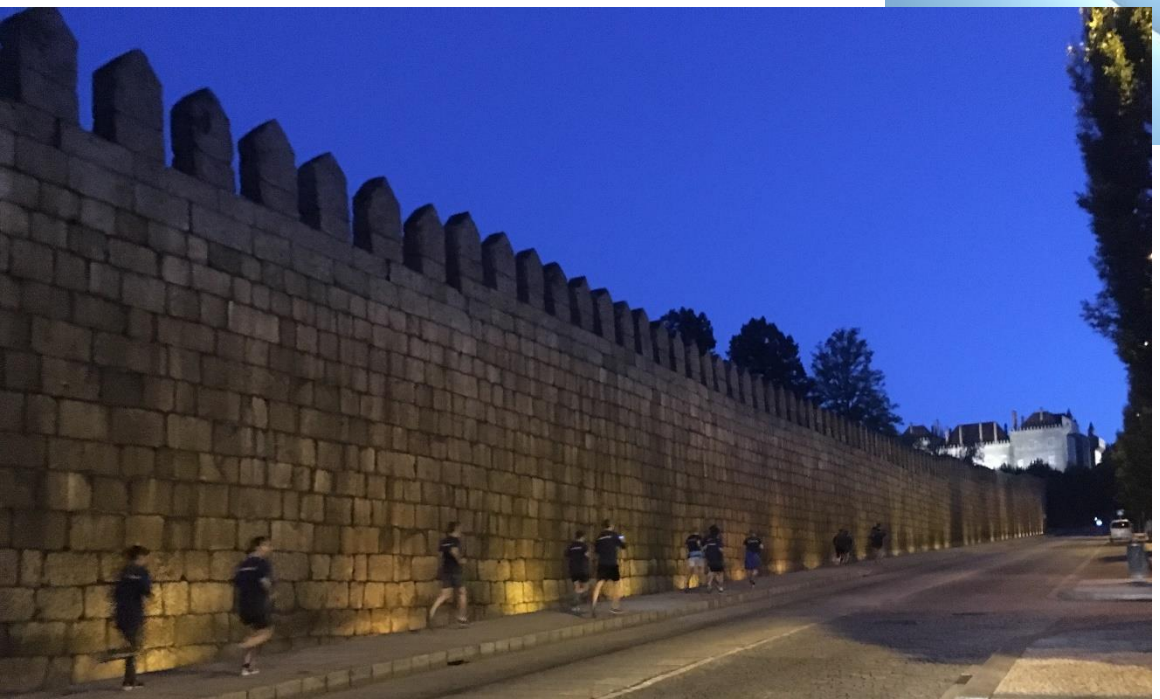
Cuff blood pressure is progressively more biased with increasing age: individual participant level analysis from the *INSPECT* consortium

Dean Picone, Martin Schultz, Petr Otahal, Ahmed Al-Jumaily, Willem Bos, Chen-Huan Chen, Hao-Min Cheng, Antoine Cremer, Ricardo Fonseca-Diaz, Brian Gould, Alun Hughes, Peter Lacy, Esben Laugesen, Sandy Muecke, Nobuyuki Ohte, Stefano Omboni, Christian Ott, Xiaoqing Peng, Telmo Pereira, Giacomo Pucci, Niklas Rossen, Roland Schmieder, Velandai Srikanth, Ralph Stewart, George Stouffer, Daisuke Sueta, Kenji Takazawa, Jiguang Wang, Thomas Weber, Berend Westerhof, Bryan Williams, Hirotsugu Yamada, Eiichiro Yamamoto, James Sharman

ARTERY
Association for Research into Arterial Structure and Physiology

INSPECT
Invasive Blood Pressure Consortium

Disclosures



Blood pressure is a potent risk factor

High blood pressure #1 risk factor for death and disability worldwide[1]

High blood pressure leading cause of CVD[2]

Lowering blood pressure reduces risk[3]

All evidence based on blood pressure measurement from upper arm cuff

1. GBD 2013 risk factors collaborators, *Lancet,* 2015; 386(10010): 2287-323
2. Lewington et al, *Lancet,* 2002; 360(9349):1903-13
3. Ettehad et al*, Lancet*; 2016;387(10022):957-67

Blood pressure measurement is one of the most important tests in clinical medicine

Hypertension
Journal of the American Heart Association

American Heart Association

Recommendations for Blood Pressure Measurement in Humans and Experimental Animals : Part 1: Blood Pressure Measurement in Humans: A Statement for Professionals From the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research

Thomas G. Pickering, John E. Hall, Lawrence J. Appel, Bonita E. Falkner, John Graves, Martha N. Hill, Daniel W. Jones, Theodore Kurtz, Sheldon G. Sheps and Edward J. Roccella

Hypertension. 2005;45:142-161; originally published online December 20, 2004;
doi: 10.1161/01.HYP.0000150859.47929.8e
Hypertension is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 0194-911X. Online ISSN: 1524-4563

Pickering et al, *Hypertension,* 2005; 45: 142-61

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Accuracy of Cuff-Measured Blood Pressure

