Technical Note No: 15

Improved Population Reference Statistics for SphygmoCor Px

AtCor has worked with Cambridge University and the Welsh National Heart Institute in the UK to substantially enhance the population reference data. The same group of researchers responsible for the previous population reference data[1] constructed this new population reference data.

It is important to note that the generalised transfer function and the waveform feature extraction algorithms used in SphygmoCor software (7.1) to calculate the haemodynamic parameters on the Pulse Wave Analysis reports have not changed from those in previous versions (6.31 – 7.01) of the SphygmoCor software. Installing this version of the software will not change the basis of calculation for any of the SphygmoCor haemodynamic parameters in your ongoing studies.

The following sections demonstrate the difference between the population reference data sets used in the new SphygmoCor software version 7.1 and the previous SphygmoCor software versions (6.31 – 7.01). Please note throughout this document when references are made to the previous version of the SphygmoCor software, it is referring to versions 6.31 – 7.01.

1. Population Profiles

a) Previous (Version 7.01)

The reference population data set was based on I. Wilkinson et al paper in Hypertension[1].

A total of 405 subjects (239 male and 166 female) were used in this analysis. Subjects with a history of cardiovascular disease, diabetes mellitus or who were receiving medication were not included in the analysis.

Subjects in the included sample had an average age (±SD) of 48(±15.6) years, an average height of 1.7 (±0.097) m and average weight of 74.8(+13.2) kg.

A distribution of age and gender for this population is illustrated in figure 1.

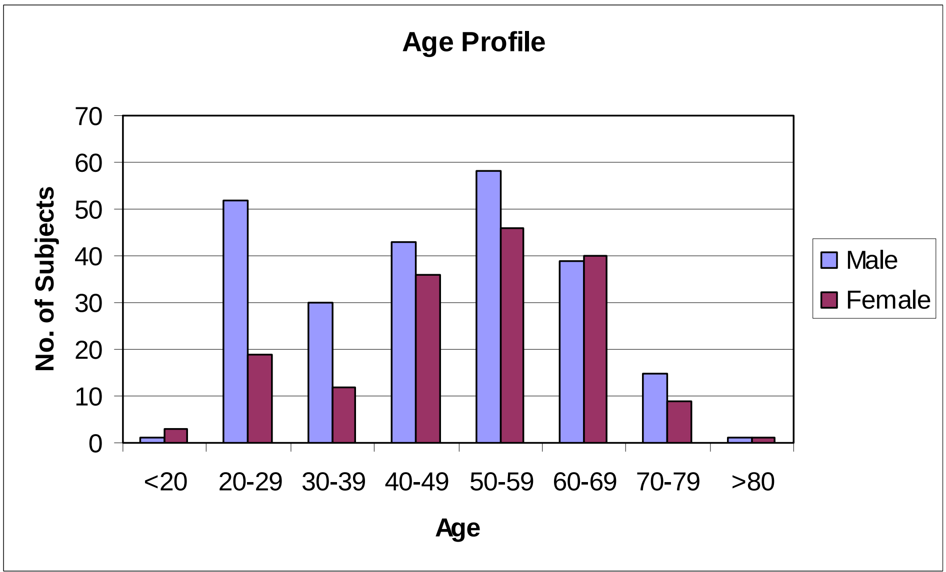

Figure 1: Previous reference population data set age profile.

b) New SphygmoCor (Version 7.1)

The reference population data set included in SphygmoCor Version 7.1 software was based on analysis of a total of 3975 subjects (1968 male and 2007 female).

Subjects with hypertension (blood pressure ≥ 140/90 mmHg), diabetes mellitus, a serum cholesterol ≥ 6.5 mmol/L, renal disease (defined as a clinical history, creatinine ≥ 150 mol/L or an active urinary sediment), cardiovascular disease (defined as a clinical history or evidence on examination), were excluded from this analysis, as were subjects receiving any medication. This yielded a total of 3975 individuals who were used in the analysis and formed the basis of the reference population data set.

