to 56%, and from 51 to 75%, respectively (Table 1).

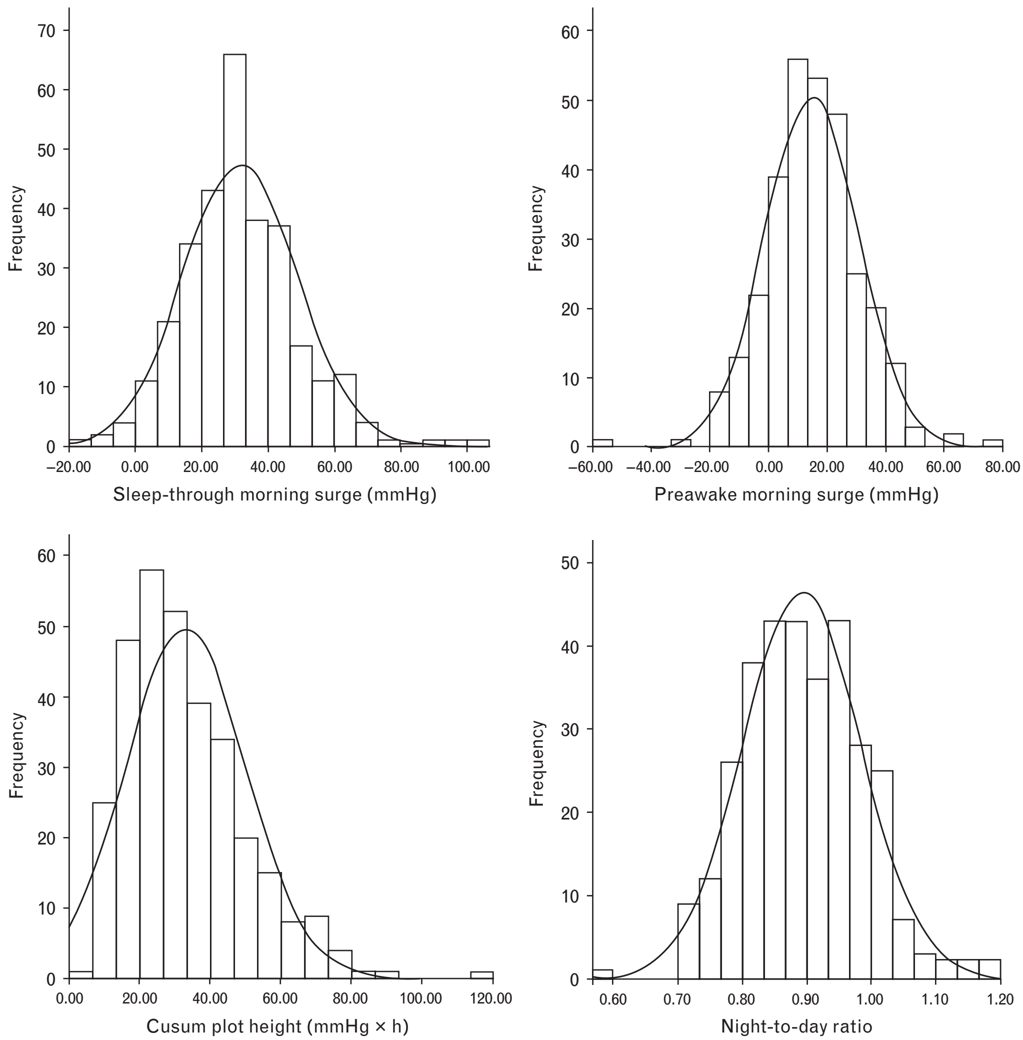
In the categorical analysis of short-term repeatability (Table 3), of 157 patients with available data on the sleep-through morning surge, 89 (56.7%) were consistent nonsurgers, 24 (15.3%) were consistent surgers, and 44 (28.0%) changed their surging status ($P = 0.13$; $\kappa = 0.33$). Of 157 patients with available data on the preawake morning surge, 97 (61.8%) were consistent nonsurgers, 18 (8.7%) were consistent surgers, and 42 (26.8%) changed their status ($P = 0.54$; $\kappa = 0.28$). All correlations of differences between repeat recordings in the sleep-through and preawake morning surge, and the cusum plot height with difference in the time of awakening, were nonsignificant ($r < 0.14$; $P > 0.8$).

Long-term repeatability on placebo

In the 219 patients available for the study of the long-term repeatability, the median time-interval between the duplicate measurements was 10 months (interquartile range, 7.7–13.2 months; range, 6–26 months). The technique of ambulatory BP recording was consistently oscillometric in 158 patients (72.2%) and consistently auscultatory in 42 patients (19.2%).

