

# The use of central aortic pressure for determination of cardiovascular risk - effect of heart rate

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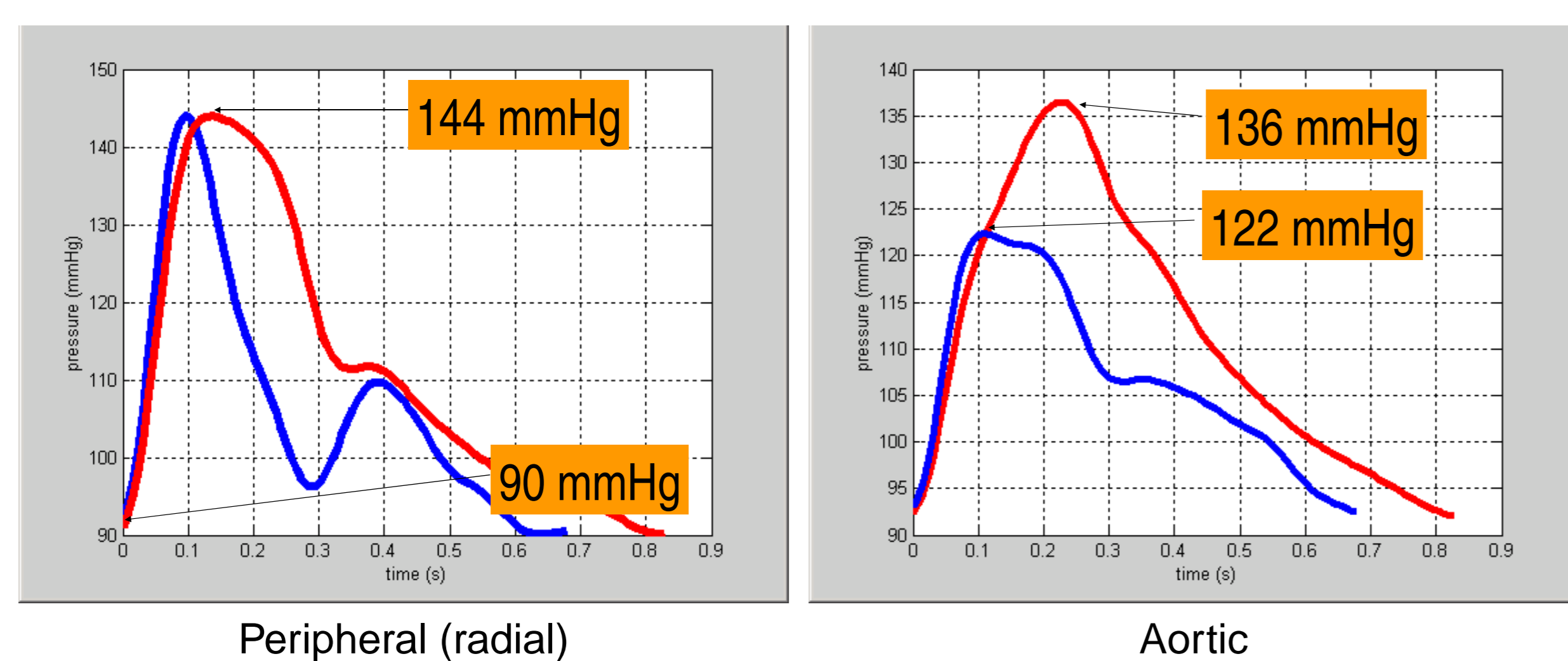
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## Introduction

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.