Subjects in the included sample had an average (±SD) age of 52 (±17.5) years, an average height of 1.68 (±0.1) m and an average weight of 74 (±14.7) kg.

A distribution of age and gender for this population is illustrated in figure 2.

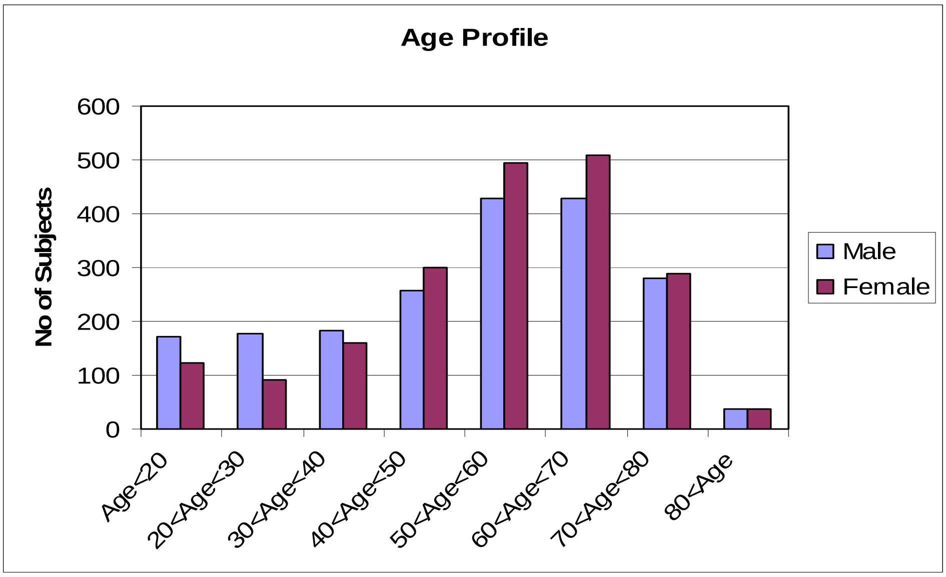

Figure 2: New reference population data set age profile

2. Augmentation Index Vs Age

The previous version of SphygmoCor represents the relationship of Augmentation Index (AIx) Vs Age as a linear regression line independent of gender and without the application of heart rate correction.

The new 7.1 version of SphygmoCor represents the relationship of Augmentation Index Vs Age as a curvilinear regression, specific for each gender and heart rate corrected to 75 beats per minute. (AIx@HR75).

Figure 3 shows for males, the comparison of the Augmentation Index Vs Age between the two population reference data sets. Please note the linear plot of the data set representing the previous SphygmoCor version comprises both males and females and is not heart rate corrected, whereas the curvilinear plot of the larger data set representing the new SphygmoCor 7.1 version is heart rate corrected and is comprised of males only. The dotted lines represent the 90% confidence intervals.

Figure 4 shows for females, the comparison of Augmentation Index Vs Age between the two population reference data sets. Please note the linear plot of the data set representing the previous SphygmoCor version comprises both males and females and is not heart rate corrected, whereas the curvilinear plot of the larger data set representing the new SphygmoCor 7.1 version is heart rate corrected and is comprised of females only. The dotted lines represent the 90% confidence intervals.

