Original Article

# Does resting heart rate measured by the physician reflect the patient's true resting heart rate? White-coat heart rate

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ABSTRACT

*Objectives:* In cardiology, resting heart rate (HR) and blood pressure (BP) are key elements and are used to adapt treatment. However HR measured in consultation may not reflect true resting HR. We hypothesize that there may be a "white-coat" effect like with BP and that there may be an association between HR variations and BP variations.

*Methods:* This prospective, monocentric, observational, pilot study (January-April 2016) included 57 consecutive ambulatory patients at Poitiers University Hospital, France (58% male, mean age 64 years). Patients' resting HR and BP were recorded with the same automated blood pressure sphygmomanometer in consultation by the physician then with self-measurement at home.

*Results:* In the overall cohort, we found that HR was significantly higher in consultation (70.5 bpm ± 12.6 vs. 68.1 bpm ± 10.1, p = 0.034). HR also correlated with diastolic BP (r = 0.45, p = 0.001).

Patients were divided into three groups to look for associations with BP: masked HR, (higher HR at home, 38.6%), white-coat HR, (lower HR at home 52.6%) and iso HR, (no change between HR at home and consultation, 8.8%).

Although there was no difference between groups in diastolic BP measured in consultation, home diastolic BP was lower in the white-coat HR group (74.3 mmHg ± 9.8 vs. 77.9 mmHg ± 7.5, p = 0.016).

*Conclusions:* Our study brings to light an exciting idea that could have a major therapeutic and maybe prognostic impact in cardiology: resting HR measured by the physician in consultation does not reflect true resting HR. This must be taken into account to adapt treatment.

## 1. Introduction

Resting heart rate (HR) is part of the basic physical examination in a cardiology consultation. In most cases, HR is determined by the sinus node, under the influence of sympathetic and parasympathetic activity. Many epidemiological studies have shown that high resting HR was associated with greater cardiovascular mortality in ischemic heart disease[1,2] and heart failure,[3] but also in healthy subjects.[4] More recently, studies have shown the prognostic impact of nocturnal HR measured at home in all-cause and cardiovascular mortality.[5,6]<

Resting HR measured by the physician during a consultation is used for therapeutic management in most cardiomyopathies. It is also a basic measurement that needs to be recorded, whatever the patient's complaint. However, due to the great variability of HR,[7] we hypothesize that this measurement may not reflect the patient's true resting HR. This could be explained by a "white-coat effect".[8] This "white-coat"[9–11] phenomenon has already been widely demonstrated in blood pressure (BP) analysis and taken into account in international guidelines.[12] Masked hypertension has also been well described.

However these effects have not been assessed in HR and there are no established values of normal resting HR. Mancia et al.,[13] are the only ones to have shown, thirty years ago, that HR could vary of 15 bpm (beats-per-minute) parallel to blood pressure changes during a consultation with an immediate reversible effect.

Our primary aim is to look for differences between resting HR measured during a consultation by a physician with a validated automated blood pressure sphygmomanometer and HR self-measured at home by the patient with the same device. Our secondary aim is to look for an association between HR variations and BP variations.

## 2. Methods

### 2.1. Study population

This study is a prospective, observational, open, pilot study. It took place in Poitiers University Hospital, France, between January and April 2016. Inclusion criteria were all patients >18 years old seen in standard cardiology follow-up consultation for any reason or in the heart failure clinic (RADIC: Réseau d'aide à domicile pour les insuffisants cardiaques). Exclusion criteria were: atrial fibrillation, presence of a pacemaker or dual or triple chamber internal defibrillator, change in treatment on the day of the inclusion, lack of understanding of self-measurement technique. Patients with single chamber internal defibrillators were included if no pacing was confirmed on the resting ECG during consultation. Patients in atrial fibrillation were excluded because the self-measurement device is not validated in atrial fibrillation. All patients gave their informed consent; the study conformed to the declaration of Helsinki and was approved by the hospital's ethic committee.

### 2.2. Study design

HR and BP were measured in consultation. The same physician recorded all the consultation measurements for the 57 patients. Patients had a 12-lead ECG after 5 min' rest, to identify and exclude those in atrial fibrillation and those paced if they had a single chamber internal defibrillator. Resting HR and conduction abnormalities were reported. After 5 min' rest in a sitting position, with an automated blood pressure sphygmomanometer validated by the French Society of Hypertension, and appropriate cuff size (BP A100 PLUS, MICROLIFE, PARIS, FRANCE), the physician recorded 3 consecutive measurements of systolic BP (SBP), diastolic BP (DBP) and HR. Measurements were separated by 5 min intervals. The 3 measurements were then averaged to obtain the average "consultation HR, SBP and DBP". These are the recommendations of the French Society of Hypertension.[12]

In view of the self-measurements that would be recorded at home with the same device, the physician checked that the patient had understood how to take the measurements correctly. Written instructions were also available in the box containing the device. All measurement devices were identical automated blood pressure sphygmomanometers (BP A100 PLUS, MICROLIFE, PARIS, FRANCE). Either the patient had his own validated device, or one was lent to him after the consultation.

