

## **Influence of Coronary Artery Disease over Exercise Systolic Blood Pressure in Men with Hypertension**

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### **Abstract**

**Aim:** Disclosing coronary artery disease by analyzing the rates of systolic blood pressure response to workload during exercise stress test. **Methods:** 53 males with hypertension underwent exercise stress test on bicycle ergometer and coronary angiography within one month. Rates of systolic blood pressure to workloads in the first stage peak exercise, second, fourth and sixth minute of recovery were analyzed and compared. Also basic characteristics of patients involved in the study were also analyzed. **Results:** All systolic blood pressure to workload rates during exercise and recovery resulted higher in males with coronary artery disease and hypertension compared with hypertension but no coronary artery disease. **Conclusion:** High levels of systolic blood pressure to workloads rates in males with hypertension reveal the diagnosis of coronary artery disease despite the ECG variations during exercise stress test and this are not influenced by other basic characteristics of the patients.

**Keywords:** Coronary Artery Disease, Exercise Systolic Blood Pressure, Men, Hypertension

### **Introduction**

There is much interest in correlation between blood pressure response during exercise in patients with coronary artery disease (CAD). Some of the studies have documented that the abnormal response of systolic blood pressure (SBP) post exercise in patients with angina pectoris was a predictor of severe ischemia of the myocardium during exercise and can be the cause of increasing stroke volume of the left ventricle in the setting of increased peripheral vascular resistance and sympathetic tone (Amon 1984, Hashimoto 1993, Bourque 2015, Grogan 1993, Naimark 1992, Lin 2015, Kontsas 2013). Also has been shown that abnormal post exercise blood pressure response of SBP can be useful in detecting the CAD in patients with and without high blood pressure (HBP)(Lin 2015). In our point view is not the peak systolic blood pressure that determines the SBP response during recovery but, instead it is the workload (WL) which provokes the SBP response during exercise and as a consequence also during the recovery. In this study we have investigated rates of systolic blood pressure response to workloads during exercise but also during recovery in men with hypertension.

## Methods

In the study were included 53 men patients with hypertension from 40 to 60 years old. All patients underwent a progressive maximal or symptom limited exercise stress test (EST) with stages lasting 3 minutes each. EST were performed with ergometric bicycle. All the patients underwent coronary angiography within one month. According to coronary angiography result patients were divided in two groups. The first group 17 individuals with normal coronary arteries and the second group 36 with CAD.

The following parameters are analyzed.

1. Rate between SBP in the third minute of the first stage of exercise to the workload at that stage.
2. Rate of peak SBP to the peak workload.
3. Rates of the SBP in the second, fourth and sixth minute of recovery to peak workload.

## Statistical analyses

All the variables are compared between two groups with *t* test .To determine the role that other independent factors to SBP is used stepwise regression analyses.

## Results

Basic characteristics of hypertensive man with or without CAD as age , height , body mass index (BMI) ,ejection fraction of the left ventricle and blood pressure during rest ,different stages od exercise and recovery do not show significant difference statistically. Table 1. While workload in the first stage 39 to 31 watt  $p < 0.0018$  and peak workload 139 to 103,  $p 0.0025$  watts were significantly higher in males with normal coronary arteries in comparison with those with CAD .On the other hand the percentage of achieved heart rate was significantly higher in hypertensive males with normal coronary arteries in comparison to the hypertensive man with CAD 84.3 to 71.9 %  $p < 0.0007$ .