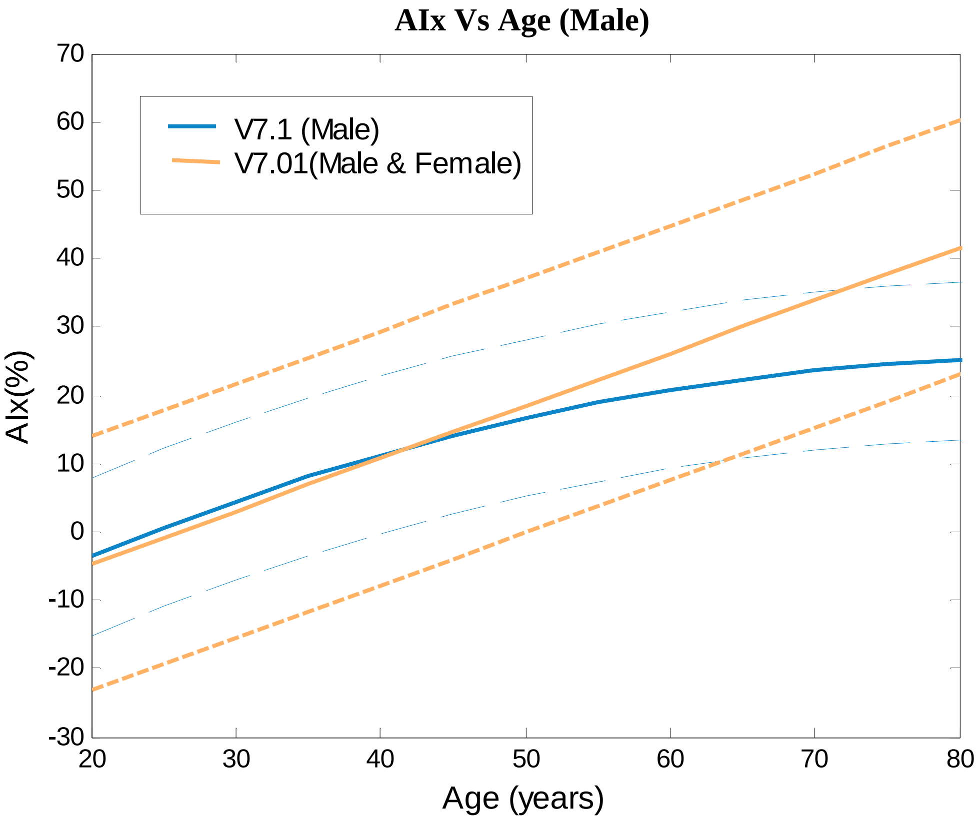

Figure 3: Comparison between the two reference population data sets for AIx Vs Age for males.