Systematic Reviews and Meta-Analyses

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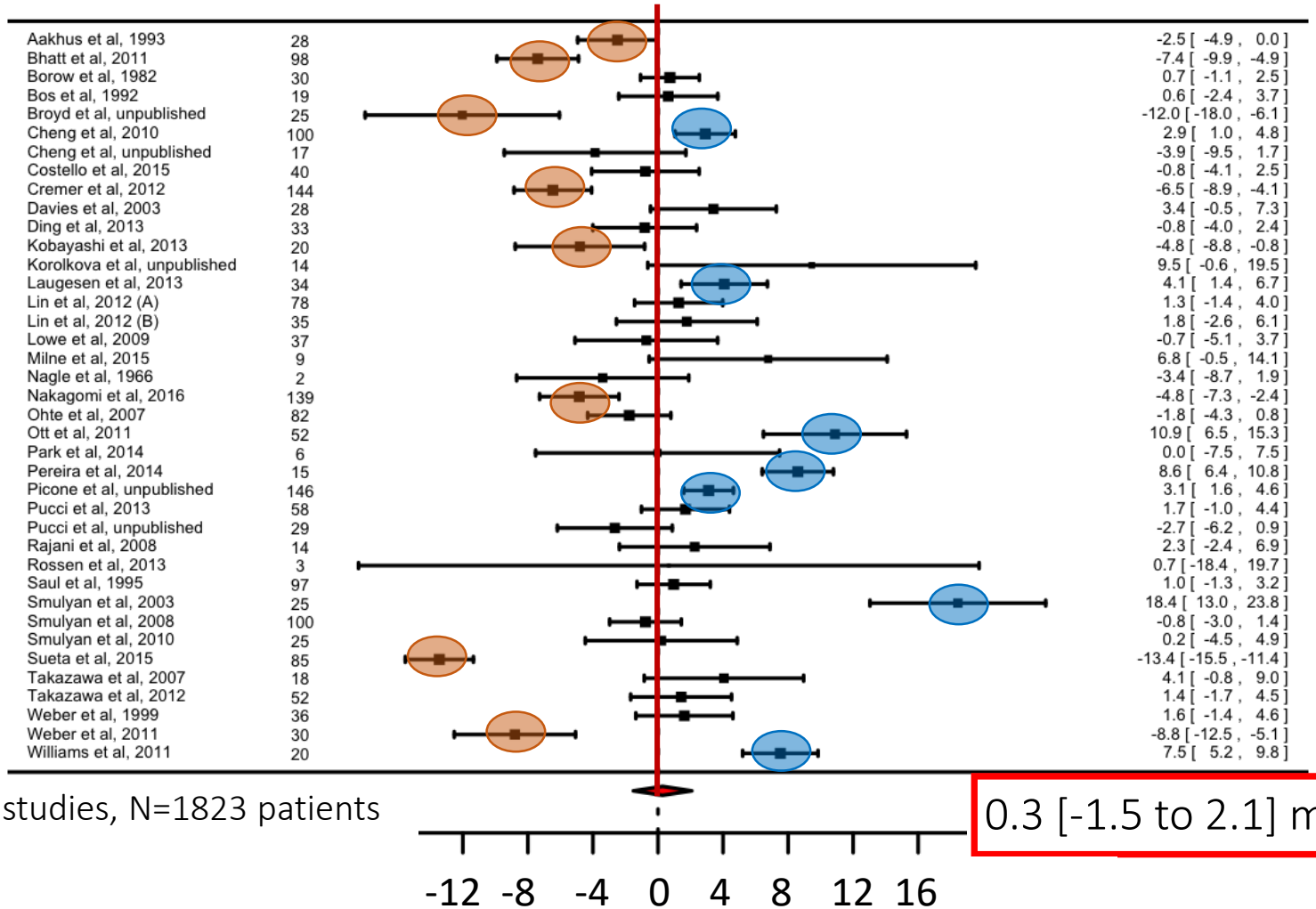
Picone et al. *JACC*, 2017; 70(5): 576-82

Cuff and invasive aortic systolic BP (studies from 1966-2016)



39 studies, N=1823 patients

0.3 [-1.5 to 2.1] mmHg

Cuff underestimates aortic SBP ⟷ Cuff overestimates aortic SBP

Cause of cuff inaccuracy?

