

The Usefulness of Electronic Activity Measurement for 24-hour Ambulatory Blood Pressure Monitoring

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ABSTRACT

Background and Objectives : The overriding influence of physical activity and the diurnal variation during ambulatory blood pressure monitoring (ABPM) has been well demonstrated. We prospectively evaluated the usefulness of electronic activity monitoring for deriving the actual physical activity and the diurnal variation of ABPM. **Subjects and Methods :** 24-hour ABPM with using an electronic activity monitor was performed on ten normotensive volunteers and fifteen hypertensive subjects. To interpret the ABPM results of the fifteen hypertensive subjects, we obtained the actual awake/sleep periods of every subject with using an electronic activity monitor. **Results :** The activity values obtained from the ten normotensive volunteers correlated well with the values of the blood pressure (BP) and the heart rate. In the hypertensives, the nocturnal mean BP derived by the actual period was significantly lower than that derived by the arbitrary period ($130 \pm 16/81 \pm 13$ mmHg versus $124 \pm 13/77 \pm 12$ mmHg, respectively, $p < 0.05$). The nocturnal BP fall derived by the actual period was significantly larger than that derived by the arbitrary period ($14.9 \pm 8.7/11.6 \pm 7.5$ mmHg versus $21.1 \pm 8.6/16.2 \pm 7.4$ mmHg, respectively, $p < 0.01$). Four among the 7 non-dippers determined by the arbitrary period were re-classified as dippers when the actual period was used. One among the 13 hypertensives, as determined by the arbitrary period, was also re-classified as a non-hypertensive. **Conclusion :** The electronic activity monitor was able to determine the actual activity level. The interpretation of ABPM may be altered by the use of the electronic activity monitor. These results suggest that the accuracy and reproducibility of the 24-hour ABPM will be improved by using an electronic activity monitor. (Korean Circulation J 2006;36:91-98)

KEY WORDS : Ambulatory blood pressure monitoring.

Introduction

Since a person's blood pressure (BP) varies from moment to moment, abnormal BP is difficult to diagnose and treat when this is based on measuring the BP once or twice at the time of visiting the hospital. The change of BP at the time of the measurement is related to the temperature, physical activity, noise, sleep, fatigue, stress and the posture, and it varies not only with the person measuring the blood pressure, but it also depends on the accuracy of the measuring devices, the time and sea-

son of the measurement, and it particularly depends on the normal changes of the 24-hour circadian rhythm.¹⁻³⁾ Twenty-four hour ambulatory blood pressure monitoring (ABPM) is an effective method of assessing the diurnal variations of BP.^{4,5)} Also, the 24-hour ambulatory BP accurately reflects the target organ damage that is caused by hypertension, and the left ventricular hypertrophy,^{6,7)} and it is valuable for determining the prognosis of hypertension and for evaluating the effects of anti-hypertensive drugs.⁸⁻¹⁰⁾

For the analysis of the 24-hour ambulatory BP, it is important to consider the variations of BP that are due to activity and to the fall in BP that occurs during sleep. The effects of activity and the circadian rhythm on the 24-hour ABPM were usually assessed by examining the diaries of patients. However, the diary can be subjective, and the level of activity or the sleeping hours can not be accurately assessed in this fashion. An electronic activity monitor is now widely used both for the quantitative

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assessment of physical activity during the day and for assessing the duration and quality of sleep. Hence, in this study, we employed an electronic activity monitor so that the activity level and sleeping hours could be objectively quantitated and simultaneously measured. Based on this and by analyzing the results of the 24-hour ABPM, we assessed the clinical usefulness of performing electronic activity monitoring.

Subjects and Methods

Normotensive volunteer group

The normotensive volunteer group consisted of individuals who didn't have a history of cardiovascular disease or a diagnosis of hypertension; they were also not taking medication and they had no disease or condition that may have affected their BP. In addition, their casual clinic BP was lower than 140/90 mmHg. The clinic BP of the subjects was measured at 5 minute intervals with the patient in three different positions, i.e., the standing position, the sitting position and the lying position, and all the BP measurements were taken more than 2 times. Ten volunteers between the ages of 25 and 35 years were selected as the normotensive volunteer group for this study. The normotensive volunteer group performed 4 activities: sleeping, sitting, walking (Bruce's protocol stage I exercise loading, speed: 4.0 km/h), and running (Bruce's protocol stage IV exercise loading, speed: 8.0 km/h). Each of the activities was performed with a 30 minutes rest interval between them, and the subjects were wearing a 24-hour ABPM device with the BP and heart rate (HR) being measured at 6 minutes