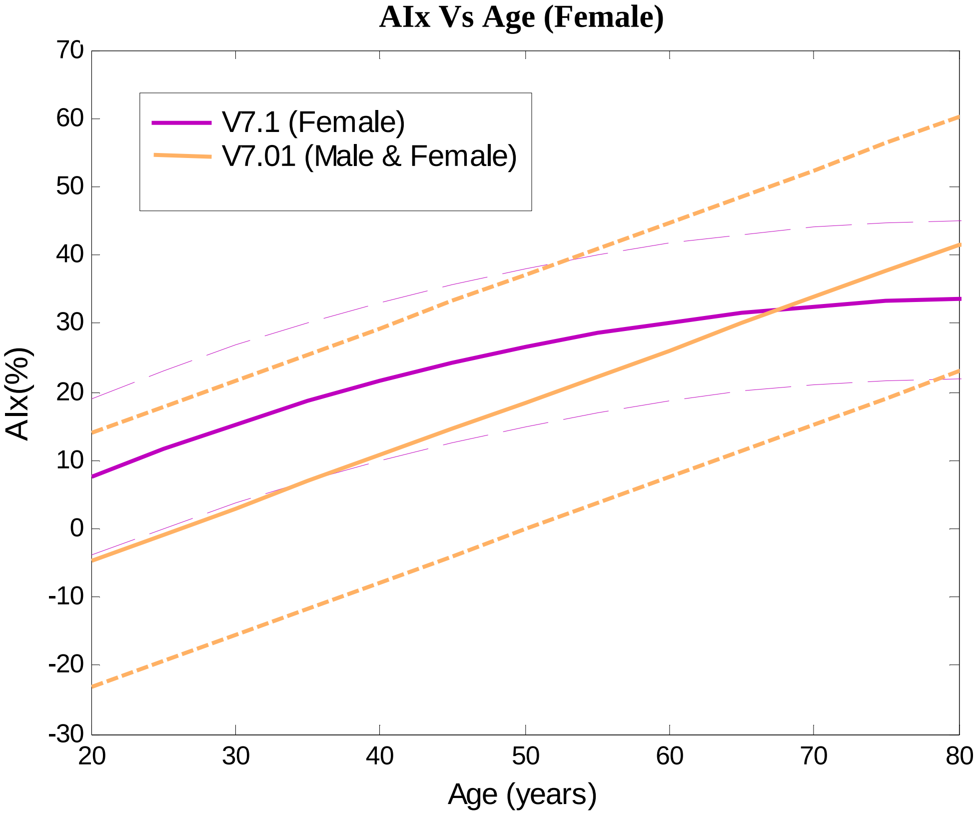

Figure 4: Comparison between the two reference population data sets for AIx Vs Age for females.

3. Ejection Duration Vs Heart Rate

The relationship between Ejection Duration and Heart Rate is still linear and taken as being independent of gender.

Figure 5 illustrates the difference in the representation of Ejection Duration Vs Heart Rate between the two reference population data sets. The dotted lines represent the 90% confidence intervals.

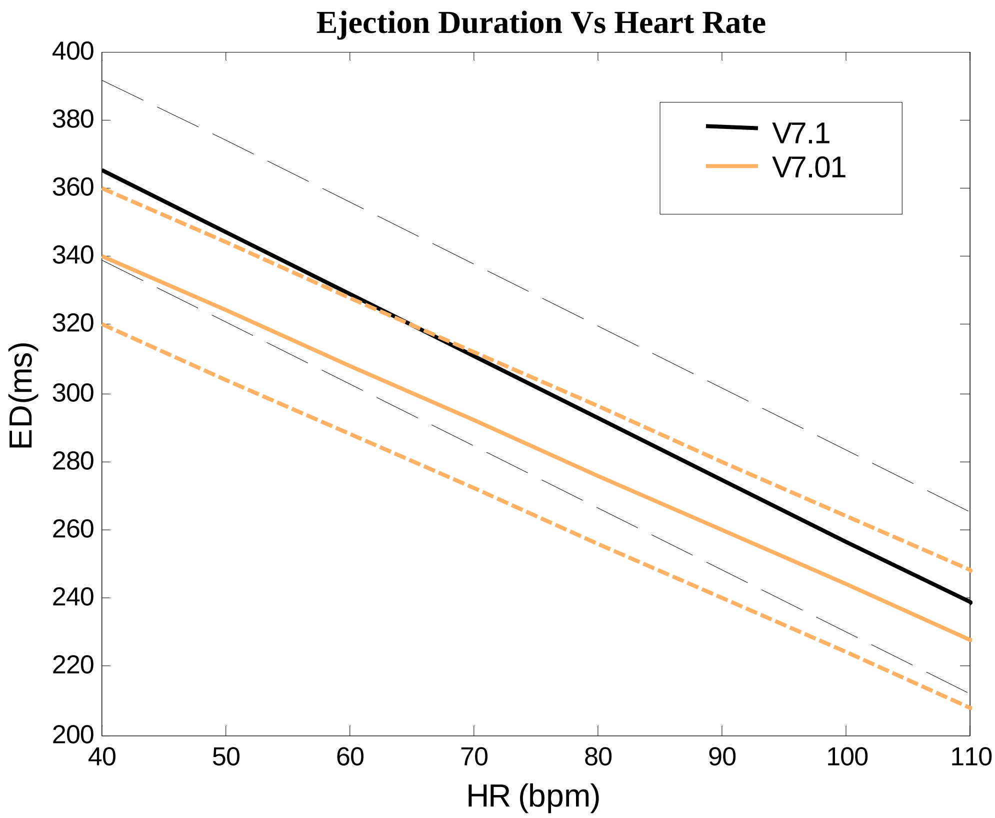

Figure 5. Comparison between the two reference population data sets for Ejection Duration Vs Heart Rate.