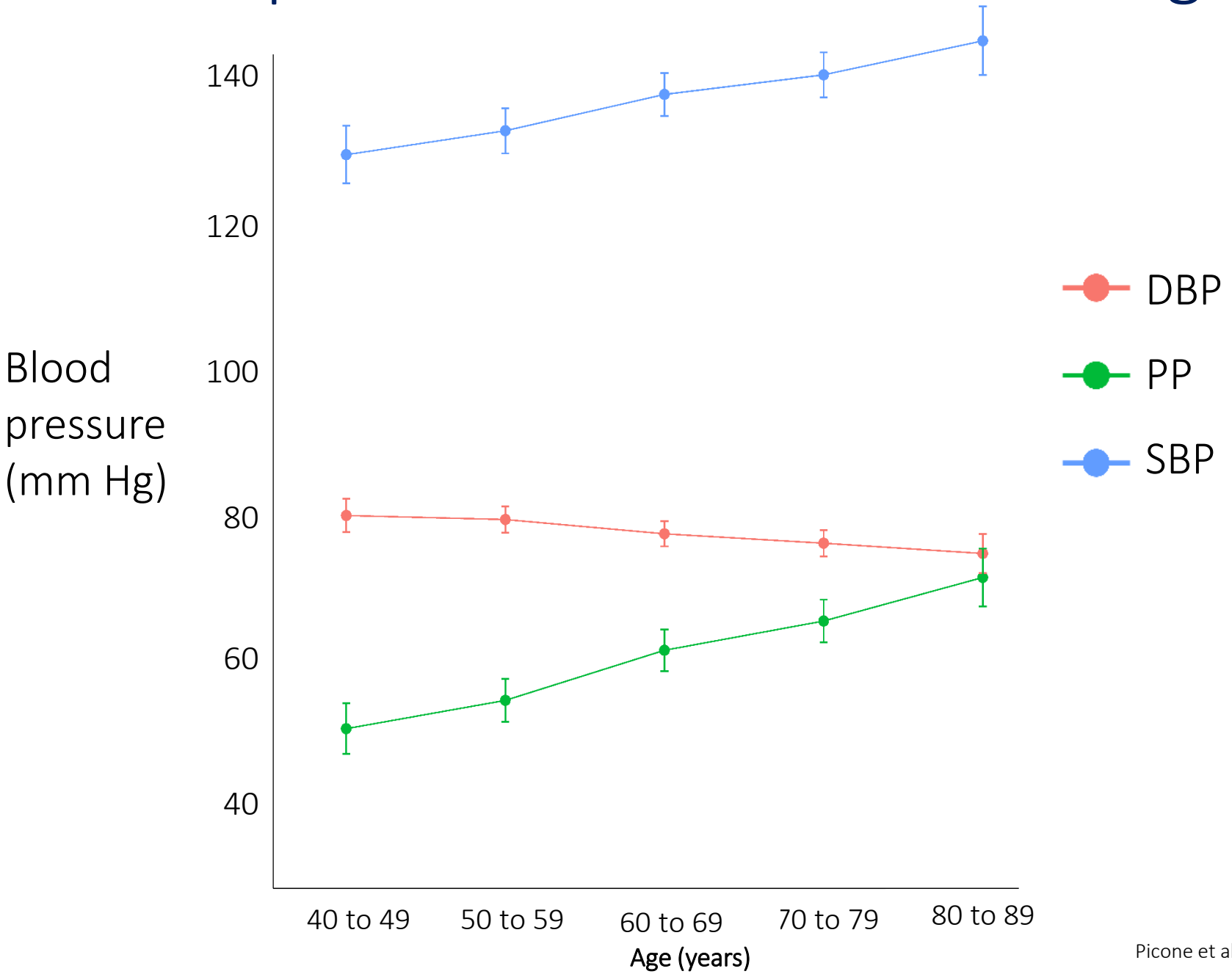
Greater vascular stiffness / calcification
→ difficulty compressing the artery?

Disease related changes to blood flow and vascular function
– affect ability of measurement algorithms to correctly detect BP?

Occur with advancing age

Influence of age on cuff accuracy?

Blood pressure in middle to older age



Picone et al. unpublished

Aim and hypothesis

To determine the influence of age on the accuracy of cuff measured BP by comparison with invasive (intra-arterial) aortic BP

Age will significantly influence the accuracy of cuff BP

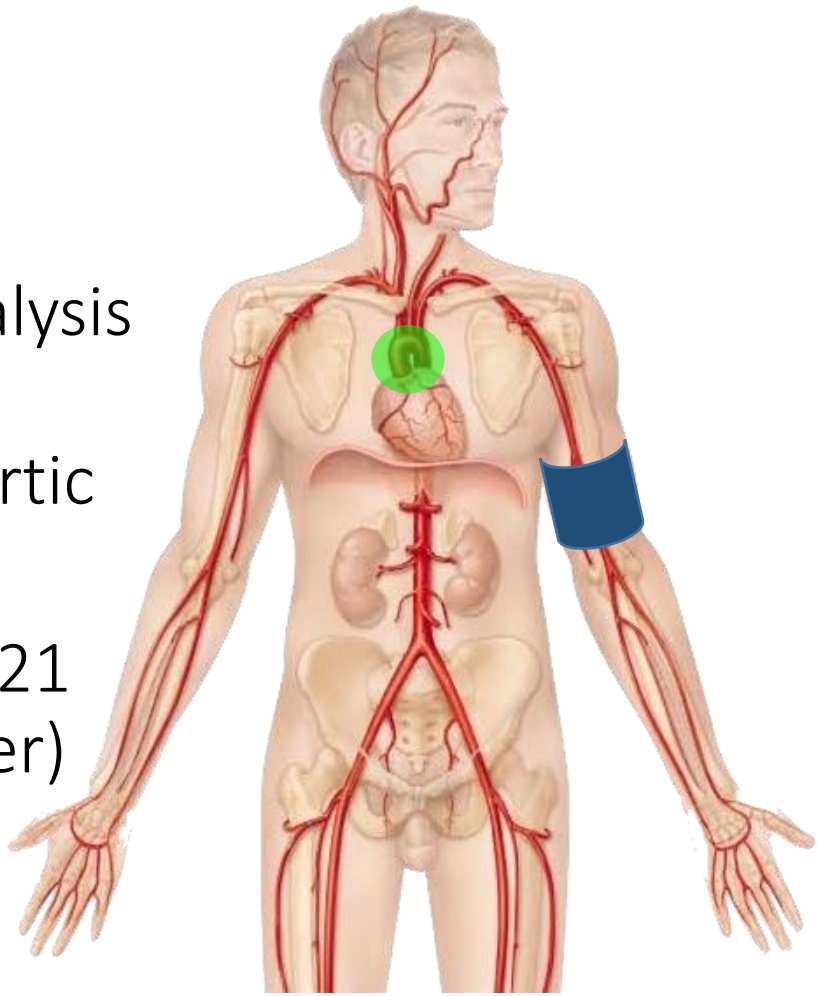
Study design

INSPECT consortium

n=1689 subjects in the current analysis

Cuff BP compared with invasive aortic BP

- oscillometric devices (except n=21 with mercury sphygmomanometer)



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Quality control of consortium database

Studies that recorded data under basal conditions

Invasive (intra-arterial) BP measured from micromanometer tip or fluid-filled catheters

