NEW PAPERS

Cardiovascular prognosis prediction by a novel home blood pressure stability score: The J-HOP Study

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Introduction

Hypertension is one of the most common chronic conditions globally and plays a central role in the development of major cardiovascular diseases (CVD), including stroke, myocardial infarction, heart failure, and renal dysfunction. Traditionally, diagnosis and treatment evaluations were based primarily on office blood pressure (BP) measurements. However, in the digital age, the importance of home BP monitoring (HBPM) is being increasingly emphasized.

HBPM reflects BP fluctuations in daily life settings, making it excellent for detecting white coat and masked hypertension. Measuring BP over several days allows for assessment of variability and long-term trends, improving risk prediction accuracy.[1] One key advantage of HBPM is the ability to collect a large number of readings, enhancing the accuracy of averages and increasing sensitivity to variability and outliers. Prior evidence shows that BP variability, both in the office and via ambulatory BP monitoring (ABPM), independently predicts cardiovascular risk.[2,3]

Given this context, new predictive indicators and treatment targets based on HBPM have recently been developed.[4-7] This article outlines a novel approach to cardiovascular risk prediction incorporating home BP variability, with a focus on the "Home BP Stability Score (HBPS Score)," developed from the nationwide Japanese cohort study J-HOP (Japan Morning Surge–Home Blood Pressure).[7]

Composition and Evaluation of the HBPS Score

The HBPS Score is a composite metric combining quantitative (mean) and qualitative (variability) aspects of HBPM. It includes the mean systolic BP (MEave) and three BP variability indicators: Average Real Variability (ARV), Peak SBP (average of the three highest SBP readings), and Time in Therapeutic Range (TTR).

The score ranges from 0 to 10. Higher scores indicate more stable and optimally controlled BP, defined as the "stabilized home BP control status" **(Figure 1A, 1B)**. Those in the optimal score range (9-10 points) had a cardiovascular event incidence of 6.4% per 1,000 person-years **(Figure 1C)**.[7]

MEave is the average of systolic BP readings taken three times each morning and evening over 14 days. It serves as the fundamental indicator of baseline BP load. A value below 125 mmHg was considered optimal, while values ≥160 mmHg were classified as high risk, consistent with the Japanese Society of Hypertension's home BP target (SBP <125 mmHg) **(Figure 2A)**. Only 26.7% achieved the 125 mmHg target, but those who did showed significantly better long-term outcomes.[8]

Three BP Variability Indicators Used in HBPS

1. Average Real Variability (ARV) ARV captures day-to-day BP fluctuations by averaging the absolute differences in SBP between consecutive days **(Figure 1A)**. Compared to traditional standard deviation (SD), ARV better reflects real-world fluctuations due to lifestyle stress or irregularities. An ARV ≥8.5 mmHg significantly