4. Augmentation Pressure Vs Age

The new 7.1 version of SphygmoCor includes population reference data for Augmentation Pressure (Heart Rate Corrected at 75 bpm) Vs Age and is characterised by a linear relationship specific for each gender.

The calculation and steps taken to calculate the heart rate corrected central Augmentation Pressure (AP@HR75) are described in Appendix A.

Figure 6 shows the Augmentation Pressure, heart rate corrected at 75bpm (AP@HR75) Vs Age for males. The dotted lines represent the 90% confidence intervals.

Figure 7 shows the Augmentation Pressure, heart rate corrected at 75bpm (AP@HR75) Vs Age for females. The dotted lines represent the 90% confidence intervals.

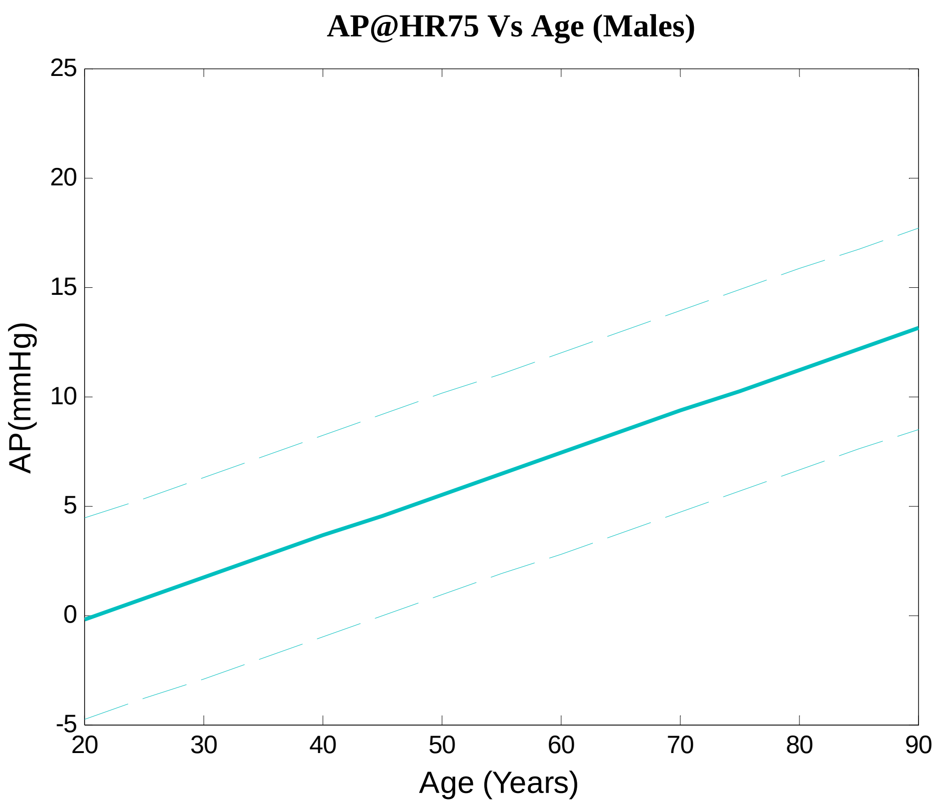

Figure 6. Augmentation Pressure @HR75 Vs Age for males.