During follow-up, significant decreases occurred in the systolic and diastolic daytime and nighttime BPs ($P < 0.05$), as well as in the preawake morning surge and cusum plot height of systolic pressure (Table 2). The repeatability coefficients expressed as percentages of the mean ranged from 19 to 26% for the BP levels and the night-to-day BP ratio, and from 80 to 252% for the morning surge in BP and the cusum plot height (Table 2).

Fig. 3



Distributions of the sleep-through and preawake morning surge, the cusum plot height, and night-to-day ratio in 320 patients whose blood pressure was recorded during the run-in placebo period.

These estimates, expressed as percentages of maximal variation, ranged from 45 to 71% and from 50 to 83%, respectively (Table 2).

In the categorical analysis of long-term repeatability (Table 3), of 206 patients with available data on the sleep-through morning surge, 116 (56.3%) were consistent nonsurgers, 24 (11.7%) were consistent surgers, and 66 (32.0%) changed their surging status ($P = 0.46$; $\kappa = 0.20$). Of 206 patients with available data on the preawake morning surge, 122 (59.2%) were consistent nonsurgers, 18 (8.7%) were consistent surgers, and 66 (32.0%) changed their status ($P = 0.049$; $\kappa = 0.15$).

Consistency between short-term and long-term repeatability

Of 62 patients with three recordings of sufficient quality, 28 (45.2%) were consistent nonsurgers, 6 (9.7%) were consistent surgers, and 28 (45.2%) changed their surging status across the three recordings. The κ-statistic was 0.25. The corresponding numbers for a preawake morning surge were 28 (45.2%), 2 (3.2%), and 32 (51.6%), respectively, with a κ-statistic of 0.07.

Discussion

Several studies have suggested that a rapid rise of BP in the morning might represent an additional risk factor for cardiovascular events in hypertensive patients as well as in the general population [3,4,6,7,24]. To our knowledge, only one prior report, however, addressed the reproducibility of the morning surge in BP. To what extent the morning surge is reproducible might be relevant for the interpretation of the aforementioned outcome studies. Indeed high reproducibility might strengthen the prognostic significance of the morning surge. The key finding of our current study was that the BP changes in the

Table 1 Short-term repeatability of ambulatory blood pressure measurements

	N	First (mean ± SD)	Repeat (mean ± SD)	*P*	Difference[a]		Repeatability		
					Mean ± SD	95% CI	RC	%M	%MV
Daytime BP (mmHg)									
Systolic	173	158.6 ± 16.1	157.3 ± 16.4	0.13	−1.3 ± 10.7	−2.9 to 0.4	21.5	14	35
Diastolic		85.5 ± 10.8	84.9 ± 10.2	0.28	−0.7 ± 8.1	−1.9 to 0.6	16.2	19	42
Nighttime BP (mmHg)									
Systolic	173	143.1 ± 18.3	142.0 ± 18.5	0.31	−1.1 ± 13.9	−3.2 to 1.0	27.8	20	41
Diastolic		71.5 ± 10.6	71.4 ± 9.9	0.83	−0.1 ± 7.8	−1.3 to 1.0	15.6	22	41
Night-to-day BP ratio									
Systolic	173	0.905 ± 0.10	0.906 ± 0.10	0.97	0.001 ± 0.09	−0.01 to 0.01	0.18	20	50
Diastolic		0.840 ± 0.10	0.845 ± 0.10	0.54	0.005 ± 0.10	−0.01 to 0.02	0.20	24	56
Sleep-through morning surge (mmHg) [2]									
Systolic	157	32.2 ± 18.1	33.4 ± 16.9	0.46	1.2 ± 18.7	−1.8 to 4.2	37.4	114	63
Diastolic		25.2 ± 12.6	26.1 ± 12.5	0.32	0.8 ± 11.6	−1.0 to 2.6	23.2	90	52
Preawake morning surge (mmHg) [2]									
Systolic	157	14.6 ± 16.8	14.8 ± 16.6	0.92	0.2 ± 20.0	−3.0 to 3.3	40.0	272	75
Diastolic		12.3 ± 11.7	13.0 ± 12.2	0.51	0.6 ± 12.1	−1.3 to 2.6	24.2	191	59
Cusum plot height (mmHg × h) [19]									
Systolic	124	33.4 ± 16.9	35.0 ± 19.8	0.35	1.6 ± 19.4	−1.8 to 5.1	38.8	113	62
Diastolic		24.8 ± 13.9	24.0 ± 13.8	0.50	−0.8 ± 12.6	−3.0 to 1.5	25.2	103	51

[a] Difference between repeat minus first recording. The repeatability coefficient (RC) is twice the standard deviation of the signed differences between duplicate measurements, expressed as the percentage of the mean of the repeated recordings (%M), or as a percentage of four times the standard deviation of the mean value of the two recordings (%MV). BP, blood pressure; CI, confidence interval.

