

# INFLUENCE OF GENDER, TRAINING AND CIRCADIAN TIME OF TESTING IN THE CARDIOVASCULAR RESPONSE TO STRESS TESTS

I. Alonso, J. R. Fernández, R.C. Hermida, A. Mojón  
Bioengineering & Chronobiology Labs.  
Signal Processing Department, University of Vigo, Spain.

**Abstract** - Several studies have been performed on the cardiovascular response to physical and psychical stress and their value as early predictors of hypertension. The conclusions of these studies have been discrepant or even opposite. These discrepancies could be due in part to factors such as the time when the test is done, the degree of training of the subject in relation with the test, or the gender, usually ignored in the design of the trials. We have tested the statistically significant influence of these factors in the cardiovascular response to a physical and psychical test repeated several times at different circadian times in normotensive volunteers of both genders<sup>a</sup>.

**Keywords** - Stress test, Isometric test, Psychical test, Blood pressure, Heart rate, Circadian variability, Hypertension.

## I. INTRODUCTION

The relation between blood pressure (BP) increase during stress tests and future levels of BP is still under study. It is believed that hyperreactors to stress tests, that is, subjects with big BP increases, can be habitual overresponders to different stimulus and the repeated episodes with high BP can lead to sustained hypertension. Most researches agree on the large and statistically significant pressor effect due to stress tests in normotensive and hypertensive subjects [1-6]. The prognostic value of several stress tests has also been investigated and opposite results have been found. BP increase during several stress tests, such as bicycle exercise [2], isometric test [3], color word test [3] or cold pressor test [1,4], has been suggested as a potential predictor of future development of hypertension. Positive family histories of hypertension have also been related with higher BP increases during physical and psychical tests [3]. On the other hand, some studies question the use of BP increases in mental and cold pressor tests as clinical indexes of the course of future BP [5] or suggest weak predictive capacity of BP reactivity to dynamic and isometric exercise [6]. We think the differences among the conclusions can be due not only to methodological grounds or the definitions of hyperreactivity, but to ignoring in some cases important factors in the analysis of the results, such as gender, the time when the test was done or the number of times the subject did the test previously. In order to evaluate the possible influence of these factors on the cardiovascular response to psychical and physical stress tests, we studied the evolution of BP and heart rate (HR) of a group of young normotensive subjects who repeated the same stress test at different circadian times.

## II. METHODS

We studied 114 apparently healthy young normotensive subjects (59 men), without medical history of hypertension,  $21.2 \pm 2.3$  (mean  $\pm$  SD) years of age (range 18 to 27), who underwent the same stress test at least one week apart at three different circadian times: morning (MN, 09:00 to 11:00 h), afternoon (AF, up to 90 min after lunch), and evening (EV, 18:00 to 21:00 h). The order of the tests was assigned to each volunteer using a random table following a latin-square design and according to the order of recruitment. The test was divided in three 5-min resting periods with the subjects remaining seated, and two 3-min stress tests (the first psychical and the second physical) done after the first and second resting periods, respectively. In the psychical test, the subjects tried to follow an irregular path drawn on a paper, using a pen with their non-dominant hand, and looking to the path through a mirror. The physical test consisted on an isometric handgrip exercise test. BP and HR were sampled during the whole test every min with a Colin BP-103N automatic device (San Antonio, TX). The mean BP and HR values obtained for each minute of the test were compared among groups divided by gender, circadian time of the test, and number of times the test was previously done for each subject using a parametric t-test and ANOVA.

## III. RESULTS

The mean values of systolic BP (SBP) and HR are represented in Figs. 1 and 2, respectively, for both genders. Men present higher mean BP and lower mean HR, as expected [7]. In general, mean increases in the response are higher in men for both variables. Differences between men and women are highly statistically significant. The mean SBP difference is above 10 mm Hg at many times during the test.

The most remarkable difference between the behavior of BP and HR is that BP has a mean decreasing trend during the first resting span, whereas HR presents an increasing trend.

Comparing the results of the test performed at different circadian times, the highest difference is found in mean HR between AF and MN or EV. These mean differences are statistically significant for more of the 95% times of measurement for both genders. The mean difference between AF and MN is about 5 beats/minute and between AF and EV about 7 beats/minute. There are also differences in BP at different test times of testing. BP presents lower mean values in the morning (Fig. 3), and the differences between MN and AF or EV are statistically significant at several sampling times.

