

# Influence of heart rate on determination of cardiovascular risk using central aortic blood pressure

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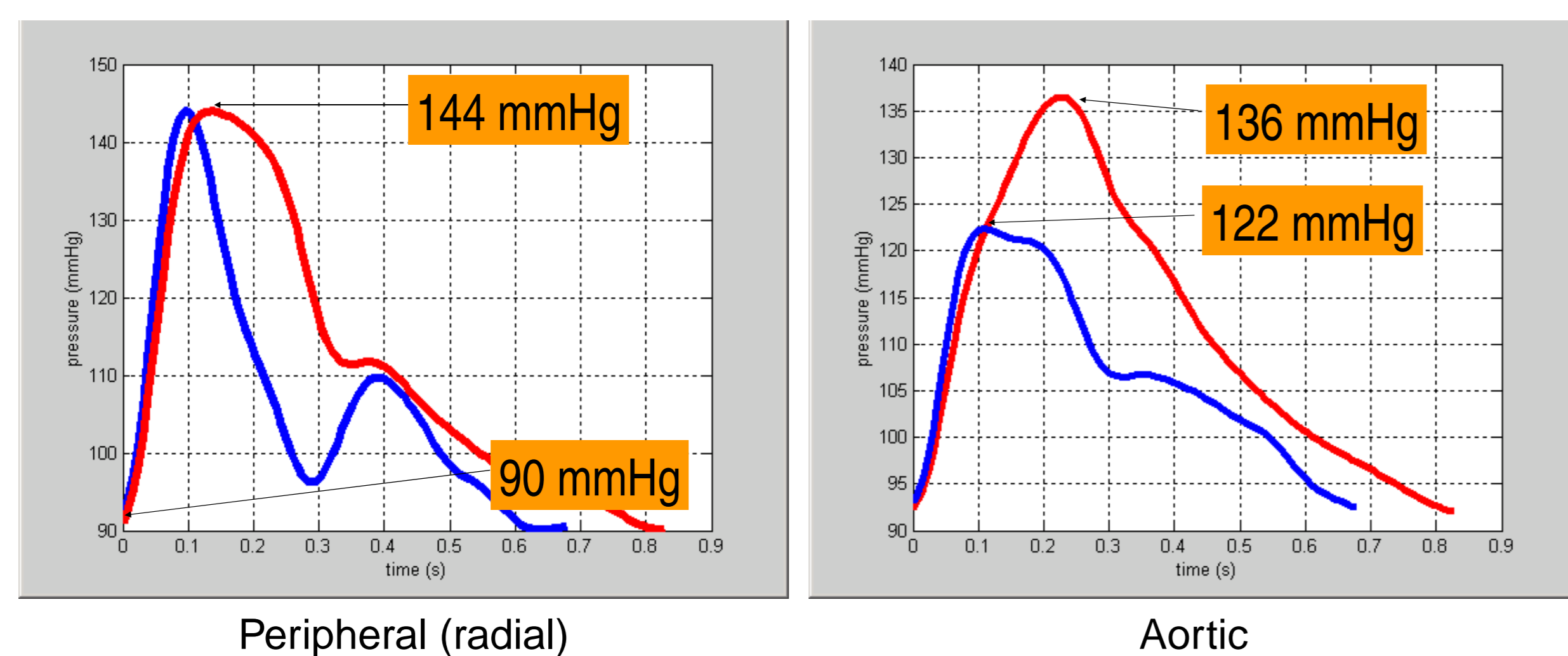
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## Introduction