morning were poorly reproducible, irrespective of whether they were analysed as a continuous or categorical variable. In the continuous analyses, the repeatability coefficients of the sleep-through and preawake morning surge in BP, and the cusum plot height, were consistently higher than 50%. Higher values of the repeatability coefficient indicate worse reproducibility. For comparison, the repeatability coefficient of the conventionally measured clinic BP is usually around 50% [25,26]. In the short-term study, the repeatability coefficients for systolic and diastolic daytime and nighttime BPs were approximately 40%. In the categorical analyses of the sleep-through and preawake morning surge, the κ-statistics were substantially lower than 0.4 or 0.8, which are usually considered as thresholds for moderate or high reproducibility, respectively [23]. The κ-statistics were consistent for both the short-term and long-term repeatability of BP changes in the morning.

Wang *et al.* [27] studied 36 community-dwelling hypertensive patients, who all were newly diagnosed and had never been treated with BP lowering drugs. These investigators performed ambulatory BP monitoring each time on a weekday, 1, 5, and 12 weeks after enrolment. They used the correlation coefficients as a measure of agreement. Although they did not find any significant

Table 2 Long-term repeatability of ambulatory blood pressure measurements in the placebo group

	N	First (mean ± SD)	Repeat (mean ± SD)	*P*	Difference[a]		Repeatability		
					Mean ± SD	95% CI	RC	%M	%MV
Daytime BP (mmHg)									
Systolic	219	152.2 ± 16.0	148.4 ± 16.8	<0.001	−3.8 ± 15.6	−5.9 to −1.8	31.2	21	54
Diastolic		84.2 ± 10.3	82.2 ± 9.9	<0.01	−2.0 ± 9.5	−3.3 to −0.7	19.0	23	53
Nighttime BP (mmHg)									
Systolic	219	134.5 ± 16.6	131.8 ± 17.7	<0.01	−2.7 ± 12.6	−4.3 to −1.0	25.2	19	64
Diastolic		70.2 ± 9.6	69.0 ± 10.0	0.03	−1.2 ± 8.1	−2.3 to −0.2	16.2	23	45
Night-to-day BP ratio									
Systolic	219	0.885 ± 0.09	0.890 ± 0.10	0.43	0.005 ± 0.10	−0.01 to 0.02	0.20	22	71
Diastolic		0.837 ± 0.09	0.843 ± 0.11	0.34	0.006 ± 0.11	−0.01 to 0.02	0.22	26	69
Sleep-through morning surge (mmHg) [2]									
Systolic	206	31.6 ± 17.0	30.2 ± 15.4	0.30	−1.4 ± 19.6	−4.1 to 1.3	39.2	127	76
Diastolic		23.9 ± 11.2	24.6 ± 12.0	0.49	0.7 ± 14.3	−1.3 to 2.6	28.6	118	78
Preawake morning surge (mmHg) [2]									
Systolic	206	15.8 ± 15.3	12.4 ± 14.3	0.01	−3.4 ± 18.4	−5.9 to −0.9	36.8	261	79
Diastolic		11.2 ± 11.0	11.2 ± 11.1	0.98	0.02 ± 14.1	−1.9 to 2.0	28.2	252	83
Cusum plot height (mmHg × h) [19]									
Systolic	126	34.0 ± 15.5	30.7 ± 15.5	0.03	−3.3 ± 16.8	−6.3 to −0.3	26.0	80	50
Diastolic		23.7 ± 11.7	21.9 ± 10.5	0.14	−1.8 ± 13.6	−4.2 to 0.6	27.2	119	78

[a] Difference between repeat minus first recording. The repeatability coefficient (RC) is twice the standard deviation of the signed differences between duplicate measurements; expressed as the percentage of the mean of the repeated recordings (%M), or as a percentage of four times the standard deviation of the mean value of the two recordings (%MV). BP, blood pressure; CI, confidence interval.

Table 3 Categorical analysis of short-term and long-term reproducibility of the morning surge

	First	Second vs. first ($n=157$)	*P, κ	Third vs. first ($n=206$)	*P, κ
Sleep-through MS [2][‡]		<40 mmHg vs. ≥40 mmHg		<40 mmHg vs. ≥40 mmHg	
	<40 mmHg	89 (56.7%) vs. 27 (17.2%)	$P=0.13$, $\kappa=0.33$	116 (56.3%) vs. 30 (14.5%)	$P=0.46$, $\kappa=0.20$
	≥40 mmHg	17 (10.8%) vs. 24 (15.3%)		36 (17.5%) vs. 24 (11.6%)	
Preawake MS [2][‡]		<25 mmHg vs. ≥25 mmHg		<25 mmHg vs. ≥25 mmHg	
	<25 mmHg	97 (61.8%) vs. 19 (12.1%)	$P=0.54$, $\kappa=0.28$	122 (59.2%) vs. 25 (12.1%)	$P=0.049$*, $\kappa=0.15$
	≥25 mmHg	23 (14.6%) vs. 18 (11.5%)		41 (19.9%) vs. 18 (8.7%)	