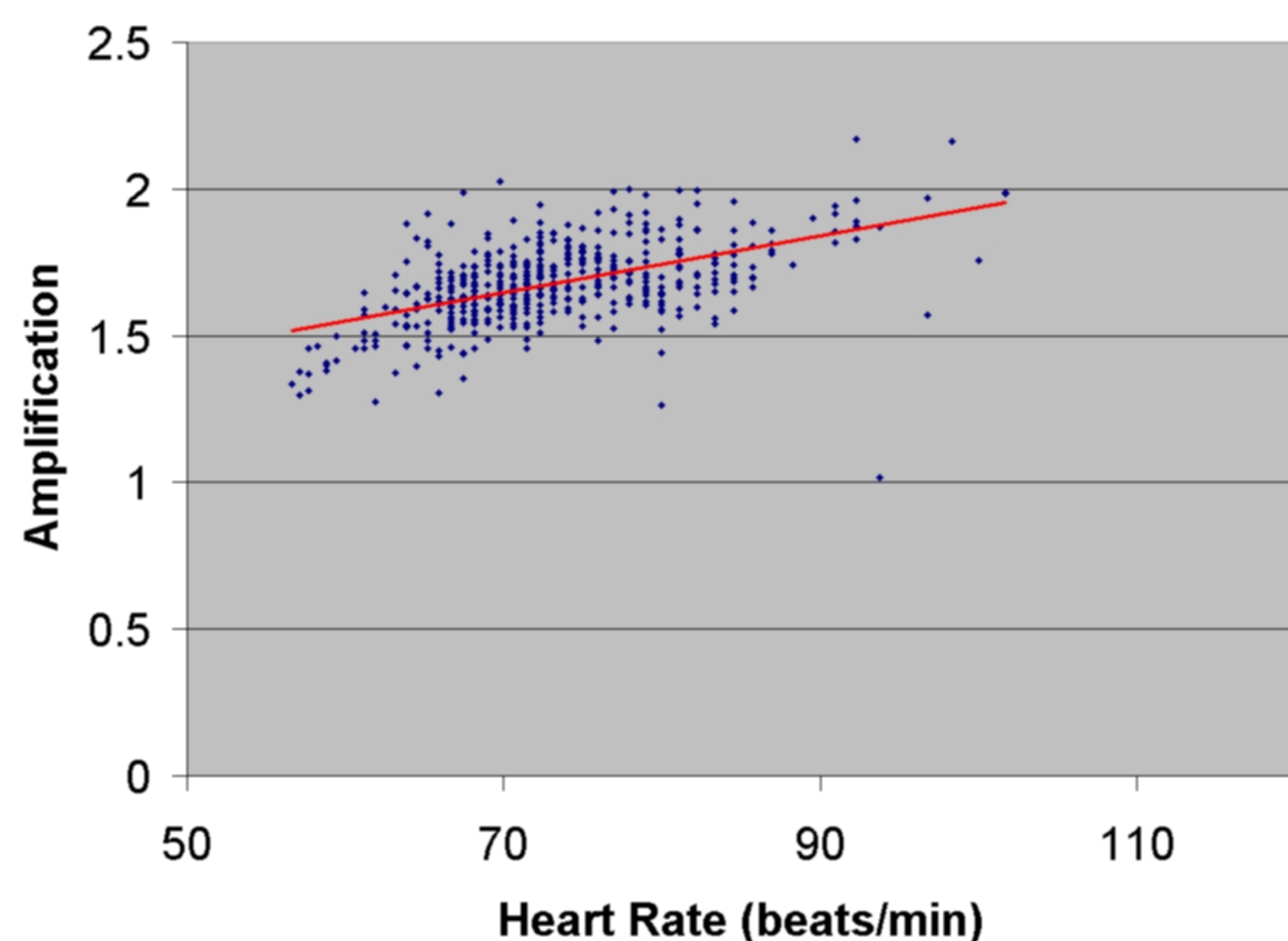
The effect of this change in pulse wave shape is a significant amplification of the measured pulse pressure towards the periphery. Much of this difference in pulse pressure is seen as a difference in systolic pressure and not so much in diastolic pressure.

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)

## PPr/PPa



**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

1. stratifying cardiovascular risk factors
2. quantifying the effects on the heart of agents that alter blood pressure and heart rate