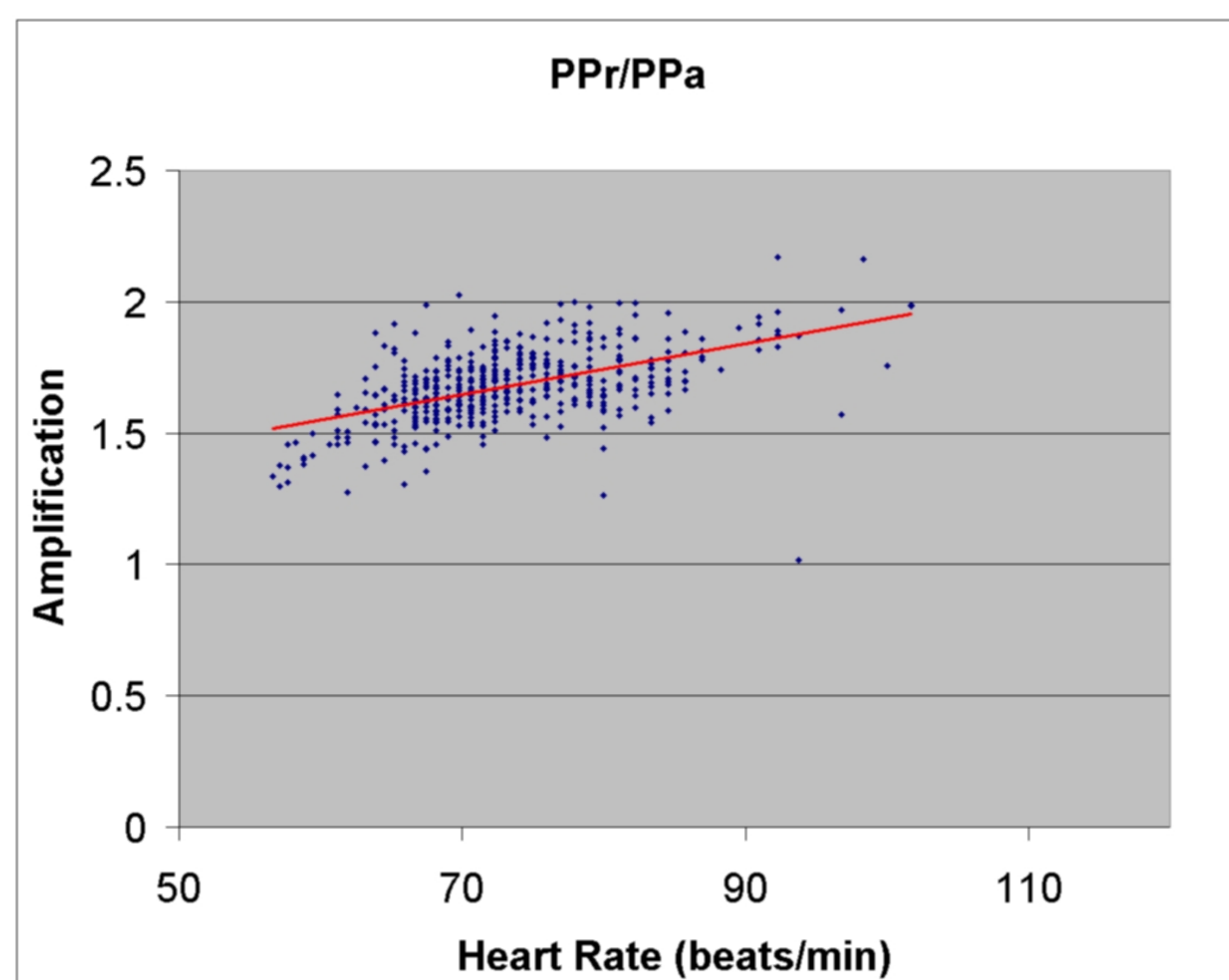
The pressure pulse changes amplitude and shape as it travels from the heart along the aortic trunk to peripheral arteries in the limbs (Figure 1). This is mainly due to the elastic and geometric non-uniformity of the arterial tree and peripheral wave reflection.

The effect of this change in pulse wave shape is a significant amplification of the measured pulse pressure towards the periphery. Much of this difference in pulse pressure is seen as a difference in systolic pressure and not so much in diastolic pressure.

The difference in pulse amplitude between central and peripheral pressure can be quantified in terms of the frequency characteristics of the arterial path length. That is, the difference between central and peripheral systolic pressure is significantly affected by heart rate (HR) (Figure 2). Hence interventions that alter both arterial haemodynamic conditions and HR have a compound effect on the difference between conventionally measured brachial systolic pressure and aortic systolic pressure, which is a more accurate representation of left ventricular load (Figure 1).



**Figure 1:** Difference between central aortic and peripheral pulse pressure cannot be detected by conventional measurements of systolic and diastolic pressure in the arm. Both subjects have identical peripheral systolic and diastolic pressures, but markedly different central pulse pressures. The difference is a function of wave shape and HR. Differences in pulse pressures increase with HR; peripheral pressure can be more than double central pulse pressure with HRs achieved during exercise. (Blue: subject 1; Red: subject 2)



**Figure 2:** The increase in amplification between the aorta and periphery is mainly seen as differences in systolic pressure, which is dependent on HR. The nominal change in Systolic pressure is 10% for a change in 10 bpm from a HR of 60 bpm.

The HR dependence of the difference in central and peripheral systolic pressure is an important consideration with respect to the characterisation of the pressure load on the left ventricle. This also has significant implications in stratifying cardiovascular risk factors and in quantifying the effects on the heart of agents that alter blood pressure and heart rate.

## Aim

To determine the effect of HR on cardiovascular (CV) risk when assessed from central pressure.