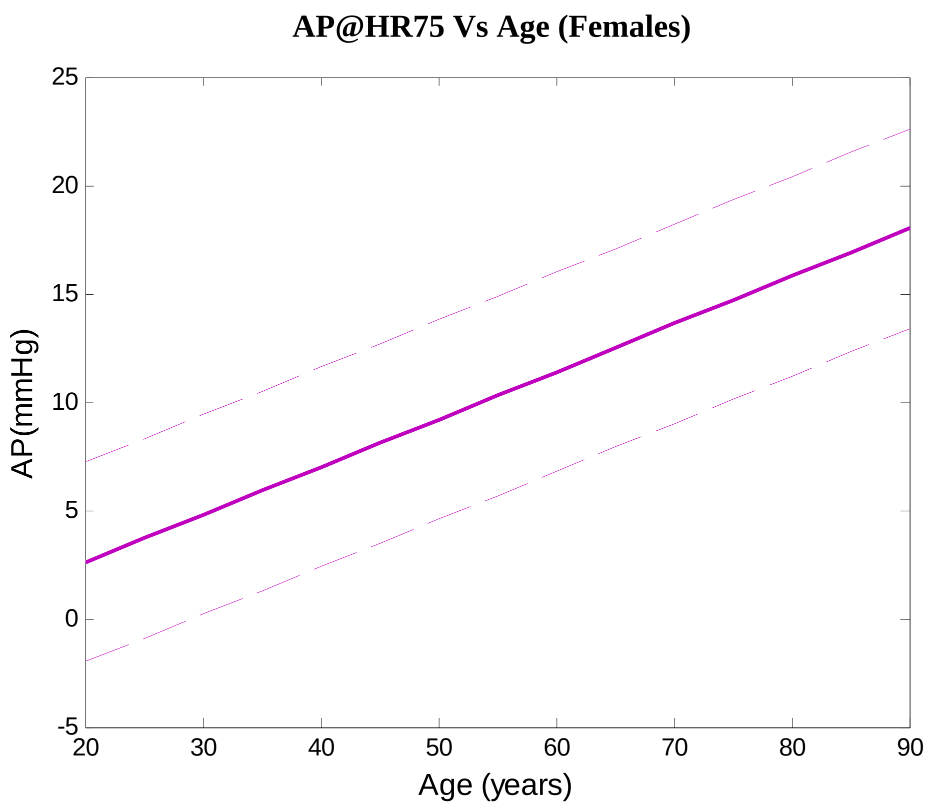

Figure 7. Augmentation Pressure @HR75 Vs Age for females.

APPENDIX A

The following procedure describes the steps necessary to calculate the heart rate corrected central Augmentation Pressure (AP@HR75).

Given that

$$AIx = \left(\frac{P_2 - P_1}{SP - DP} \right) \times 100$$

where P_2 is the pressure at the 2^{nd} peak in systole,
P_1 is the pressure at the 1^{st} peak in systole,
SP is the central systolic pressure, and
DP is the central diastolic pressure

Then

$$P_2 = \left[\frac{AIx \times (SP - DP)}{100} \right] + P_1$$

If AIx@HR75 is positive, whereby SP equals P_2 , the equation for P_2 corrected to 75bpm (P_2@HR75) will be:

$$P_2 @ HR75 = \left(\frac{(100 \times P_1) - (AIx @ HR75 \times DP)}{100 - AIx @ HR75} \right)$$

It is not necessary to heart rate correct P_1 and DP since these parameters are not affected by heart rate[2].

If AIx@HR75 is negative, whereby SP equals $P_{1,}$ the equation for P_2 corrected to 75bpm (P_2@HR75) will be:

$$P_2 @ HR75 = \left[\frac{AIx @ HR75 \;\; \times (SP - DP)}{100} \right] + P_1$$

The Augmentation Pressure heart rate corrected to 75bpm is given by:

AP@HR75 = P_2@HR75 - $P_{1.}$

References:

1. Wilkinson I, Franklin S, Hall I, Tyrell S, Cockcroft J. "Pressure Amplification Explains Why Pulse Pressure Is Unrelated to Risk in Young Subjects" *Hypertension*. 2001;38:1461-1466.
2. Wilkinson, Ian et al, "Heart Rate Dependency of Pulse Pressure Amplification and Arterial Stiffness" *American Journal of Hypertension*, 2002; 15:24-30