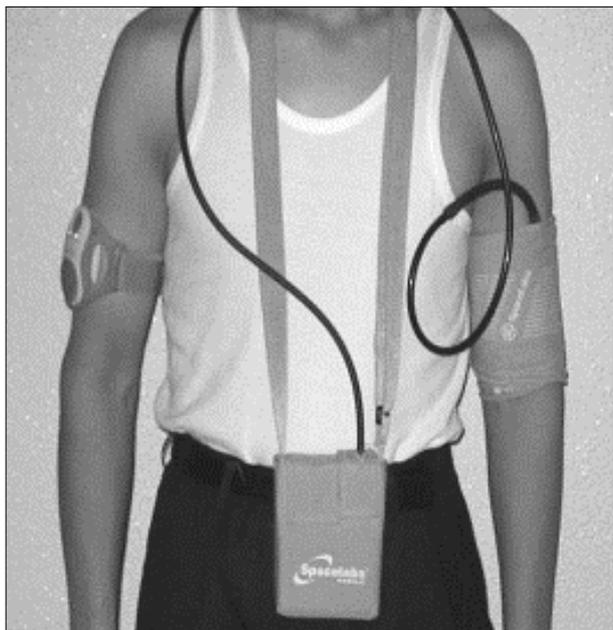


Fig. 1. The subject wore a 24-hour ambulatory blood pressure monitor on the left upper arm and an electronic activity monitoring device on the right upper arm.

intervals. In such a manner, we assessed the relation of the activity level and the BP at each stage, and the relation between the HR and the activity level, as was measured by an electronic activity monitor.

Hypertension patient group

The hypertensive subjects were 15 hypertension patients who visited to Chungbuk National University Hospital, and those patients with diabetes, renal failure, coronary artery diseases, retinopathy higher than grade II, heart failure, metabolic diseases and other systemic diseases in their past and current history were excluded from the study population. The subjects wore a 24-hour ABPM device on their left upper arm and they had an electronic activity monitor on their right upper arm (Fig. 1).

The measurement of the 24-hour ambulatory blood pressure

The Spacelabs Model 90207 Monitor (Spacelabs, Redmond, WA, USA) was used as the 24-hour ABPM device, and a standard adult cuff was used for monitoring the ambulatory BP. The subjects were advised to wear the cuff of the ABPM device on the left upper arm and to carry out their normal daily activities, and they were to stop using their left arm only during the BP measurement.

The measurement of the activity level with the electronic activity monitor

The monitor to measure the activity level was the electronic activity monitor, SenseWear[®] PRO₂ Armband (BodyMedia[®] Body Monitoring System, USA); its weight was 80 g and it was rather convenient to carry. It operates by making contact with the skin and by wearing an armband that is without any special operation method, and it is turned off only by taking off the armband. The subjects were asked to wear the electronic activity monitor on the right upper arm, and the subjects were to wear it at the the same time as wearing the 24-hour ABPM device, as well as taking it off simultaneously with the 24-hour ABPM device. The physiological data that were measured were the activity level, as accessed by the transverse and longitudinal accelerometer, the total energy expenditure, the temperature due to the level of heat generated, the step counter and etc. The device was programmed to measure at 1 minute intervals; after the testing, the physiological data that was stored was analyzed by the InnerView Wearer Software. The activity level assessed by the electronic activity monitoring system was quantitated ($1 g=9.8 m/sec^2$) by the mean of the absolute difference (MAD) via an accelerometer in the electronic activity monitor.

Blood pressure analysis

In regard to the analysis of the fixed day/nighttime BP,

daytime was considered to be from 06 : 00 to 22 : 00, and nighttime was considered to be from 22 : 00 to 06 : 00 of the next day. As a difference from the fixed, arbitrary methods of defining daytime and nighttime, by using an electronic activity monitor in our study, the actual sleeping time was considered as the nighttime, and the period when the activity level was measured was defined as the daytime. We then compared the difference of the BP parameters between the arbitrary method and the actual method with using an electronic activity monitor.