Characteristics	Normal coronary <u>angiography</u> Mean (SD)	P-Value	Abnormal coronary <u>angiography</u> Mean (SD)
Age, y	47.8 (7.4)	0.054	52.3 (7.7)
Weight, kg	80.4 (10.4)	0.16	76.6 (8.1)
Height, m	1.72 ((0.05)	0.0	1.72 (0.03)
Body mass index	27.3 (2.8)	0.1	26.0(2.6)
Ejection fraction, %	0.73 (0.09)	0.5	0.64 (0.13)
Systolic blood pressure at rest, mm Hg	146 (11.4)	0.56	148 (15.9)
Systolic blood pressure at the end of 1 <sup>st</sup> exercise stage, mm Hg	190 (20.8)	0.48	181.5 (18.1)
Peak systolic blood pressure, mm Hg	206 (27.8)	0.18	196 (21.3)

<i>Systolic blood pressure at recovery minute 2</i>	160 (18.6)	0.88	160.8 (19.3)
<i>Systolic blood pressure at recovery minute 4</i>	145.6 (14.9)	0.38	149.9 (16.5)
<i>Systolic blood pressure at recovery minute 6</i>	136.9 (16.1)	0.076	145.2 (12.3)
<i>Starting work load, watt</i>	39.0 9(11.1)	0.0018	31.0 (6.5)
<i>Peak work load, watt</i>	139.0 (39.7)	0.0025	103.0 (37.4)

Table 1: Characteristic of both hypertensive men with normal and abnormal coronary angiography

Differently from SBP the rates of SBP to workloads during exercise and recovery were significantly higher in males with hypertension and coronary artery disease Tab 2 .So the mean difference between the rates of SBP to workload in the first stage was 1.047 (CI 95 % 0.283 –1.81 p=0.0082) .

The mean difference of peak SBP / WL was 0.668 (CI 95 %, 0.16 –1.176, p=0.011)

The mean difference of SBP / WL in the second minute of recovery was 0.587 (CI 95 %, 0.146 –1.027, p=0.01).

Table 2. Systolic blood pressure to workload rates (SBPR) in hypertensive men with normal and abnormal coronary angiography

<i>Systolic blood pressure rate (SBPR)</i>	<i>Normal coronary angiography Mean (SD)</i>	<i>P-Value</i>	<i>Abnormal coronary angiography Mean (SD)</i>
<i>Starting SBPR</i>	4.461 (1.399)	0.0082	5.507 (1.241)
<i>Peak SBPR</i>	1.582 (0.578)	0.011	2.251 (0.921)
<i>Recovery minute 2<sup>nd</sup> SBPR</i>	1.253 (0.422)	0.0101	1.840 (0.850)
<i>Recovery minute 4<sup>th</sup> SBPR</i>	1.130 (0.454)	0.009	1.718 (0.802)
<i>Recovery minute 6<sup>th</sup> SBPR</i>	1.041 (0.315)	0.0038	1.652 (0.765)

The mean difference of SBP / WL rate in the fourth minute of recovery was 0.587 (CI 95 %, 0.154 –1.021, p=0.01).

The mean difference of SBP / WL rate in the sixth minute of recovery was 0.612 (CI 95 %, 0.208–1.015, p=0.0038).

Analyses for sensitivity, specificity and correctness of the test for first stage SBP/WL was 80, 60.7 and 47.2 % respectively.

Analyses for sensitivity, specificity and correctness of the test for peak SBP/WL was 87.5, 65.9 and 64.6 % respectively.

Analyses for sensitivity, specificity and correctness of the test for SBP/WL in the fourth minute of recovery was 71, 75 and 72.3 % respectively.

The criterion of positivity of the stress test according to ECG was 85.3, 72.2 and 66.7 % for sensitivity, specificity and correctness of the test respectively.

This shows that higher levels of SBP to WL rates can detect CAD independently from the ECG changes during stress test in this subset of patients.

Stepwise regression analyses showed that age, weight, height, body mass index, heart rate and diastolic pressure do not have any influence on the SBP to WL rates. Table 3.