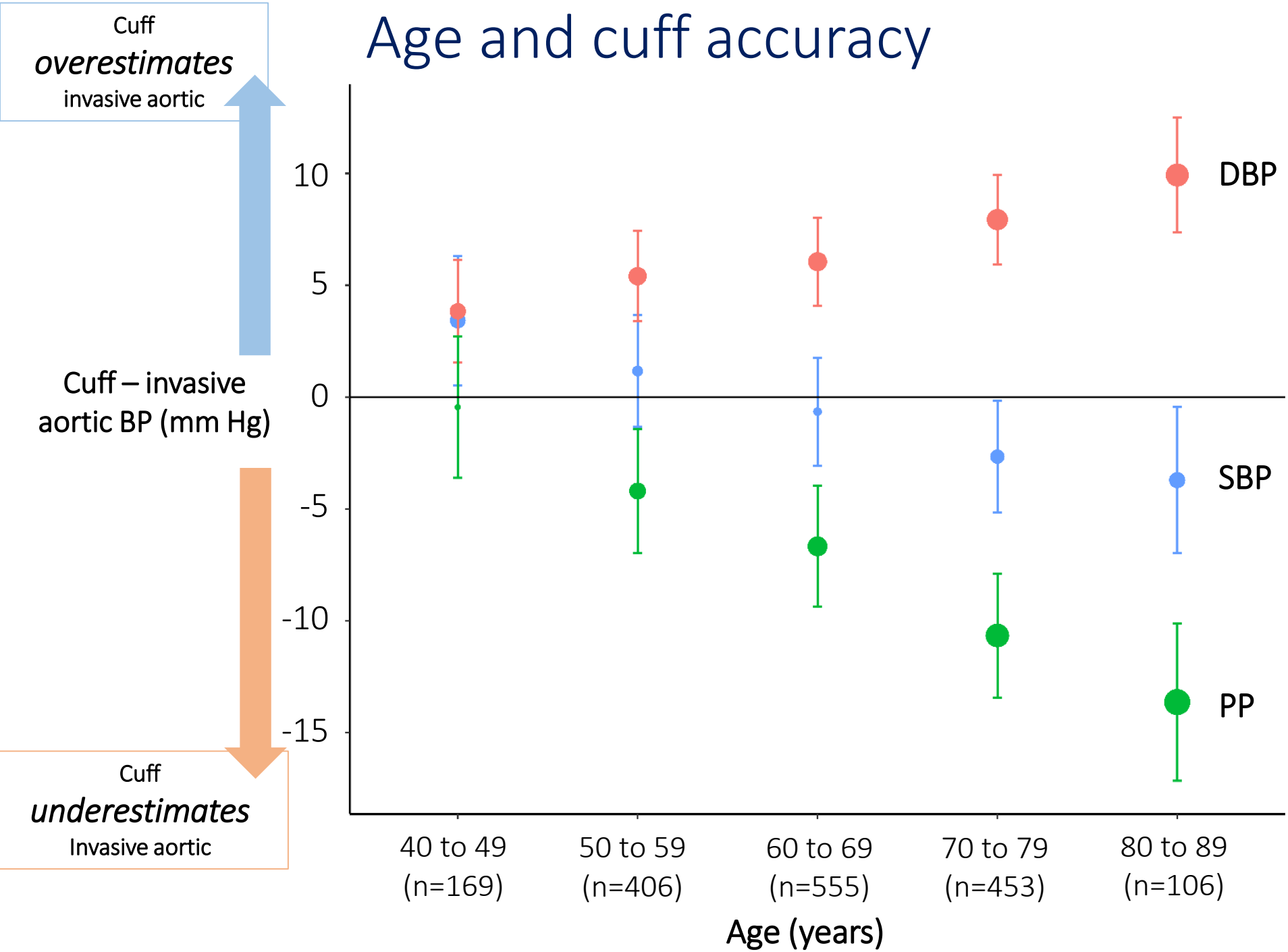
BP measurements recorded within the immediate period of each other