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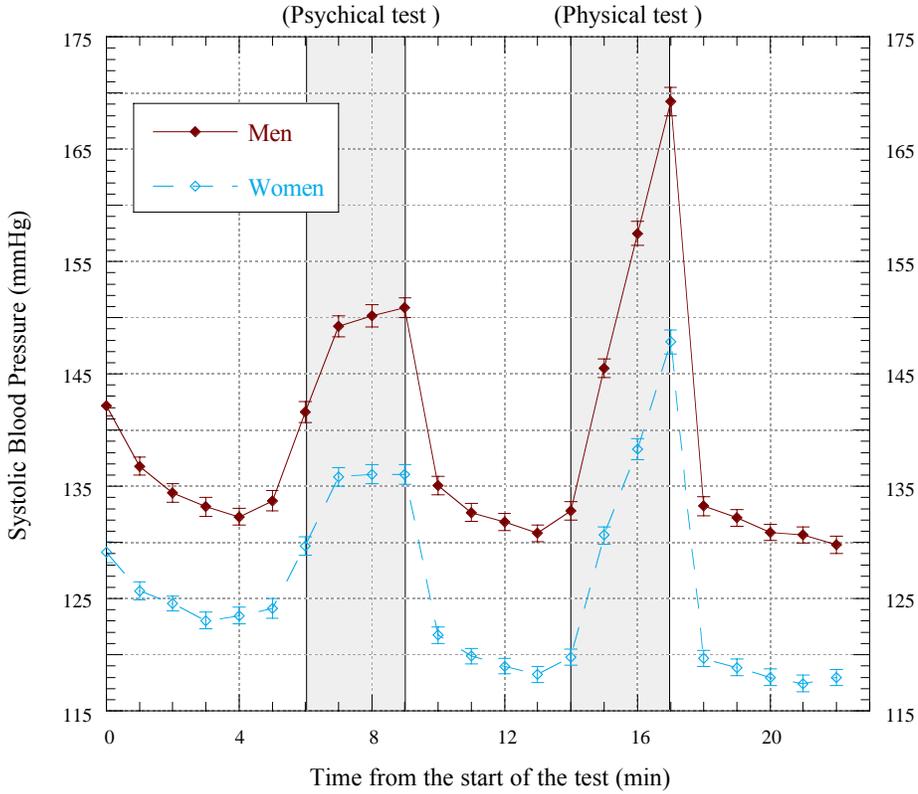