The BP variables analyzed in our study were the maximum/minimum/mean BP, the pressure load, the level of the nocturnal BP fall, the dippers/non-dippers and the number of patients diagnosed as having hypertension. Regarding the pressure load, during the daytime, it was based on a systolic BP of 140 mmHg and a diastolic BP of 90 mmHg, and at the nighttime, it was based on a systolic BP 125 of mmHg and a diastolic BP of 75 mmHg. The percentage of the measurement frequency that was higher than these values was considered as the systolic pressure load and the diastolic pressure load, respectively. The nocturnal BP fall represented the decreased level of the nocturnal BP in comparison with the daytime mean BP, and the patients whose nighttime BP was 10% lower than the daytime BP were defined as the dippers; the patients whose nighttime BP was decreased less than 10% were defined as the non-dippers. The diagnosis of hypertension was arrived at when the mean BP during the 24 hours was higher than 135/85 mmHg, the daytime BP was higher than 140/90 mmHg and the nighttime BP was higher than 125/75 mmHg.¹¹⁾

Statistics

All the data except the number of patients were presented as means \pm standard deviation, and the statistical analysis was performed by MS Window[®] SPSS 10.0 (SPSS Inc, Chicago, IL, USA). All the statistical results with *p* lower than 0.05 were considered as statistically significant. The correlation of the activity level, as measured by an electronic activity monitor, and the BP and HR was analyzed by performing linear regression analysis. In addition, we analyzed, by using paired *t*-tests, the variables of BP of the arbitrary daytime/nighttime dividing method and the actual daytime/nighttime dividing method with using the electronic activity monitor.

Results

The quantitation of the activity level as measured by the electronic activity monitor

When comparing the actual sleeping hours of the hypertensives who were measured by using the electronic activity monitor with the fixed, arbitrary nighttime from 22 : 00 to 06 : 00, we found that the sleeping time and the wake up time were delayed in most cases (Fig. 2).

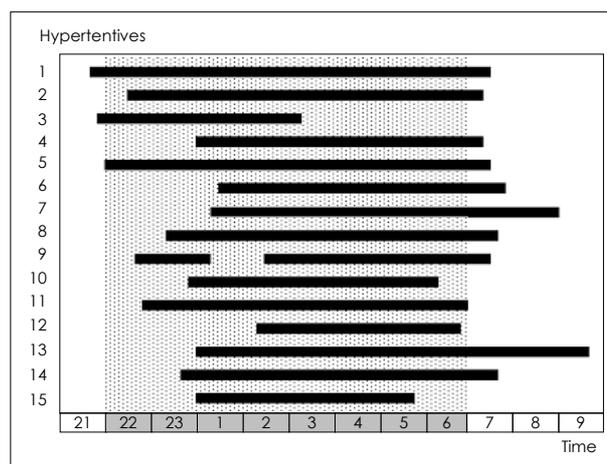


Fig. 2. When comparing the actual sleeping hours of the hypertensives who were measured by the electronic activity monitor with the arbitrary nighttime from 22 : 00 to 06 : 00, the sleeping time and the wake up time were delayed in most cases. The dotted period is the fixed, arbitrary nighttime period (22 : 00 to 6 : 00). The black bar is the actual sleep period for each subject.

In addition, the activity level quantitated by the accelerometer of the electronic activity monitor showed a different value in each patient (Table 1). The daytime MAD measured by the transverse accelerometer was from 511 g to 1,264 g, the daytime MAD measured by the longitudinal accelerometer was from 416 g to 1,065 g and the daytime activity level for each hypertensive subject displayed a very wide range of values. Similarly, the daytime energy expenditure was 1,123 kcal to 2,447 kcal, and the daytime energy expenditure level in each hypertensive showed a difference of as much as over 2 fold. The activity level during sleeping also showed a difference, and this may have indirectly represented the quality of sleep. The nighttime MAD measured by the transverse accelerometer was from 30 g to 91 g, the nighttime MAD measured by the longitudinal accelerometer was from 22 g to 73 g, the energy expenditure was from 216 kcal to 591 kcal, and differences among the individual subjects were detected.

The analysis of the 24-hour ambulatory blood pressure-electronic activity level monitoring in the normotensive volunteer group

In the normotensive volunteer group, the activity level measured by the electronic activity monitor, according to the 4-stage activity, was proportional to the systolic BP, the diastolic BP and the HR (Fig. 3). In the running activity stage, a large value was detected for the transverse and longitudinal activity level. In a similar fashion, the systolic BP, diastolic BP and HR showed a clearly larger value than the ambulatory level in the other 3 stages. In the 3 rest stages, the ambulatory level in each stage was detected to be proportional to the BP and the HR. Based on the activity level measured by the electronic activity monitor in the normotensive volunteer

Table 1. The activity level of the hypertensive subjects, as quantitated by the electronic activity monitor