Study quality score based on important methodological attributes

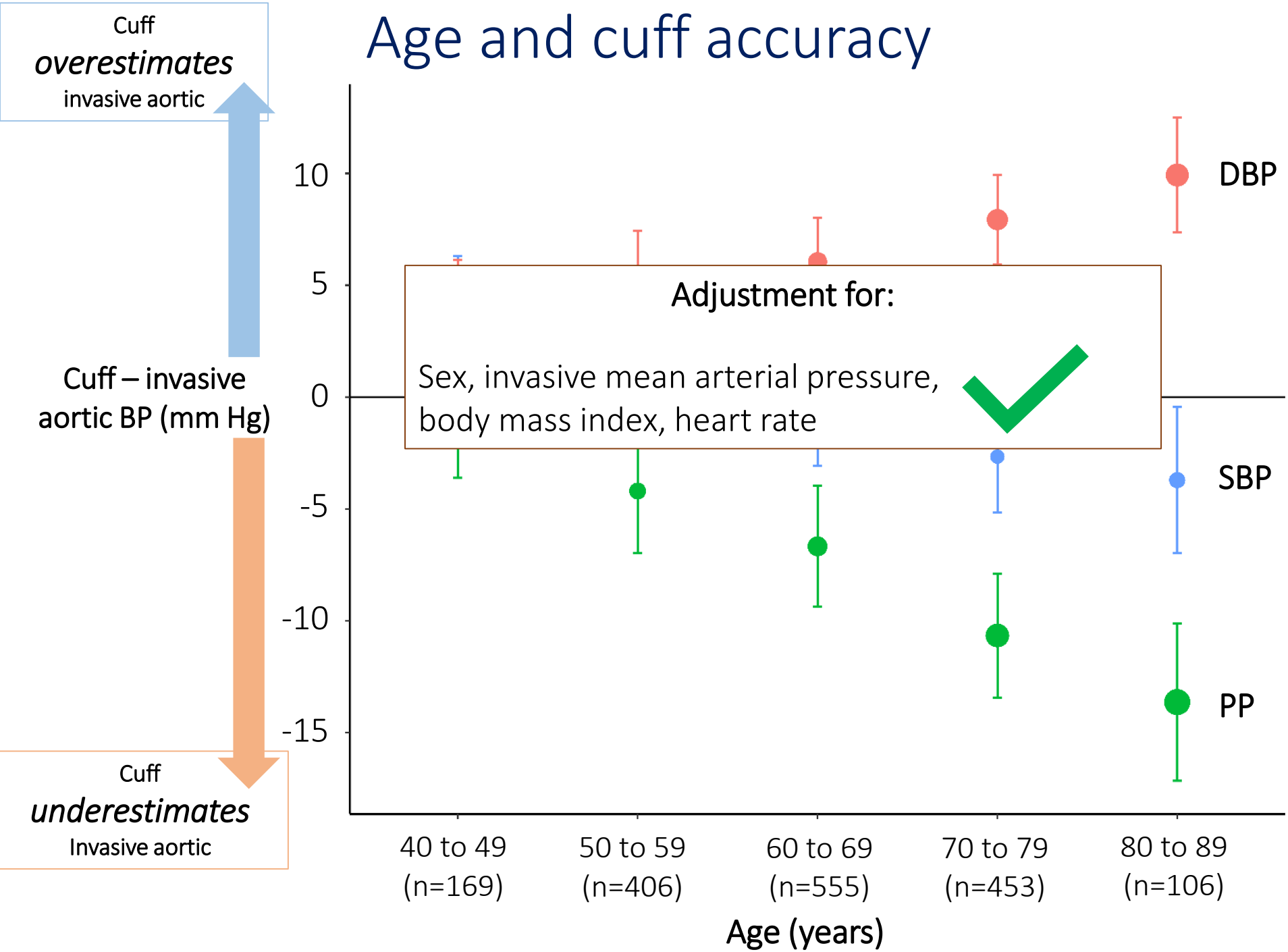
Participants

	40 to 49 years (n=169)	50 to 59 years (n=406)	60 to 69 years (n=555)	70 to 79 years (n=453)	80 to 89 years (n=106)
Age, years	45±3	55±3	64±3	74±3	83±2
Female sex, %	45 (27)	123 (31)	181 (33)	147 (33)	40 (38)
Height, cm	170.7±9.5	167.0±9.1	165.3±10.3	162.9±10.2	158.9±10.1
Weight, kg	84.3±20.8	78.2±18.5	73.6±17.6	68.0±14.5	61.1±13.0
Body mass index, kg/m^2	28.9±5.9	27.9±5.8	26.7±5.5	25.4±4.4	24.1±4.1
Heart rate, beats/min	70±12	69±12	68±12	67±12	66±12