## 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.

## Aim

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

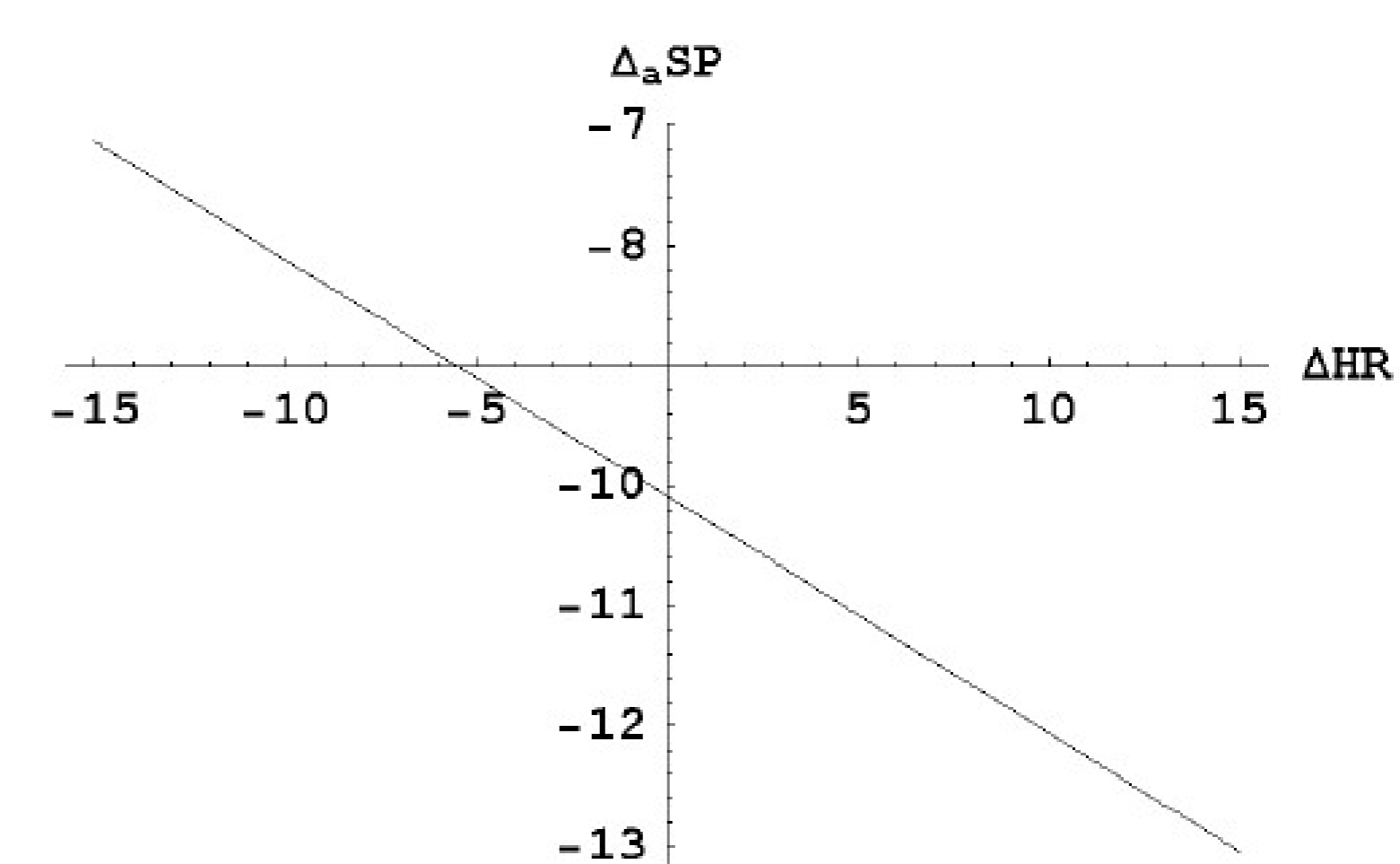
## Methods

A multi-regression model was developed from a database (n=2671 measurements in adults) containing calibrated peripheral (radial) pressure waveforms and derived central aortic pressure using SphygmoCor (AtCor Medical, Sydney).

Model parameters were optimised to derive central systolic pressure (SP) from measured peripheral pressure and HR in the absence of waveforms.

To assess the use of central SP in calculating CV risk in large-scale studies, the model was applied to results of the SHEP study<sup>1</sup>, which reports a 25% CV risk reduction for a 10mmHg reduction in brachial SP. The following relationship was obtained (Figure 3).