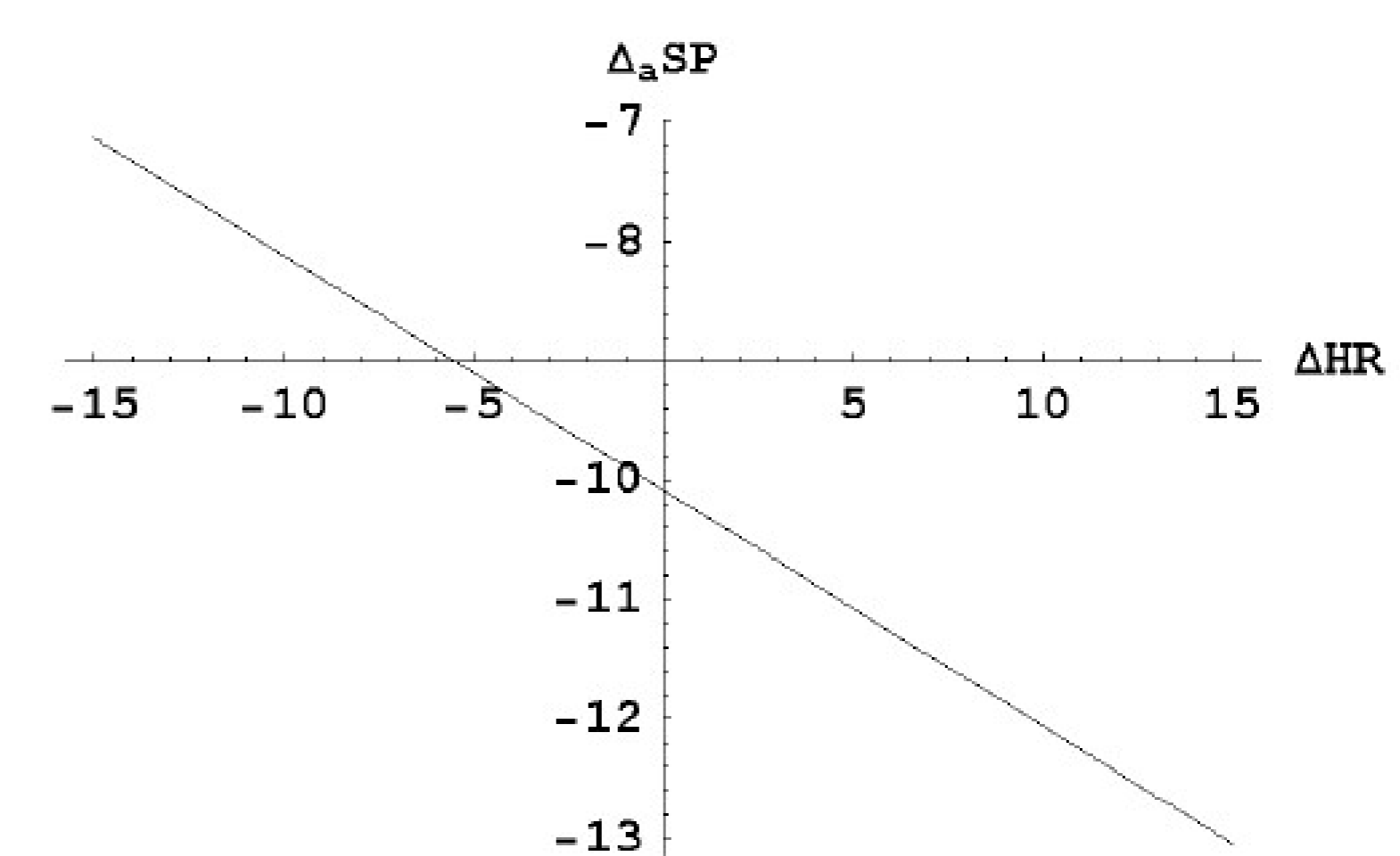
## Methods

A database was assembled ( $n = 2671$  measurements) of central waveforms determined by means of a generalised transfer function employed in the SphygmoCor device (AtCor Medical, Sydney) across a large age range in adults (mean age  $57.7 \pm 18.3$  years).

A multi-regression model was developed to obtain a relationship for change in central aortic systolic pressure as a function of HR for a given change in peripheral pressure.

For a change of 10 mmHg in peripheral systolic pressure and 5 mmHg in peripheral diastolic pressure, the following relationship was obtained (Figure 3).