Activity value No	Awake period			Sleep period		
	Transverse MAD (g)	Longitudinal MAD (g)	Energy expenditure (kcal)	Transverse MAD (g)	Longitudinal MAD (g)	Energy expenditure (kcal)
1	922.6	831.1	2042.5	45.5	42.3	510.9
2	511.1	415.9	1123.4	78.6	64.9	829.7
3	1069.2	724.7	2292.9	29.8	22.1	216.1
4	624.1	587.4	2172.7	35.9	33.9	612.0
5	843.5	716.6	1770.9	77.9	57.1	591.2
6	1137.6	746.6	1854.0	55.1	44.1	479.9
7	1096.2	703.3	1950.7	83.5	57.2	575.1
8	1152.1	1064.9	1644.5	63.7	53.9	460.1
9	898.4	723.0	1604.5	50.0	41.1	414.9
10	921.1	626.0	1420.5	65.0	51.0	425.5
11	646.6	481.8	1594.5	82.8	68.8	489.9
12	1264.2	925.3	2447.5	71.3	56.4	300.7
13	736.1	716.4	1913.8	55.4	47.1	577.5
14	923.4	678.7	1341.8	90.9	72.8	389.2
15	1031.3	997.7	1756.6	43.3	32.9	267.2
Means \pm SD	919 \pm 217	279 \pm 175	1795 \pm 360	62 \pm 19	50 \pm 14	476 \pm 155

The total activity level in each hypertensive subject showed a very wide range. MAD: mean of the absolute difference, 1 g (gravity)=9.8 m/sec²

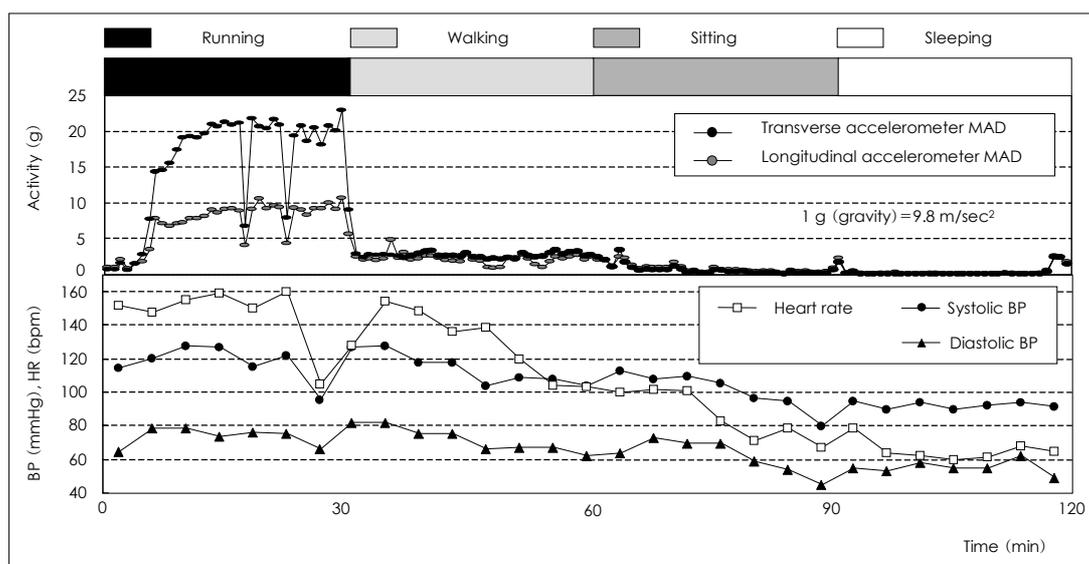


Fig. 3. In the normotensive volunteer group, the activity level measured by the electronic activity monitor, according to the 4-stage activity, was proportional to the systolic blood pressure, the diastolic blood pressure and the heart rate (this is a representative case). MAD: mean of the absolute difference, HR: heart rate, BP: blood pressure.

group, the activity level measured in other individuals could be divided to 4 stages without having to review their diary.

The analysis of the 24-hour ambulatory blood pressure-electronic activity level in the hypertension patients group

To assess the correlation of the activity level, as measured by the electronic activity monitor, and the BP variables in the 15 hypertensives, we examined the correlation of the sum of the activity level during the 20 minutes it took to measure the BP and HR. When we

individually examined the correlation in the 15 hypertensives, a significant correlation between activity and the systolic BP was detected in 14 cases, and a significant correlation was not detected in 1 case. Regarding the diastolic BP, a statistically significant correlation was detected in all 15 cases, and regarding the heart HR and the activity level, a significant correlation was detected in 13 patients; a significant correlation was not detected in 2 patients. As a whole, in all 15 patients, when considering the increment of BP and HR from the lowest value in each subject and when examining their correlation to the activity level, the correlation coefficient of