Table 3. Determining factors in hypertension men with normal and abnormal coronary angiography

SBP / WL Rates	Normal coronary angiography		Abnormal coronary angiography	
	Coefficient (SE)*	Adjusted R2	Coefficient (SE)*	Adjusted R2
<i>Starting SBPR</i>				
<i>Intercept</i>	5.213 (0.623)		4.475 (0.83)	
<i>Starting SBP</i>	0.024 (0.004)	0.96	0.033 (0.004)	0.86
<i>Starting workload</i>	-0.118 (0.006)		-0.114 (0.011)	
<i>Peak SBPR</i>				
<i>Intercept</i>	2.27 (0.483)		2.833 (0.653)	
<i>Peak SBP</i>	0.006 (0.002)	0.84	0.009 (0.003)	0.82
<i>Peak workload</i>	-0.013 (0.002)		-0.023 (0.002)	
<i>Recovery 2 SBPR</i>				
<i>Intercept</i>	2.58 (0.208)		3.877 (0.22)	
<i>Peak workload</i>	-0.01 (0.001)	0.76	-0.02 (0.002)	0.75
<i>Recovery 4 SBPR</i>				
<i>Intercept</i>	2.609 (0.208)		3.656 (0.203)	
<i>Peak workload</i>	-0.01 (0.001)	0.78	-0.019 (0.002)	0.76
<i>Recovery 6 SBPR</i>				
<i>Intercept</i>	2.215 (-0.16)		3.539 (0.192)	

Peak workload	-0.008 (0.001)	0.88	-0.018 (0.002)	0.79
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\*SE, is standard error

## Discussion

In normal individuals systolic blood pressure response is directly connected to the increase of the workload (WL). But this is partially true when there is CAD. There is no consensus which are the values of peak SBP that can be considered exaggerated response. Different investigators have considered as such the increase of peak SBP over 220 mmHg for males and 190 mmHg for females (Matthews 1998, Ha 2002). Exaggerated increase of SBP during exercise is related mostly with the prediction of having high blood pressure in the future (Jae 2015, Grossman 2014) and only weakly with the presence of CAD or mortality (Matthews 1998, Ha 2002, Hedman 2020). According to the fact that increasing blood pressure response is stimulated from the workload we have supposed that also the decrease of blood pressure during recovery is connected directly to the workload and not to peak SBP (Kamberi 1984). As a consequence this could be shown by the rate of SBP to workload. In previous studies has been shown that individuals with normal stress test and those with positive test did not show any change in peak SBP. Our results show that although the peak SBP and recovery SBPs don't show any difference between hypertensive men with or without CAD. Their peak workload was significantly different being significantly lower with those with the presence of CAD. Tab 1. It is evident that the increase of SBP in hypertensive males with CAD is disproportionate to the increase of the workload. This disproportionate increase of SBP to workload was evident in first stage SBP/WL rate and in the peak SBP/WL rate (tab. 2). So the increase of SBP should be considered exaggerated not based on the measured SBP values but from the value of SBP to workload rate. This study documents that higher levels to SBP to workload rates can detect the presence of CAD in hypertensive males with at least the same accuracy as ECG changes during stress test.

In special occasions the first stage SBP to WL rate can be of special importance because there are people that cannot perform more than one stage. In most of these cases stress ECG is normal and this SBP/WL rate in first stage is the only parameter that allows us to show the presence of CAD. Also our study shows that the slow SBP decrease during recovery can show the presence of CAD. But the rates of SBP to workload are more certain even if the peak SBP cannot be measured correctly. On the other hand the rates of SBP to WL represent sensitivity, specificity and test accuracy totally comparable with ECG depression of ST segment during stress test. Stepwise regression analysis show that for the exercise SBP to workload rates only the starting workload and starting SBP and peak workload and peak SBP were determining factors meanwhile for the SBP to workload rates in recovery the only determining factor was the peak workload. This is a strong prove of our hypothesis that in normal people not only the increase of SBP during exercise but also the decrease of SBP during recovery are dependent on the workload. is very important to emphasize that in hypertensive males with or without CAD rates of SBP to workload are not influenced by age, BMI, heart rate and systolic and diastolic blood pressure in rest. This surely increases the importance of rates of systolic blood pressure to workloads.

**Conclusion:** *High levels of systolic blood pressure to workloads rates in males with hypertension reveal the diagnosis of coronary artery disease despite the ECG variations during exercise stress test and these findings are not influenced by other baseline characteristics of the patients.*

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