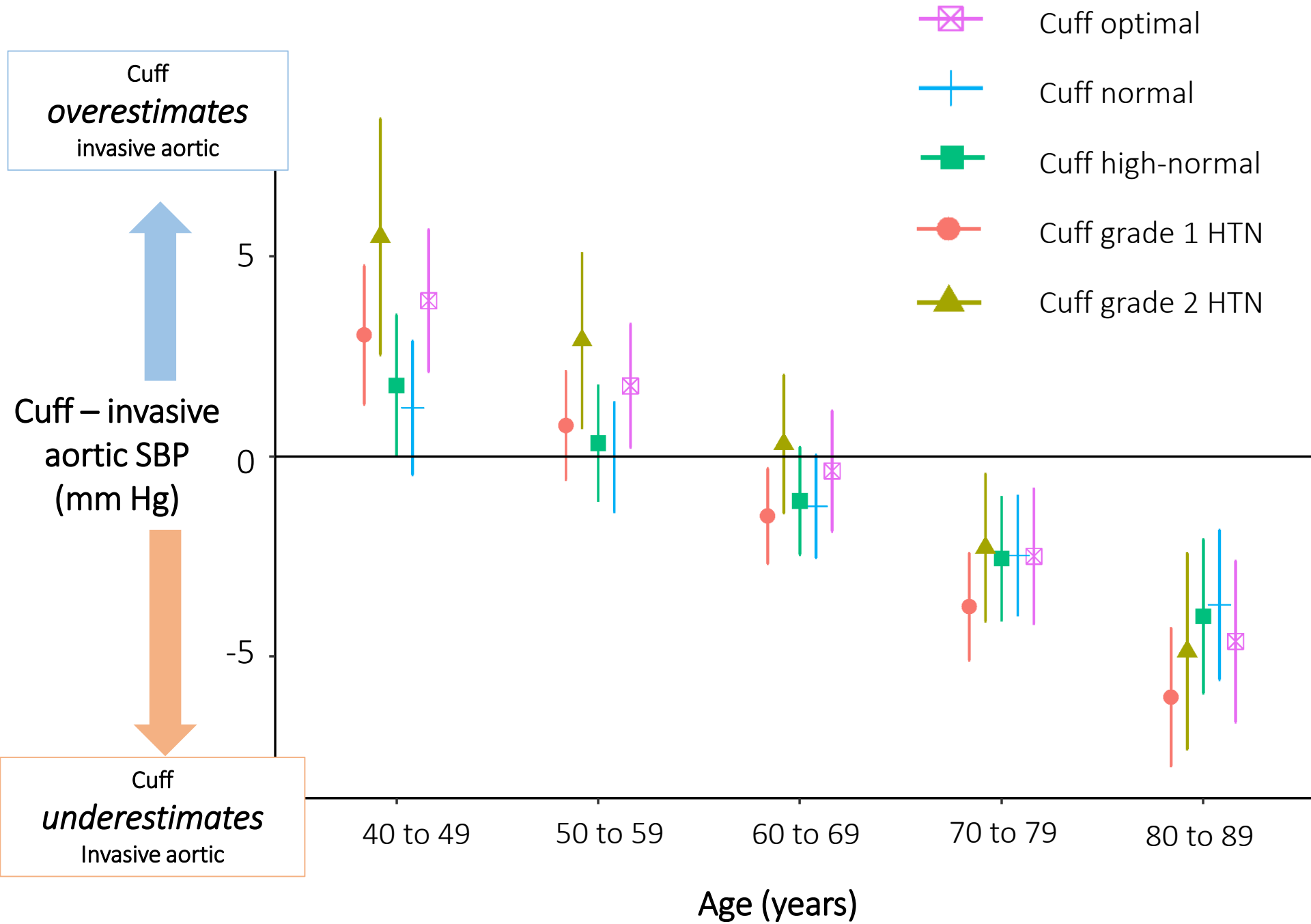
Age and cuff accuracy

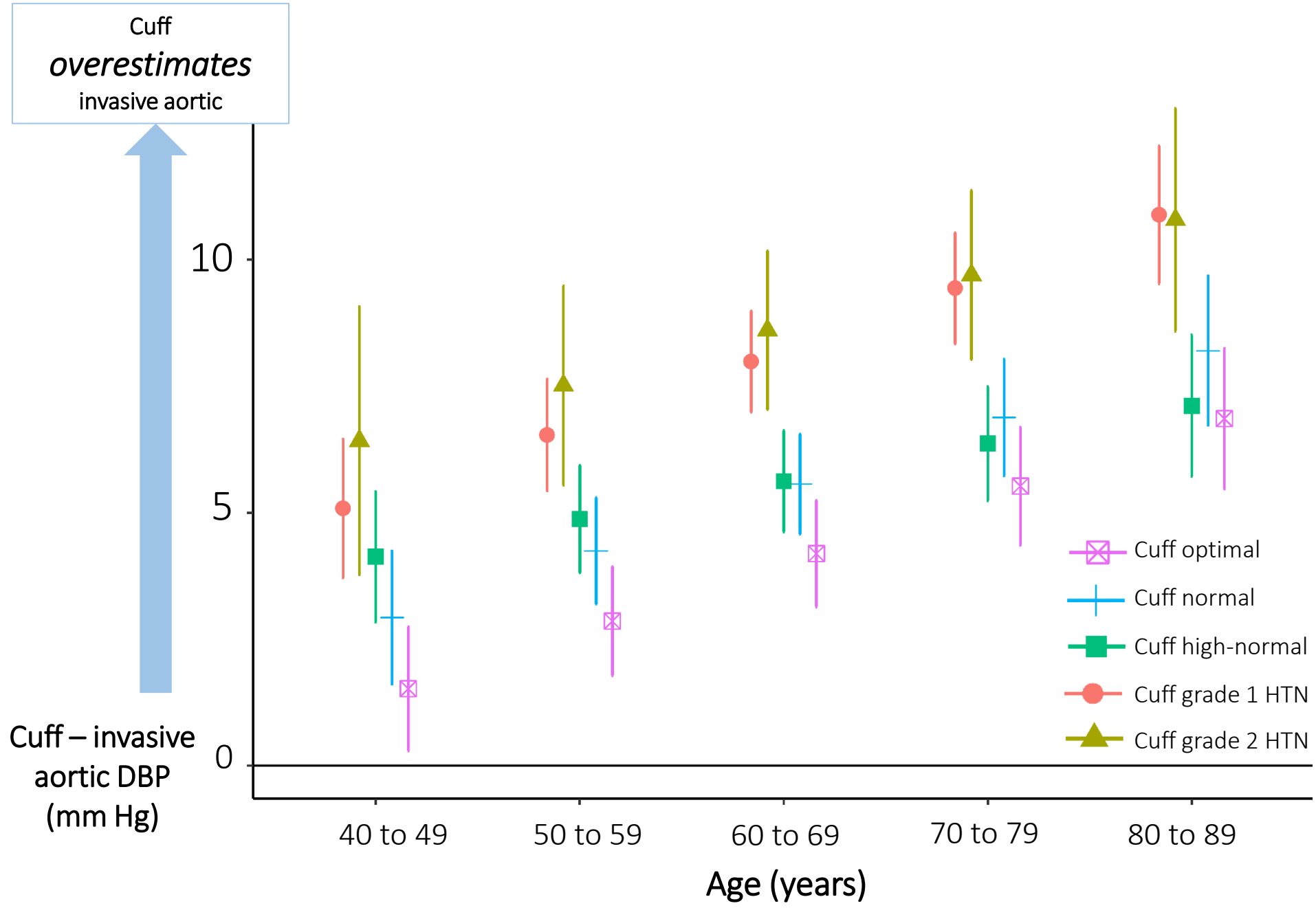


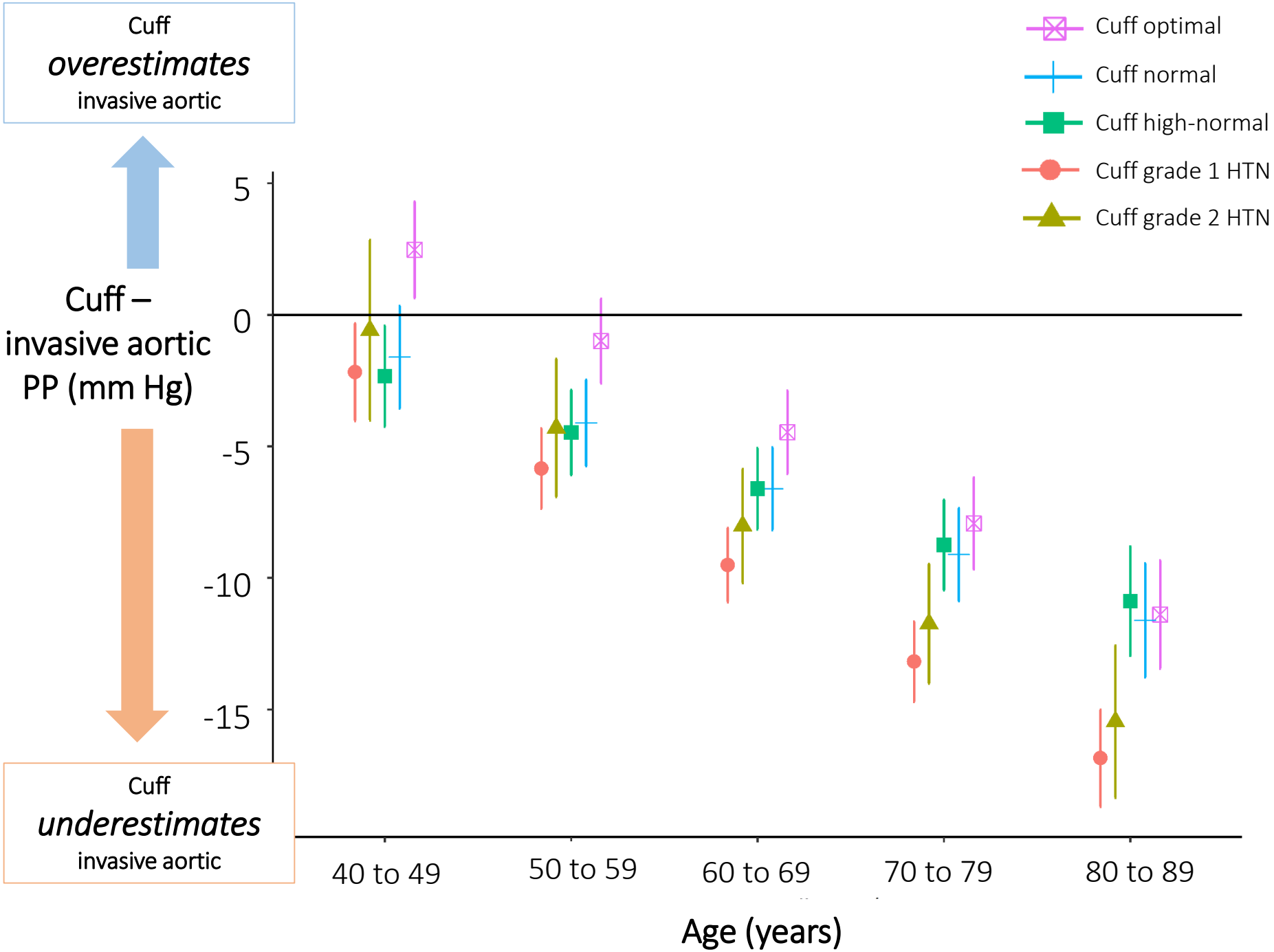
Age and cuff accuracy



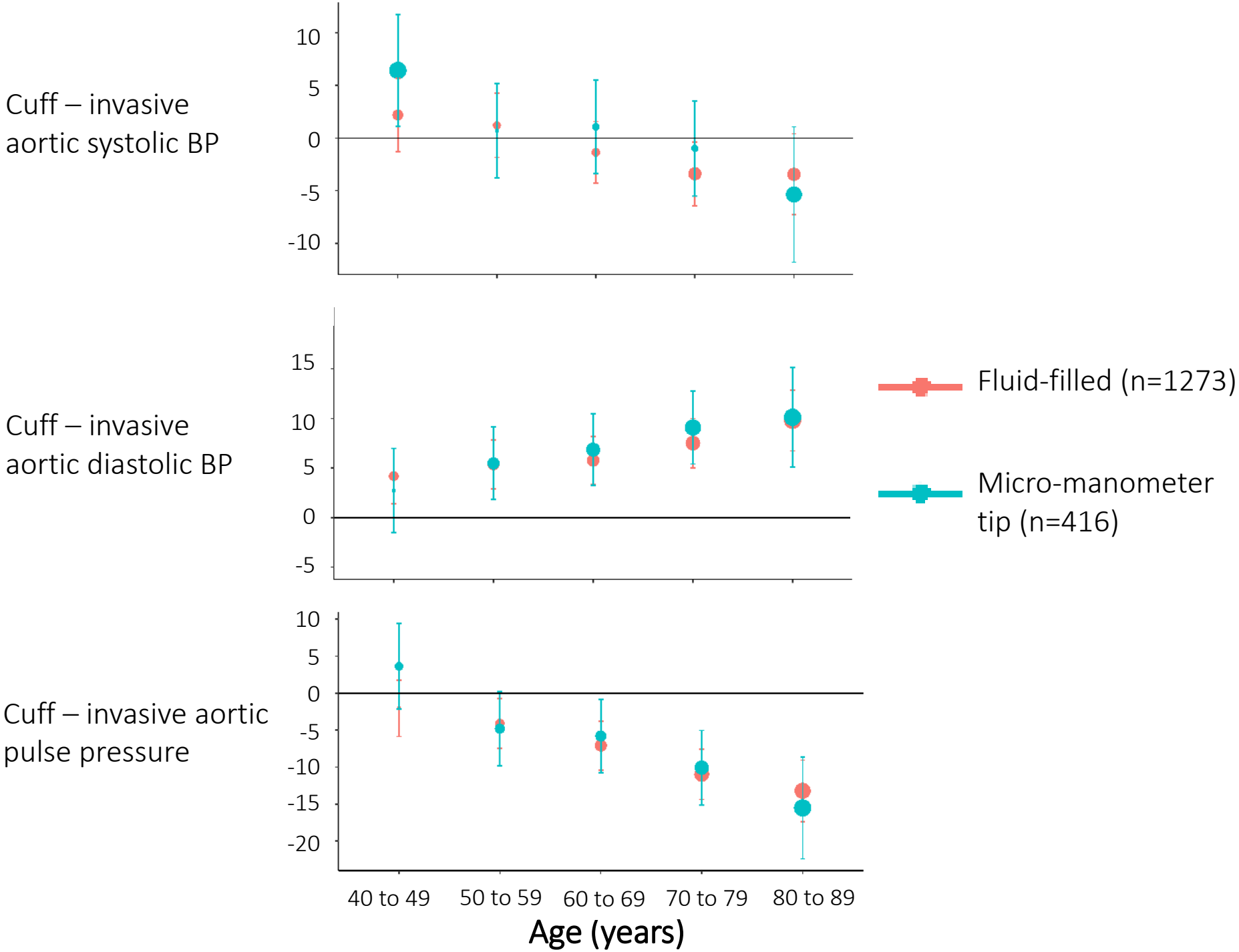
Is the influence of age on cuff accuracy different according to BP guideline categories?


Cuff
overestimates
invasive aortic
Cuff – invasive aortic SBP (mm Hg)
Cuff
underestimates
Invasive aortic
5
0
-5
Cuff optimal
Cuff normal
Cuff high-normal
Cuff grade 1 HTN
Cuff grade 2 HTN
40 to 49
50 to 59
60 to 69
70 to 79
80 to 89
Age (years)


Cuff
overestimates
invasive aortic
Cuff – invasive aortic DBP (mm Hg)
10
5
0
40 to 49
50 to 59
60 to 69
70 to 79
80 to 89
Age (years)
Cuff optimal
Cuff normal
Cuff high-normal
Cuff grade 1 HTN
Cuff grade 2 HTN


Cuff
overestimates
invasive aortic
Cuff –
invasive aortic
PP (mm Hg)
Cuff
underestimates
invasive aortic
Cuff optimal
Cuff normal
Cuff high-normal
Cuff grade 1 HTN
Cuff grade 2 HTN
5
0
-5
-10
-15
40 to 49
50 to 59