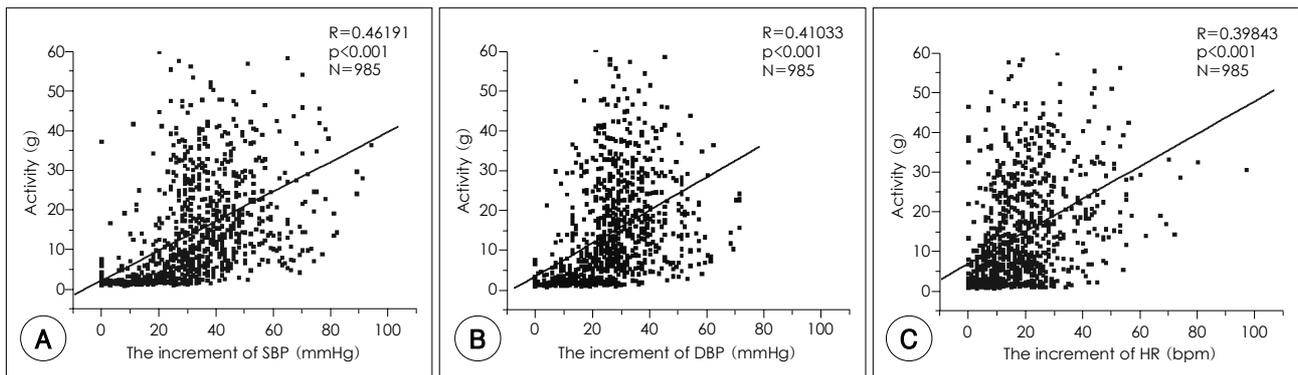


Fig. 4. As a whole, for all 15 patients, when considering the correlation of the increment of blood pressure, heart rate and the activity level, the correlation coefficient showed a statistically significant correlation ($p < 0.0001$). A: the correlation between the activity and the increment of SBP. B: the correlation between the activity and the increment of DBP. C: the correlation between the activity and the increment of HR. SBP: systolic blood pressure, DBP: diastolic blood pressure, HR: heart rate.

Table 2. The mean blood pressure, the blood pressure load and the nocturnal blood pressure fall according to the actual versus arbitrary definition of the sleeping period in the 24-hour ABPM

Parameters	SBP	DBP
Mean BPs (mmHg) [†]		
Arbitrary daytime	145.6 ± 10.1	92.9 ± 9.2
Actual awake	145.8 ± 9.7	93.9 ± 9.2
Arbitrary nighttime	129.6 ± 15.6	81.2 ± 12.2
Actual sleep	123.6 ± 12.8*	77.1 ± 11.6*
BP loads (%) [‡]		
Arbitrary daytime	55.7 ± 26.9	54.5 ± 30.2
Actual awake	60.4 ± 26.4	58.2 ± 31.3
Arbitrary nighttime	58.8 ± 36.3	62.3 ± 38.9
Actual sleep	45.8 ± 39.2	51.8 ± 41.7
Nocturnal BP fall (mmHg) [§]		
Arbitrary	14.9 ± 8.7	11.6 ± 7.5
Actual	21.1 ± 8.6*	16.2 ± 7.4*

Statistics for the continuous measures are shown as means ± SD. SBP: systolic blood pressure, DBP: diastolic blood pressure. *: $p < 0.05$ compared with the other period, †: the nocturnal mean BP derived by the actual period was significantly lower than that derived by the arbitrary period (SBP: $p = 0.014$, DBP: $p = 0.012$). ‡: the daytime-awake BP loads; percentage of the BPs exceeding 140/90 mmHg, the nighttime-sleep BP loads; percentage of the BPs exceeding 125/75 mmHg, §: the nocturnal BP fall derived by the actual period was significantly larger than that derived by the arbitrary period (SBP: $p = 0.008$, DBP: $p = 0.002$)

the activity level and the increment of the systolic BP, the diastolic BP and the HR was 0.46, 0.41 and 0.40, respectively, and all these showed a statistically significant correlation ($p < 0.0001$) (Fig. 4).

The analysis of the 24-hour ambulatory blood pressure by the electronic activity monitor