$$\Delta_aSP = -10.1 - 0.197\Delta HR \quad (1)$$

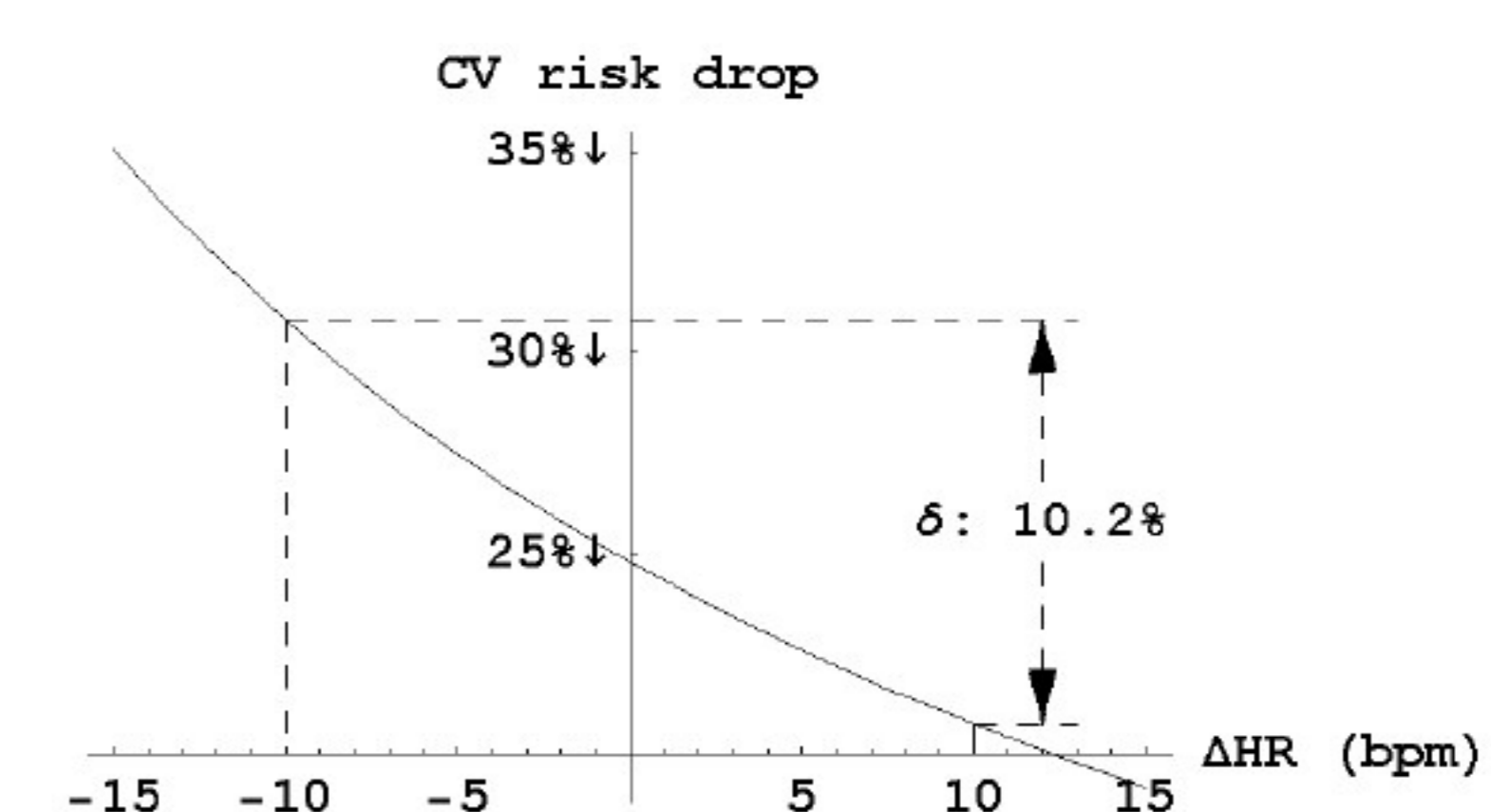


**Figure 3:** The relation between change in central systolic pressure as a function of HR for a rate for a given change of peripheral systolic (-10 mmHg) and diastolic pressure (-5 mmHg).

To calculate the effects of HR on central aortic systolic pressure and VC risk estimation, the above equation was applied to the SHEP study<sup>1</sup>, which showed a reduction of overall CV risk for a decrease in systolic brachial systolic and diastolic pressure of 10 and 5 mmHg respectively.

## Results

From the above regression model, the reduction in the CV risk calculated on the basis of central aortic systolic pressure was expressed in relation to a 25% CV reduction for a 10 mmHg reduction in peripheral systolic pressure (Figure 4, Table 1).



**Figure 4:** Relation between change in HR and reduction of CV risk for a change in peripheral systolic and diastolic pressure of 10/5 mmHg.

**Table 1:** Calculated results for 10 mmHg change in peripheral systolic pressure.

Change in HR	Relative risk	Relative estimated change
0	1.0	0
10 bpm increase	0.88	12% reduction
10 bpm decrease	1.28	28% increase

## Conclusions

Pressure related effects on CV risk can be different for interventions that have concomitant changes in blood pressure (BP) and HR.

## References

1. J.A. Staessen, J.G. Wang, L. Thijs, and R. Fagard. Overview of the outcome trials in older patients with isolated systolic hypertension. *J Hum Hypertens*, 13(12):859-63, 1999.