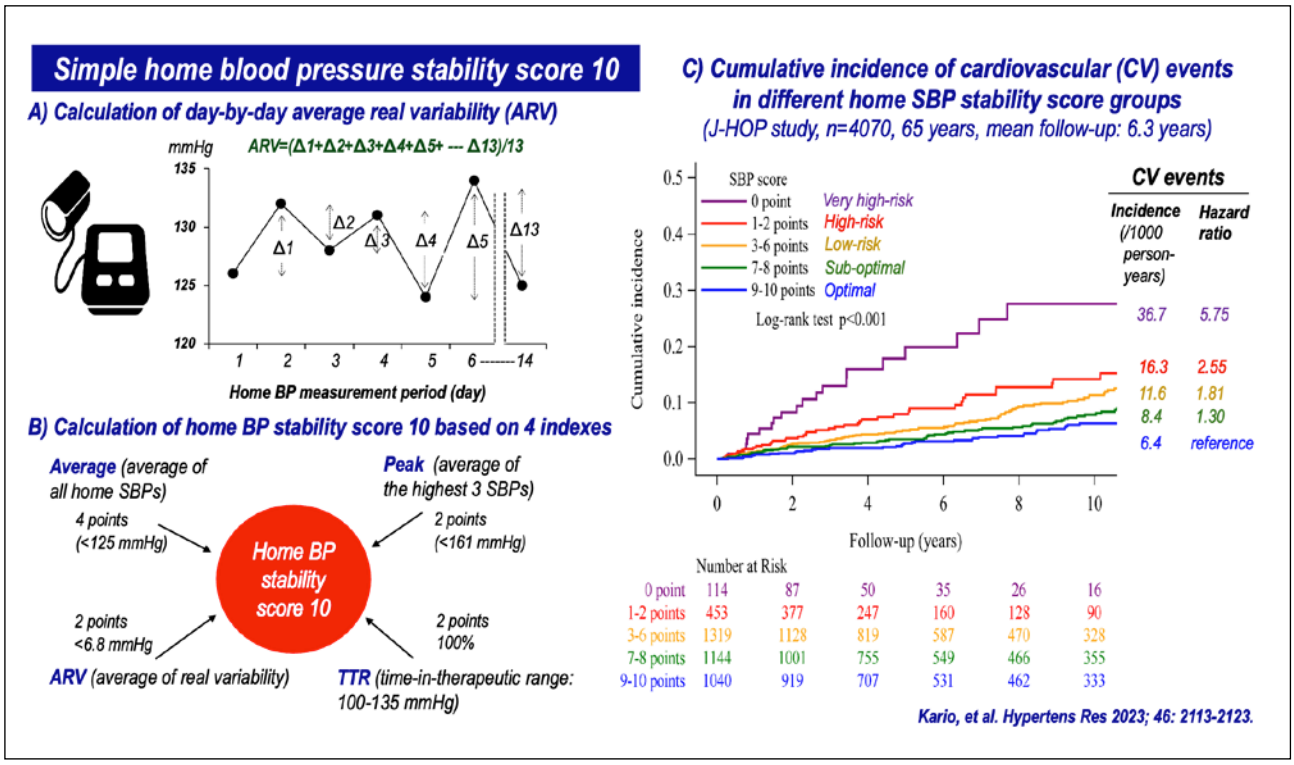

Figure 1. Simple home blood pressure stability score 10

increased event risk **(Figure 2B)** and has been shown to correspond to an aging-related risk equivalent to 15 years.[9]

2. Peak SBP This is the average of the top three SBP values during the measurement period and visualizes extreme momentary BP spikes not reflected in the average **(Figure 2C)**. It is useful for assessing the risk of acute events such as stroke or heart failure. A threshold ≥173 mmHg was associated with a clear increase in risk, consistent with previous findings[5] and defined as the top quintile.

3. Time in Therapeutic Range (TTR) TTR indicates the proportion of time SBP remains within the therapeutic range (100–135 mmHg), reflecting how consistently BP is controlled **(Figure 2D)**. A TTR <15% was associated with a 1.75-fold increase in cardiovascular risk. This threshold has been validated in prior studies.[6]

Predictive Ability of the HBPS Score for Cardiovascular Outcomes

In the J-HOP study, 4,070 outpatients with hypertension (mean age 64.9 years) recorded 14 days of home BP data for HBPS score calculation. Over a mean follow-up period of 6.3 years, 260 cardiovascular events occurred (stroke, heart failure, coronary artery disease, aortic dissection).

Event rates were significantly lower in higher HBPS score groups. Compared to the most stable group (score 9–10), the most unstable group (score 0) had approximately a fourfold increased risk (adjusted hazard ratio: 3.97, 95% CI: 2.22–7.09, p<0.001) **(Figure 1C)**.[7] These associations remained robust after adjusting for age, sex, BMI, diabetes, dyslipidemia, smoking history, and antihypertensive medication use.

Clinical Significance and Potential Applications

The HBPS Score enables risk stratification based solely on home BP, without relying on office-based measurements or expensive diagnostic equipment. It holds particular utility for elderly or immobile patients and in telemedicine. Each component of the score reflects distinct pathophysiological mechanisms: ARV (lifestyle instability), peak SBP (acute stress response), and TTR (long-term BP control). Together, they form a comprehensive risk profile.