Fig. 1. Average SBP for men and women

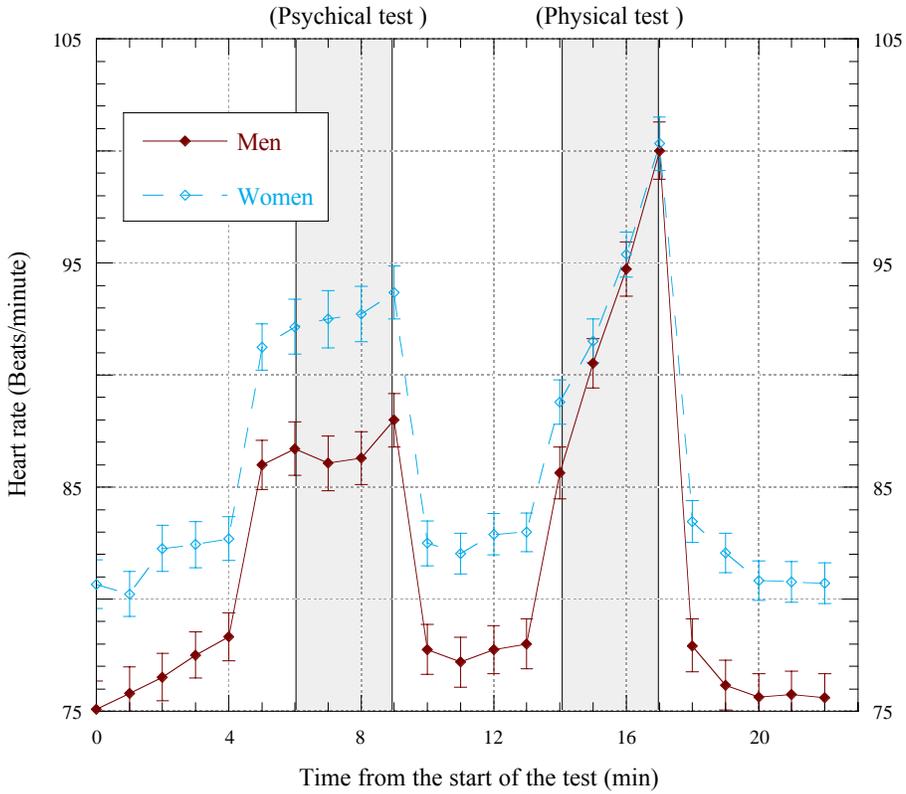


Fig. 2. Average HR for men and women

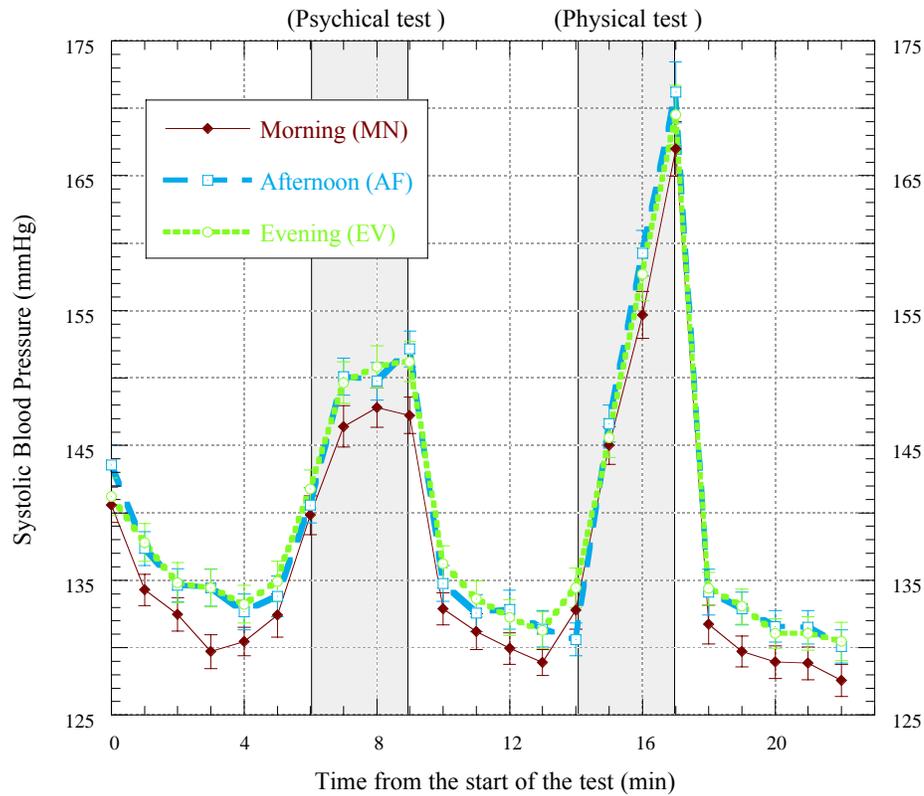


Fig. 3. Average SBP for men at different circadian times

In general, differences are more frequently significant in SBP than in diastolic BP (DBP) or mean arterial BP (MAP), and more pronounced in men than in women. Differences evaluated for the mean values at the different stages of the test are included in Table I, where the p-values show the statistically significant differences between MN and AF or EV.

We also compared the results of the different realizations of the stress test by the same subjects. The mean BP tends to decrease from the first to the third realization of the test. As it can be observed in Fig.4 for SBP in women, this response reduction is specially outstanding during the first half of the test, until the psychological trial ends. The highest quantitative

differences and the largest number of statistically significant differences are present between the first and the third realization.

#### IV. DISCUSSION

The highly predictable circadian rhythm of large amplitude in BP and HR has been shown in many studies [7,8]. Therefore, statistical significant differences on these variables in relation to the circadian time when the stress test is performed are somehow expected. As circadian models suggest, BP levels during the stress test are lower in the morning than in the evening or in the afternoon.

TABLE I  
AVERAGE VALUES FOR EACH SUBJECT WERE CALCULATED IN THE DIFFERENT STAGES OF THE TEST. IN THIS TABLE THE OBSERVED DIFFERENCES OF THESE AVERAGES BETWEEN THE DIFFERENT CIRCADIAN TIMES WHEN THE TEST WAS DONE ARE INCLUDED. SMALL P-VALUES REPRESENT STATISTICALLY SIGNIFICANT DIFFERENCES BETWEEN CIRCADIAN TIMES.