At home the patient recorded his own BP and HR measurements, according to the guidelines on BP self-measurement of the French hypertension society[12]:

−2 series of 3 consecutive measurements, after 5 min' rest in a sitting position, with a 5 min interval between measurements. This was done once at breakfast in the morning and once in the evening before bed on 3 consecutive days.

The patient recorded the 18 measurements of SBP, DBP and HR on a paper document that was given at the inclusion. (Appendix) These measurements were then averaged according to the guidelines of the French hypertension society.[12] When the patient returned the document, the physician checked that the values in the device memory were identical to those transcribed on the paper.

### 2.3. Statistical analysis

Data were analysed using SPSS 20 MAC. The distribution of the data was assessed by visual review when plotted as a histogram, with normality further confirmed using the Kolmogorov Smirnov test. All data were normally distributed and presented as mean ± standard deviation. The student *t*-test was used to compare normally distributed continuous variables between groups. The Chi-squared test, or Fischer test if the sample was less than 5, were used to assess differences in categorical variables between groups. Pearson correlation was used to assess association between HR and BP measurements. We adjusted HR variation to gender with a covariance analysis (ANCOVA). All tests were two-tailed and the cut-off for statistical significance was 0.05.

## 3. Results

60 consecutive patients were included. 3 were excluded because of missing data. All data were normally distributed. Demographic data on study population is presented in Table 1.

### 3.1. Heart rate profile

In the overall cohort, HR in consultation was significantly higher by 2.4bpm (70.5bpm ± 12.6 vs. 68.1bpm ± 10.1) than average HR at home, p = 0.034. Average HR at home in the morning (68.0 bpm ± 10.7) was even further (2.5bpm) from consultation HR (70.5 bpm ± 12.6), p = 0.028. However, the difference between HR at home in the evening and HR in consultation was not significant. (2bpm: 70.5 bpm ± 12.6 vs 68.5 bpm ± 10.6, p = 0.118). Fig. 1 shows the average HR recorded in clinic vs. average HR at home in the evening and then vs. home in the morning. The correlation coefficients (< 1) show us that HR tends to be higher in consultation. Furthermore, the difference is greater between home-morning HR and clinic HR than between evening HR and clinic HR. (0.85 < 0.92).

These differences between morning and evening HR show that it is interesting, as with BP, to average HR measurements recorded at different times of day, and not to rely on one measurement only. We adjusted our results to gender as it has been shown that female sex is an independent predictor for white-coat hypertension.[14] After adjusting to gender we found no significant association between HR variation and gender in a covariance analysis.

**Table 1**
Patient Baseline characteristics.

|  | n = 57 |
|---|---|
| Age (years) (mean ± SD) | 63.8 ± 12.2 |
| Male n (%) | 33 (57.9) |
| Weight (kg) (mean ± SD) | 80.1 ± 19.6 |
| Height (cm) (mean ± SD) | 166.7 ± 9.5 |
| Body mass index (kg/cm²) (mean ± SD) | 28.5 ± 5.7 |
| LVEF (%)(mean ± SD) | 55.4 ± 15.4 |
| Preserved LVEF (>50%) n(%) | 41 (71.9) |
| Reduced LVEF (<40%) n(%) | 16 (28.1) |
| Mid range LVEF (40–49%) n(%) | 0 (0) |
| Treated with a beta-blocker n(%) | 36 (63.2) |
| Dose in equivalent metoprolol (mg) (mean ± SD) | 62.6 ± 57.5 |
| Treated with a non dihyrdopriridine calcium antagonist n(%) | 1 (1.8) |
| Treated with ivabradine n(%) | 0 (0) |
| Treated with LCZ-696 n(%) | 1 (1.8) |
| Internal defibrillator n(%) | 4(7) |
| Ischemic cardiomyopathy n(%) | 21 (36.8) |
| Non ischemic dilated cardiomyopathy n(%) | 10 (17.5) |
| Arrhythmia-induced cardiomyopathy n(%) | 8 (14) |
| Valvular cardiomyopathy n(%) | 2 (3.5) |
| Hypertensive cardiomyopathy n(%) | 31 (54.4) |
| Right bundle branch block n(%) | 5 (8.8) |
| Left bundle branch block n(%) | 11 (19.3) |
| 1st degree atrioventricular block n(%) | 3 (5.3) |
| Follow-up in Heart Failure clinic n(%) | 20 (35.1) |
| Asthenia n(%) | 13(22.8) |
| NYHA I n(%) | 40(70.2) |
| NYHA II n(%) | 16(28.1) |
| NYHA III n(%) | 1(1.8) |
| NYHA IV n(%) | 0(0) |

LVEF: left ventricular ejection fraction, NYHA: New York Heart Association.