When comparing the daytime/nighttime BP as defined by the arbitrary method and the actual awake/sleep BP as measured by the electronic activity monitor, a significant difference was detected for several diverse variables. The difference of the BP was bigger during the nighttime. In general, the actual awake BP measured by the electronic activity monitor had a tendency to be slightly higher than the arbitrary daytime BP, and the

sleep BP showed a tendency to be lower (Table 1). The nighttime mean BP measured by the arbitrary method was $130 \pm 16/81 \pm 13$ mmHg, the actual sleep mean BP measured by the electronic activity monitor was $124 \pm 13/77 \pm 12$ mmHg, and the difference between them was $5.0 \pm 5.3/3.4 \pm 3.6$ mmHg ($p < 0.05$) (Table 2). In regard to the nocturnal BP fall, the value for the arbitrary method was $14.9 \pm 8.7/11.6 \pm 7.5$ mmHg, and the value for the actual method was $21.1 \pm 8.6/16.2 \pm 7.3$ mmHg, and a statistically significant difference between them was detected ($p < 0.01$) (Table 2). Regarding the difference of the nocturnal BP loads, by the arbitrary method, the systolic BP load was $58.8 \pm 36.3\%$ and the diastolic BP load was $62.3 \pm 38.9\%$, and for the actual method by the electronic activity monitor, the systolic BP load was $45.8 \pm 39.2\%$ and the diastolic BP load was $51.8 \pm 41.7\%$. Although the difference was not statistically significantly, a difference of $11.0 \pm 14.2\%$ for the systolic BP load and $9.3 \pm 12.4\%$ for the diastolic BP load was detected (Table 2). Hence, we think the difference has important clinical significance.

For the diagnosis of the non-dippers or for the diagnosis of the hypertensive subjects, by using the arbitrary method, 7 patients were diagnosed as non-dippers, whereas by the actual method with using the electronic activity monitor, 3 patients were diagnosed as non-dippers. Hence, it was found that although 4 patients were actually dippers, they were diagnosed as non-dippers by the arbitrary method. In addition, by using the arbitrary method, the number of patients diagnosed as having hypertension was 13 cases, whereas 12 patients were diagnosed as having hypertension by the actual method used in our study. Therefore, it was proven that 1 patient was diagnosed as having hypertension although the patient was not truly suffering with hypertension.