	MN-AF		MN-EV		AF-EV	
	Average Difference	p-value	Average Difference	p-value	Average Difference	p-value
First Resting Period	-2.71	0.009	-2.89	0.019	-0.19	0.861
<b>Psychical test</b>	-3.46	0.002	-3.49	0.009	-0.03	0.993
Second Resting Period	-1.61	0.090	-2.20	0.018	-0.59	0.600
<b>Physical test</b>	-2.16	0.015	-1.95	0.170	0.21	0.877
Third Resting Period	-2.78	0.002	-2.58	0.007	0.20	0.852

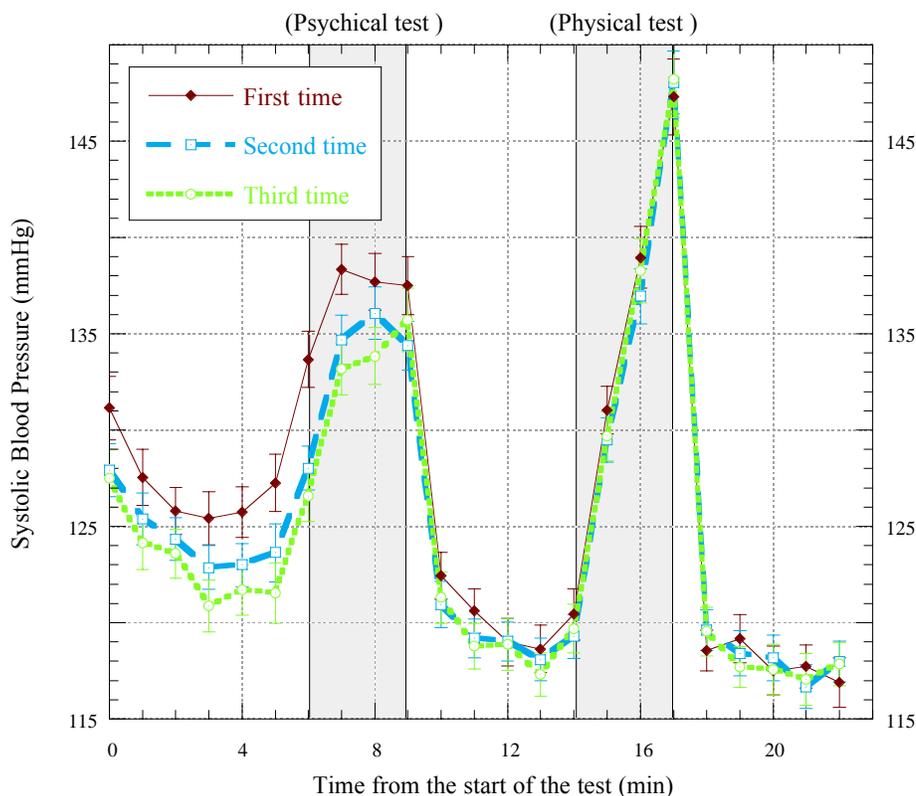


Fig. 4. Average SBP for women at different realizations of the test.

The differences found in the stress test between men and women are also expected. Many epidemiological studies of ambulatorily monitored BP have found significant gender differences for both BP and HR [7,9].

The results also indicate a significant influence of training in the response to the stress test. Psychological state affects BP and HR, and an additional pressor effect due to the novelty of the stress test should be inferred. This novelty effect is somehow diminished when the same subjects repeated the test on successive occasions.

All these factors make a significant contribution to the cardiovascular response to stress. Ignoring gender, training, and circadian time of testing can introduce an important bias on the potential use of stress tests for the evaluation of cardiovascular risk.

## V. CONCLUSION

When performing physical and psychological stress tests, factors such as the time of the day when the test is done, the degree of experience of the subjects doing the test several times, or the gender, significantly affect the cardiovascular response to the test, evaluated in terms of BP and HR. These factors should be taken into account when studying the prognostic value of physical activity in patients with cardiovascular disease or the predictive value of stress when evaluating subjects at risk of

developing hypertension. These results may account for some discrepancies in the literature.

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