**Clinic Heart Rate vs. Home-Evening Heart Rate**

y = 0,92x + 6,96

**Clinic Heart Rate vs. Home-Morning Heart Rate**
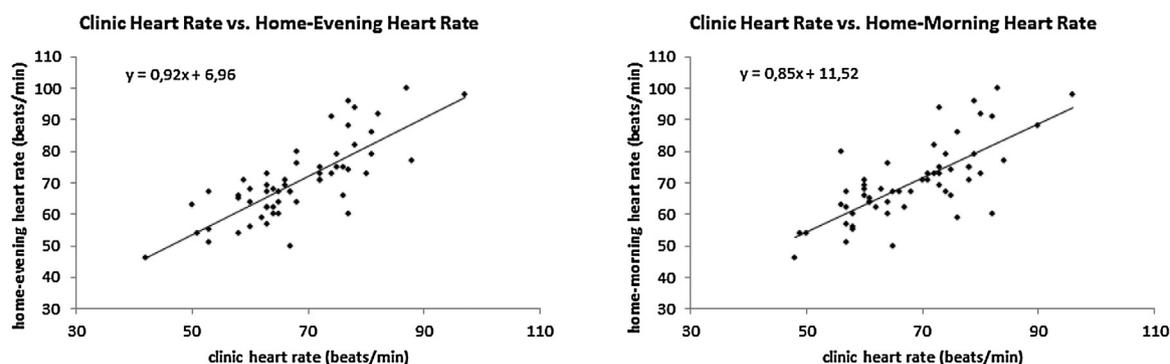
y = 0,85x + 11,52

**Fig. 1.** Heart rate scatter plots.

(p = 0.482) Furthermore, there was no difference regarding mean HR in consultation or mean HR measured at home with self-measurement between male and female subgroups.

Over a quarter (26%) of patients were reclassified as having a HR above or below 70bpm according to with home self-measurement.

`In the HR subgroup analysis, patients were divided into three groups according to the variation in HR between measurement in consultation and home self-measurement. Higher HR with home self-measurement: **masked heart rate** (22 patients, 38.6%), lower HR with home self-measurement: **white-coat heart rate** (30 patients, 52.6%), no variation: **iso heart rate** (5 patients, 8.8%).

This subgroup analysis was to look for an association between BP profile and HR profile and to see if there were significant differences between groups. Demographic data of different groups are presented and compared in Table 2. There was no significant difference in age, gender, height, weight, LVEF, type of cardiomyopathy, treatment, NYHA stage, asthenia, conductive disorders on ECG.

### 3.2. Blood pressure profile

In our overall cohort, home self-measurement systolic (132.32mmHg ± 18.59 vs. 142.2mmHg ± 25.05, p = 0.018) and diastolic BP (76.11mmHg ± 9.33 vs. 80.3mmHg ± 11.48, p = 0.035) were significantly lower than consultation BP.

In our cohort, according to the 2011 guidelines of the French society of Hypertension,[12] 26 patients (45.6%) had true hypertension (BP ≥ 140/90 mmHg in consultation and ≥135/85 with home self-measurement), 11 patients (19.3%) had white-coat hypertension (BP ≥ 140/90 mmHg in consultation and <135/85 with home self-measurement), 2 patients (3.5%) had masked hypertension (BP <140/90 mmHg in consultation and ≥135/85 with home self-measurement) and 18 patients (31.6%) had normotension (BP