Discussion

ABPM was first performed in the USA in 1962 by

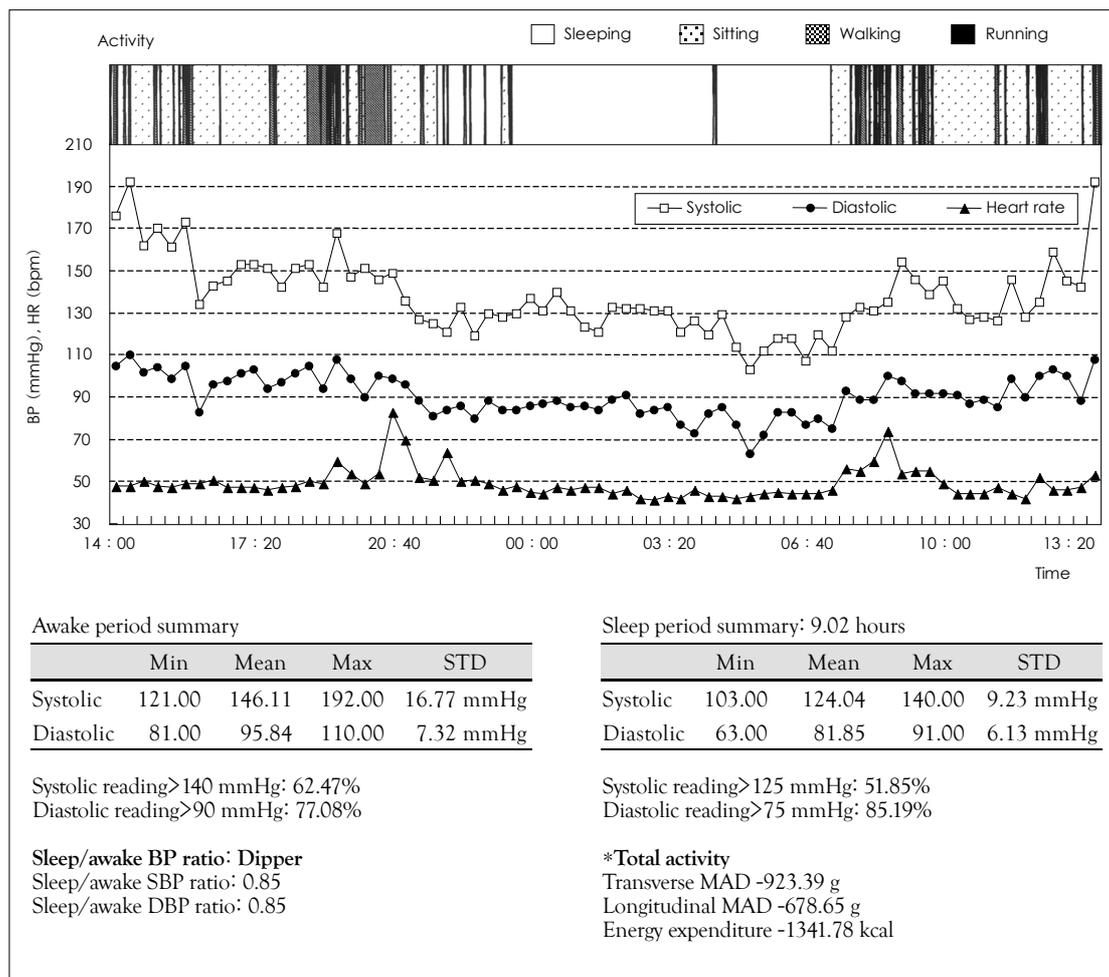


Fig. 5. The activity level measured by the electronic activity monitor and the 24-hour ambulatory blood pressure were presented as a whole, and through this, the accurate analysis of the results of the 24-hour ambulatory blood pressure monitoring was feasible (this is a representative case). BP: blood pressure, HR: heart rate, SBP: systolic blood pressure, DBP: diastolic blood pressure, MAD: mean of the absolute difference.

Allen Hinman and Maurice Sokolow with using a Remler semi-automatic BP monitoring device, and this device has been available in clinics since the 1980s. For the diagnosis, treatment and the determination of the prognosis of hypertension, this device has been reported to be more reliable than using the casual BP measured in the clinic. The advantages of the 24-hour ambulatory BP are the following. First, it is reproducible, second, it lacks the placebo effect, third, the white-coat effect that can be observed in the clinic can be ruled out, and fourth, it can analyze the variability of the BP measurements including the diurnal variation.⁴⁾⁵⁾ Moreover, the accurate diagnosis of hypertension, including borderline hypertension, has been facilitated by 24-hour ambulatory BP.¹²⁾ These measurements have been reported to be more closely correlated to the left ventricular mass index⁶⁾⁷⁾ and the renal damage¹³⁾¹⁴⁾ than the BP as measured in the clinic. Thus, the measurements are more closely associated with the target organ damage. It has also been reported that left ventricular hypertrophy, asymptomatic cerebrovascular stroke and vascular events

were more frequent for the non-dippers in comparison with the dippers,⁷⁾⁸⁾¹⁵⁾¹⁶⁾ which showed the more abundant damage of the target organs in the non-dippers.

In such a manner, with the increased awareness of physicians on the necessity of using the 24-hour ambulatory BP for the diagnosis, treatment and prognosis of hypertension, the accurate interpretation of the 24-hour ambulatory BP is required. The most important factor for the variation of the BP during one day is the circadian rhythm. Within this circadian rhythm, instead of the intrinsic circadian rhythm, the elevation of BP during activity and the dipping of BP during sleeping cause the major variations of BP.¹⁻³⁾ The effect of activity and the circadian rhythm on the 24-hour ambulatory BP were previously assessed with examining the patients' diaries. However, a diary can be subjective, it is difficult to measure accurately and quantitatively, and it has the inconvenience of being prepared by the patients themselves. In addition, for the conventional 24-hour ambulatory BP, the dividing method of the daytime/nighttime BP was analyzed by the arbitrary method; hence, this may

be quite different from the actual sleeping time and the interpretation of the results may be very different. In our study, the electronic activity monitor quantitatively measured the activity level and it accurately assessed the sleeping hours; these factors were accurately and simultaneously analyzed with the 24-hour ambulatory BP, and then their clinical usefulness was examined.

For the normotensive volunteer group, the activity levels measured by the electronic activity monitor were correlated to the four stages of activity, i.e., sitting, walking, running and sleeping. The activity level was proportional to the HR, the systolic BP and diastolic BP; thus, it can be considered that the activity level measured by the electronic activity monitor well reflects the actual activity level, the HR and the BP. Based on this, when assessing the 24-hour ambulatory BP for the hypertensive group, it was found that the activity level of the hypertensive group was also correlated to the HR, the systolic BP and the diastolic BP. One hypertensive did not show the correlation to the increment of systolic BP and 2 hypertensives did not show the correlation to the increment of HR, and these subjects were the patients who almost lacked any significant activity level during the daytime or they were the patients showing minimal variation of their BP. However, on the whole for all 15 hypertensives, the correlation of their increment of the BP variables to the activity level was found to be highly correlated. The study by Gretler et al.¹⁷⁾ and Mansoor et al.¹⁸⁾ has reported that the activity level that was measured electronically and by performing actigraphy correlated to the 24-hour BP, as was assessed with the use of a diary; however, in reality, the activity level of the individuals could be quantitated with using an electronic activity monitor, and this device can record continuous movement from 1 second to several minutes. Thus, in comparison with a diary, making accurate and continuous measurement is feasible. In fact, in several studies performed in Japan on normal subjects,¹⁹⁾²⁰⁾ analyzing the data gathered from actigraphy or via a multi-biomedical recorder (TM2425) allowed measurement of the activity level together with the 24-hour BP, and significant results were reported.