Second vs. first refers to repeat blood pressure ambulatory recordings in 157 patients during the placebo run-in period at the median interval 33 days or third vs. first refers to the ambulatory blood pressure recording during follow-up minus the first recording during placebo run-in period, obtained in 206 patients at a median interval of 10 months. MS, morning surge. * *P*-value of McNemar's test.

differences in the sleep-through morning surge between the three recordings, the correlation coefficients between the first and the second, the second and the third, and the first and the third recording were only 0.41, 0.48, and 0.57, respectively. Zakopoulos *et al.* [28] studied 20 patients with mild to moderate essential hypertension, who underwent four repeated ambulatory recordings, each time on the same day of the week, at 30-day intervals. Antihypertensive therapy was discontinued for 2 weeks before each recording. These investigators reported that the hourly BP means from 04:00 to 10:00 h were similar in the four consecutive recordings for systolic as well diastolic BP. Nevertheless, we found Zakopoulos' study difficult to interpret, because it was underpowered, and because it did not include any specific reproducibility statistics.

Several investigators demonstrated an inverse association or a negative correlation between the morning surge in BP and the level of the nighttime BP [2,7,27]. Subjects with the lowest nighttime BP usually experienced the largest increase in BP on awakening. Dippers and extreme dippers were overrepresented among the morning surgers [2]. In fact, we confirmed these findings in our current study (data not shown). We believe that the inverse association between the morning surge in BP and the nighttime BP level is a mathematical artefact. Indeed, the relation between the difference between two measurements, such as the morning and nighttime BP and one of the components of this difference, for instance the morning BP, must be statistically significant [29]. Moreover, from a biological point of view, the rise in BP in the morning must be larger in subjects with a low nighttime BP (dippers) as compared to those, whose BP level at night is elevated (nondipper).

O'Brien *et al.* [30] introduced plotting of cumulative sums as a simple statistical technique to analyse trends over time in ambulatory BP recordings. Stanton *et al.* [19] described the method in detail. The height of the cusum plot, which reflects the extent and duration of alterations of BP over time, is a measure for the circadian BP changes in 24-h BP recordings. Stanton found in 22 hypertensive patients with duplicate recordings at a 4-week interval that the repeatability coefficients of systolic and diastolic cusum plot height were 68 and 61%, respectively. Stanton *et al.* [19] and Burn *et al.* [31] hypothesized that the cusums method, which is independent of fixed time periods, would improve precision and reproducibility. In line with this hypothesis [19,31] and the 2003 recommendations of the European Society of Hypertension [32], we applied the cusums approach to a time-window spanning 6 h, including the period of awakening. Our estimates of repeatability were similar to those reported by Stanton for whole-day recordings [19].

The present study must be interpreted within the context of its potential limitations and strengths. We only studied older patients with isolated systolic hypertension. First, our findings might not be generalizable to younger subjects or to the population at large. Second, we did not monitor physical activity by actigraphy and could therefore not adjust for this potential confounder. Finally, investigators used various types of devices to record the ambulatory BP. Nevertheless, our estimate of the repeatability of the cusum plot height was in concordance with Stanton's findings [19]. All recordings in her study [19] were obtained with oscillometric SpaceLabs 90 202 recorders. On the contrary, only one previous study [27] reported on the reproducibility of sleep-through morning surge, over intervals ranging from 4 weeks to 3 months. Our short-term and long-term repeatability study included 173 and 219 patients, respectively. We applied established statistical method to study repeatability, and as recommended by Bland and Altman [20,29] we avoided correlation coefficients as measure of agreement.

In conclusion, the morning surge in BP is poorly reproducible, even at a median interval of only 1 month, irrespective of whether the BP changes during the morning surge are analysed as continuous or categorical variables. Poor reproducibility, however, does not preclude that a statistical parameter derived from ambulatory BP recordings can have prognostic significance, as shown in previous papers on the morning surge in BP [2,6,7,24]. Indeed, Japanese researchers showed that morning surge in BP, in spite of poor reproducibility, added to the stratification of risk both in hypertensive patients [2,6] and the population at large [7,24]. Further research should clarify to what extent, on a continuous scale, the morning surge in BP is a predictor of outcome over and beyond classical cardiovascular risk factors and the 24-h BP.

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There are no conflicts of interest.

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