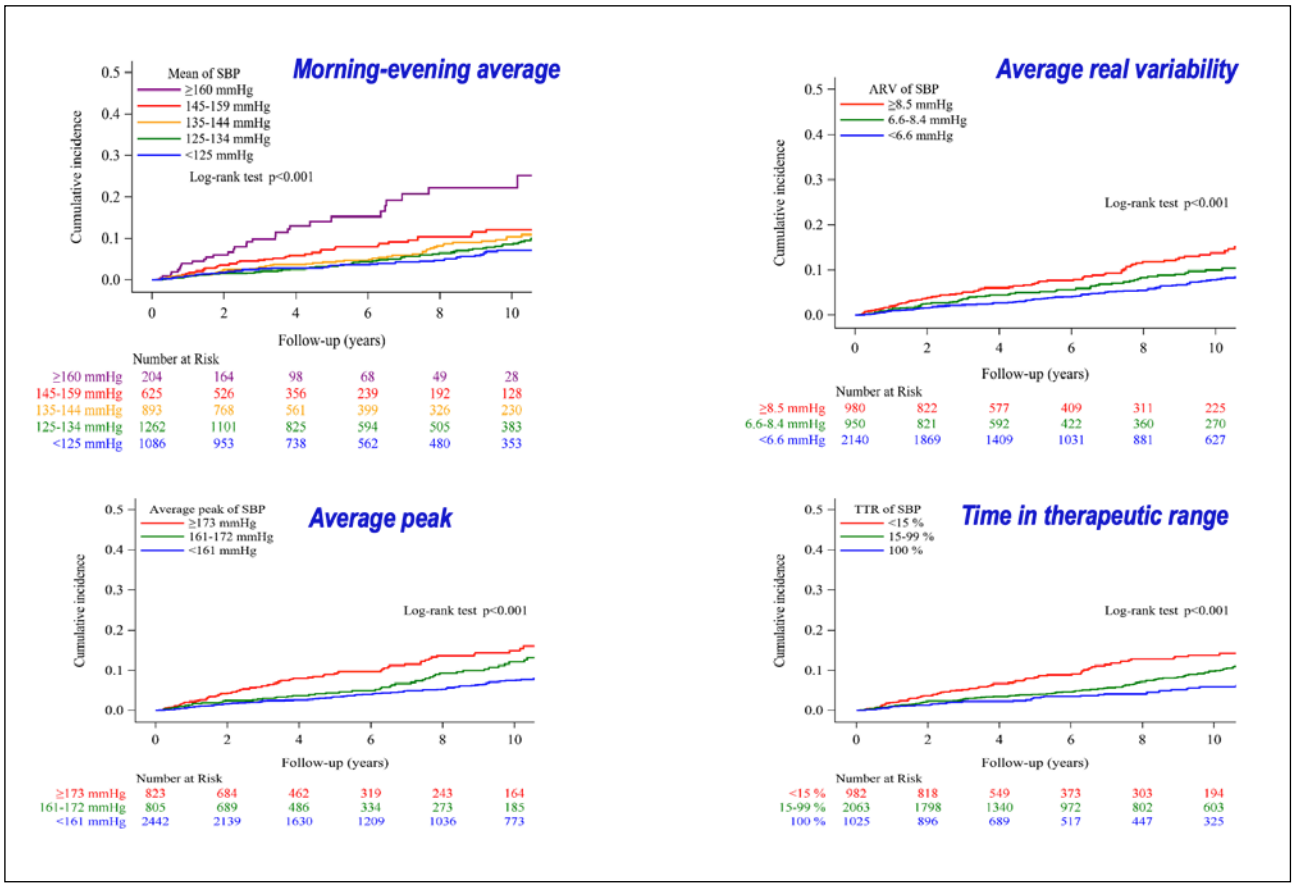

Figure 2. Cumulative incidence of total cardiovascular events by home systolic blood pressure index

Importantly, the HBPS Score supports a paradigm shift from a treatment strategy based only on average BP to one that also values stability and variability. This aligns with personalized and preventive medicine principles.

Limitations and Future Directions

Several limitations should be noted. First, the 14-day monitoring period may not reflect seasonal or long-term treatment effects. Second, nocturnal BP data were not included. Third, the cohort was limited to high-risk Japanese patients, limiting generalizability to other populations.

Future directions include integrating nighttime and 24-hour BP monitoring, extending measurement duration, and enabling real-time evaluations through digital devices and apps.[10] Incorporating artificial intelligence for prediction enhancement and applying these scores in treatment algorithms are also promising avenues.

Conclusion

In clinical practice, using validated BP monitors[11] and applying HBPM-based risk indicators like HBPS can guide optimized, personalized hypertension management. Accelerating research in digital hypertension and integrating multi-dimensional, real-time data could help establish personalized anticipation medicine strategies.[12]

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