**Table 2**
Patient Baseline characteristics in subgroups.

| | White coat heart rate n = 30 | Masked heart rate n = 22 | p |
|---|---|---|---|
| Age (years) (mean ± SD) | 64.3 ± 12.1 | 61.8 ± 12.4 | 0.666 |
| Male n (%) | 20 ± 64.5 | 11 ± 52.3 | 0.523 |
| Weight (kg) (mean ± SD) | 80.9 ± 21.7 | 80.6 ± 17.6 | 0.098 |
| Body mass index (kg/cm$^2$) (mean ± SD) | 28.7 ± 6.3 | 28.4 ± 5.1 | 0.181 |
| LVEF (%)(mean ± SD) | 55.6 ± 15.8 | 55.2 ± 15.0 | 0.926 |
| Treated with a beta-blocker n(%) | 17 (56.7) | 16 (72.7) | 0.235 |
| Treated with LCZ-696 n(%) | 1 (3.3) | 0 (0) | 0.387 |
| Internal defibrillator n(%) | 3 (10) | 0 (0) | 0.253 |
| Ischemic cardiomyopathy n(%) | 11 (36) | 9(41) | 0.756 |
| Non ischemic dilated cardiomyopathy n(%) | 5 (17) | 5(17) | 0.725 |
| Arrhythmia-induced cardiomyopathy n(%) | 4 (13.3) | 3 (14) | 0.975 |
| Valvular cardiomyopathy n(%) | 1 (3.3) | 1 (4.5) | 0.822 |
| Hypertensive cardiomyopathy n(%) | 16 (53) | 11(50) | 0.812 |
| Right bundle branch block n(%) | 3 (10.0) | 1 (4.5) | 0.629 |
| Left bundle branch block n(%) | 7 (23.3) | 2 (9.1) | 0.272 |
| 1st degree atrioventricular block n(%) | 2 (6.6) | 1 (4.5) | 0.746 |
| Follow-up in the heart failure clinic n(%) | 10 (33.3) | 7 (31.8) | 0.908 |
| Asthenia n(%) | 7 (23) | 5(23) | 0.959 |
| NYHA I n(%) | 23 (76) | 16 (73) | 0.746 |
| NYHA II n(%) | 7 (24) | 6(27) | 0.746 |
| Average home HR (bpm) (mean ± SD) | 67.13 ± 11.4 | 69.45 ± 8.2 | 0.397 |
| Average SBP consultation (mmHg) (mean ± SD) | 142.8 ± 25.8 | 139.1 ± 23.3 | 0.435 |
| Average DBP consultation (mmHg) (mean ± SD) | 80.2 ± 11.7 | 79.9 ± 9.4 | 0.867 |
| Average SBP morning home (mmHg) (mean ± SD) | 130.5 ± 19.5 | 134.5 ± 19.6 | 0.774 |
| Average SBP evening home (mmHg) (mean ± SD) | 129.7 ± 18.2 | 130.6 ± 16.7 | 0.586 |
| Average SBP home (mmHg) (mean ± SD) | 130.0 ± 18.4 | 132.5 ± 17.2 | 0.771 |
| Average DBP morning home (mmHg) (mean ± SD) | 75.2 ± 9.8 | 80.0 ± 8.8 | 0.109 |
| Average DBP evening home (mmHg) (mean ± SD) | 73.5 ± 10.5 | 80.0 ± 7.4 | **0.028** |
| Average 24 h DBP home (mmHg) (mean ± SD) | 74.3 ± 9.8 | 77.9 ± 7.5 | **0.016** |

bpm: beats per minute, HR: heart rate, LVEF: left ventricular ejection fraction, NYHA: New York Heart Association, (S, D) BP: (systolic/diastolic) blood pressure

< 140/90 mmHg in consultation and <135/85 mmHg with home self-measurement).

### 3.3. Association between blood pressure and heart rate profile

In the overall cohort analysis, there was a significant correlation between average home DBP and average home HR (r = 0.45, p = 0.001). However no correlation was found with SBP.

There was no difference in SBP or DBP measured in consultation between masked HR and white-coat HR groups.

However, we found that average home DBP (74.3 ± 9.8 vs. 77.9 ± 7.5, p = 0.016) and home evening DBP (73.5 ± 10.5 vs. 80.0 ± 7.4, p = 0.028) where significantly lower in the white-coat HR group than in the masked heart rate group although both groups had the same DBP in consultation.

## 4. Discussion

Our study is the first to introduce this white-coat HR phenomenon, and to demonstrate that the same protocol recommended by the French hypertension society to analyze BP by self-measurement at home, can be used to analyze HR.

We have shown for the first time that HR measured by a physician in consultation with a validated automated blood pressure sphygmomanometer is significantly higher than average HR self-measured at home by the patient with the same device. Furthermore, the technique is easy to use for the patient at home.

In subgroup analysis we found that average home DBP was significantly lower in the white-coat HR group than in the masked HR group although both groups had the same DBP in consultation.

### 4.1. Clinical implications

Many papers have studied the well-known white-coat hypertension phenomenon as defined by the French hypertension society guidelines in 2011. However, there are no papers on this phenomenon in HR. We hypothesized that this effect could exist as BP and HR are closely related. HR has a great variability and it is of major importance in clinical practice to know which HR (measurement in consultation or self-measurement at home) should be used to adjust treatment.