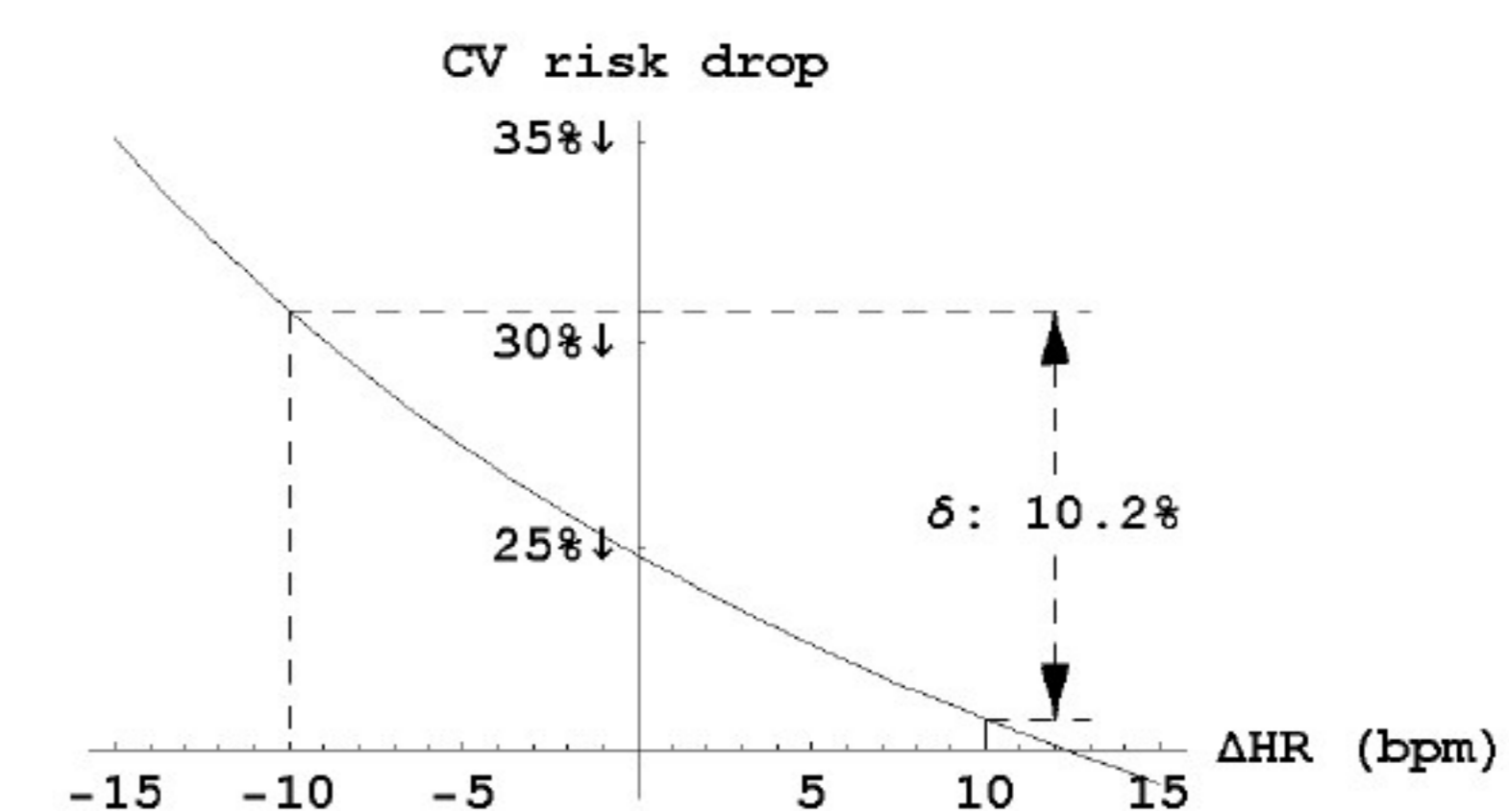
$$\Delta_a SP = -10.1 - 0.197\Delta HR$$



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

## Results

For no change in HR, the model gave a concomitant change in central and peripheral SP, with 10mmHg reduction in SP resulting in a similar calculated CV risk reduction of 25% (Figure 4, Table 1). However, for increase in HR of 10 bpm, the CV risk calculation for a similar reduction in SP was 22% (ie. a relative overestimation of 28%).



**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 calculated CV risk can be substantially different for interventions that have concomitant changes in blood pressure (BP) and HR.
- This may be applicable to determination of CV risk with use of anti-hypertensive agents that modify resting HR, such as beta blockers.