The analysis of the 24-hour ambulatory BP in this study was different from the previous standard that considered the daytime BP to be from 06 : 00 to 22 : 00 and the nighttime BP to be from 22 : 00 to 06 : 00. The time period with the actual activity level was considered as the awake period and the actual sleeping period with a low activity level was considered as the sleep period, and then we analyzed the 24-hour ambulatory BP; the results were well worth paying attention to. The time of night that was used in the previous nighttime BP analysis was from 22 : 00 to 06 : 00, yet the sleeping time and the wake up time were later than that in most cases. When the nighttime was defined based on this,

many of the subjects were not sleeping and they were active at that time and as a consequence, the nighttime BP showed the tendency to be higher than the actual nighttime BP. In the studies by Michael or Kario et al.,²¹⁾²²⁾ a significant difference was detected between the fixed nighttime BP and the actual sleeping BP, and the actual sleeping BP showed the tendency to be slightly lower than the fixed night time BP.

In regards to the level of dipping in the nighttime BP, for the normal individuals during sleeping, approximately 15% of them had a decrease of BP in comparison with the daytime BP (this is considered normal), and the subjects who had a decrease of such nighttime BP of less than 10% were defined as non-dippers, and the non-dipper was reported to be closely associated with the development of cerebral stroke and damage of the target organs.¹³⁻¹⁵⁾²³⁾ Therefore, the prognostic importance of determining who the non-dippers are among the hypertensive patients has increased. The clinical significance of the nighttime BP dipping level, as divided by the actual sleeping BP, was proven by several studies²⁴⁻²⁶⁾ that classified the BP based on a diary and it was proven again in the study by MA Eissa et al.²⁷⁾ that classified BP with using actigraphy. In our study, when the blood pressure was assessed by the arbitrary method, 7 patients were diagnosed as non-dippers, whereas when measuring the BP by using the electronic activity monitor, 3 subjects were diagnosed as non-dippers. Although there were actually 4 patients who were dippers, they had been previously diagnosed as the non-dippers. This was in agreement with the report by F. Nystorm et al.²⁶⁾ showing that when the non-dippers were divided by the actual sleeping BP, there was actually a smaller number of non-dippers than was diagnosed with using other criteria. In our study, a big difference was detected in the nighttime BP, which was also reflected on with the diagnosis of hypertension: the number of patients diagnosed as having hypertension by the arbitrary method was 13, whereas 12 patients were diagnosed as having hypertension by the divided method of using the electronic activity monitor. Thus, 1 case was diagnosed as having hypertension although the patient was actually not hypertensive.

Another clinical useful feature of electronic activity monitor is that the measurement interval of the 24-hour ABPM device can be adjusted. Presently, it is programmed in advance to measure the BP at 15-30 minute intervals during the daytime and at 30-60 minute intervals during the nighttime. If the BP was measured as the sleeping period with the low activity level by the electronic activity monitor, it could be programmed to automatically measure at 1-2 hour intervals, which wouldn't disturb the patients' sleep so much due to the frequent inflation of the BP cuff. In addition, an accurate comparison among the ambulatory BP would be possible for the identical patient cases whose 24-hour

ambulatory BP were followed with measuring the quantitated daily activity level.

Summarizing these results of our study, the activity level measured by the electronic activity monitor and the 24-hour ambulatory BP were presented as a whole, and through this, the accurate analysis of the results of the 24-hour ABPM was feasible (Fig. 5).

In such a manner, measuring the 24-hour ambulatory BP with the electronic activity monitor is more convenient than writing a diary, and quantitative and accurate measurements are feasible as well as the accurate assessment of the circadian rhythm. When comparing BP and the activity level by using an electronic activity monitoring device together with a 24-hour electronic ABPM device, and also when interpreting the daytime/night-time BP by evaluating the actual awake/asleep BP, then a more accurate interpretation of the results of the 24-hour ambulatory BP becomes possible. This may be considered as a breakthrough method that increases the importance of the ambulatory BP and its reliability for the diagnosis, treatment, and prognosis of hypertension. In the future, additional studies should be done to examine whether this method could be used to evaluate the reliability of measuring the 24-hour ambulatory BP in matched patients by using an electronic activity monitor during the follow-up observation of the 24-hour ambulatory BP.

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