Indeed, all consultation HR measurements are recorded during business hours, and due to HR variability, it is important, as with BP, to have an idea of patients HR in the morning and evening.

HR is used to adjust treatment in recent 2016 ESC heart failure guidelines. [15] In patients with reduced ejection fraction, who remain symptomatic under optimal doses of ACE inhibitor, beta-blocker and mineralocorticoid receptor antagonist, ivabradine should be added if the patient is in sinus rhythm with HR ≥ 70bpm. However there is no information on whether the physician should use HR determined in consultation, with home self-measurement of with a 24-h ECG.

We chose to use home self-measurement rather than ambulatory blood pressure monitoring or 24-h ECG, to record resting HR only. Ambulatory blood pressure monitoring or 24-h ECG would have led to a greater variability in HR with some measurements taken during physical activity and guideline targets are for resting HR, not HR on exercise.

Therefore there are two distinct groups of patients with different BP and HR profiles. It is crucial for the physician to identify which group his patient is in to optimize treatment. It is particularly important to analyze this phenomenon in ischemic heart disease, where the prognostic impact of HR has been demonstrated.[1,2]

Patients in the white-coat HR group risk being overdosed in betablockers, because their HR is artificially high in consultation.

These patients may complain of asthenia or decide they cannot tolerate betablockers, when in fact, they are simply overdosed. This could limit treatment adherence.

Although, we hypothesized a white-coat effect, the masked HR group actually represents almost 40% of the cohort. These patients will not be treated with high enough doses of beta-blockers because physicians will consider that their HR is already too low. Therefore treatment will not be optimized.

These groups behave differently regarding BP as well. We found an interesting association with BP. In the white-coat HR group, HR and DBP are both lower at home. So both these parameters are overestimated by the physician in consultation. This can be explained by the stress induced by a consultation. However, we did not find an association with SBP. This is difficult to explain. However it does not seem to be a statistical coincidence because, in the overall cohort we found that HR and DBP were correlated, but that HR and SBP were not.

### 4.2. LIMITS and FUTURE STUDIES

Every measurement technique has a standard error or repeatability. However there are no publications on the standard error of resting HR measured by automated blood pressure sphygmomanometers. Furthermore, the manufacturer of the sphygmomanometer we used BP A100 PLUS, MICROLIFE, PARIS, FRANCE, gave no information on this point. Nevertheless averaging three measurements each time reduces standard error significantly.

Our sample size was small and our cohort heterogeneous, with diverse cardiomyopathies. This could explain why we did not detect significant differences in age, gender, height, weight, LVEF, type of cardiomyopathy, treatment, NYHA stage, asthenia or conductive disorders between subgroups. It is crucial to do further studies with a greater sample size that could detect differences between masked HR and white-coat HR groups. Some characteristics may predispose patients to be in one or the other group. We found no difference in asthenia levels between groups. However this must be controlled in further studies because we could hypothesize that in the white-coat HR group, patients could be overdosed in beta-blockers.

It would be interesting to analyze HR variation in subgroups (healthy subjects, reduced ejection fraction, preserved ejection fraction, gender, age, ischemic heart disease, dilated cardiomyopathy . . . ).

The prognostic impact of white-coat and masked HR should also be studied, especially in ischemic heart disease. Maybe one group has a greater morbidity-mortality and more major adverse cardiac events.

## 5. Conclusions

Our study brings to light an exciting idea that could have a major therapeutic and maybe prognostic impact in cardiology: resting HR measured by the physician in consultation does not reflect true resting HR.

Large prospective studies are needed to explore this phenomenon in different subgroups (ischemic heart disease reduced and preserved ejection fraction . . . ) and to look at the prognostic impact of masked and white-coat HR on the occurrence of adverse cardiac events.

## Conflicts of interest

The authors declare that there are no conflicts of interest.

## Funding

## What is already known?

1. Resting HR measured by the physician during a cardiology consultation is a key element and is used to adapt treatment.
2. There is a great variability in HR therefore resting HR measured by the physician may not reflect the patient's true resting HR.
3. There may be a "white-coat" effect similar to the phenomenon that has already been widely demonstrated in BP analysis and taken into account in international guidelines.

## What this study adds?

1. Resting HR measured by the physician in consultation does not reflect true resting HR.
2. HR measured by a physician in consultation with a validated automated blood pressure sphygmomanometer is significantly higher than average HR self-measured at home by the patient with the same device.
3. It is crucial for the physician to identify which group his patient is in to optimize treatment.

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## Appendix A

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