60 to 69
70 to 79
80 to 89
Age (years)

Does the type of catheter used for invasive BP influence the cuff accuracy results?


Cuff – invasive aortic systolic BP
Cuff – invasive aortic diastolic BP
Cuff – invasive aortic pulse pressure
10
5
0
-5
-10
15
10
5
0
-5
10
5
0
-5
-10
-15
-20
40 to 49
50 to 59
60 to 69
70 to 79
80 to 89
Age (years)
Fluid-filled (n=1273)
Micro-manometer tip (n=416)

Speculative implications of the influence of age on cuff BP accuracy?

Optimal BP management thresholds

63 year old,
BP 148/86

American Heart Association

130/80
Rx: 1 drug

ESH
EUROPEAN SOCIETY OF CARDIOLOGY

140/90
Rx: 2 drugs

AAFP

150/90
Rx: no drug

Messerli and Bangalore, *JACC*, 2018; 72(11): 1313-16

Speculative implications of the influence of age on cuff BP accuracy?

Optimal BP management thresholds

Epidemiological data on prevalence of hypertension

Speculative implications of the influence of age on cuff BP accuracy?

Optimal BP management thresholds

Epidemiological data on prevalence of hypertension

BP device validation protocols

Consensus Document

A universal standard for the validation of blood pressure measuring devices: Association for the Advancement of Medical Instrumentation/European Society of Hypertension/International Organization for Standardization (AAMI/ESH/ISO) Collaboration Statement

George S. Stergiou[a,*,†], Bruce Alpert[b,†,‡], Stephan Mieke[c,†], Roland Asmar[d,*], Neil Atkins[e,*], Siegfried Eckert[f,†], Gerhard Frick[g,‡], Bruce Friedman[h,‡], Thomas Graßl[i,†], Tsutomu Ichikawa[j,†,‡], John P. Ioannidis[k,*], Peter Lacy[l,§], Richard McManus[m,§], Alan Murray[n,†], Martin Myers[o,*], Paolo Palatini[p,*], Gianfranco Parati[q,*], David Quinn[r,‡], Josh Sarkis[s,†,‡], Andrew Shennan[t,*], Takashi Usuda[u,†], Jiguang Wang[v,*], Colin O. Wu[w,‡], and Eoin O'Brien[x,*,§]

Stergiou et al, *J Hypertens*, 2018, 36:472–478

Speculative implications of the influence of age on cuff BP accuracy?

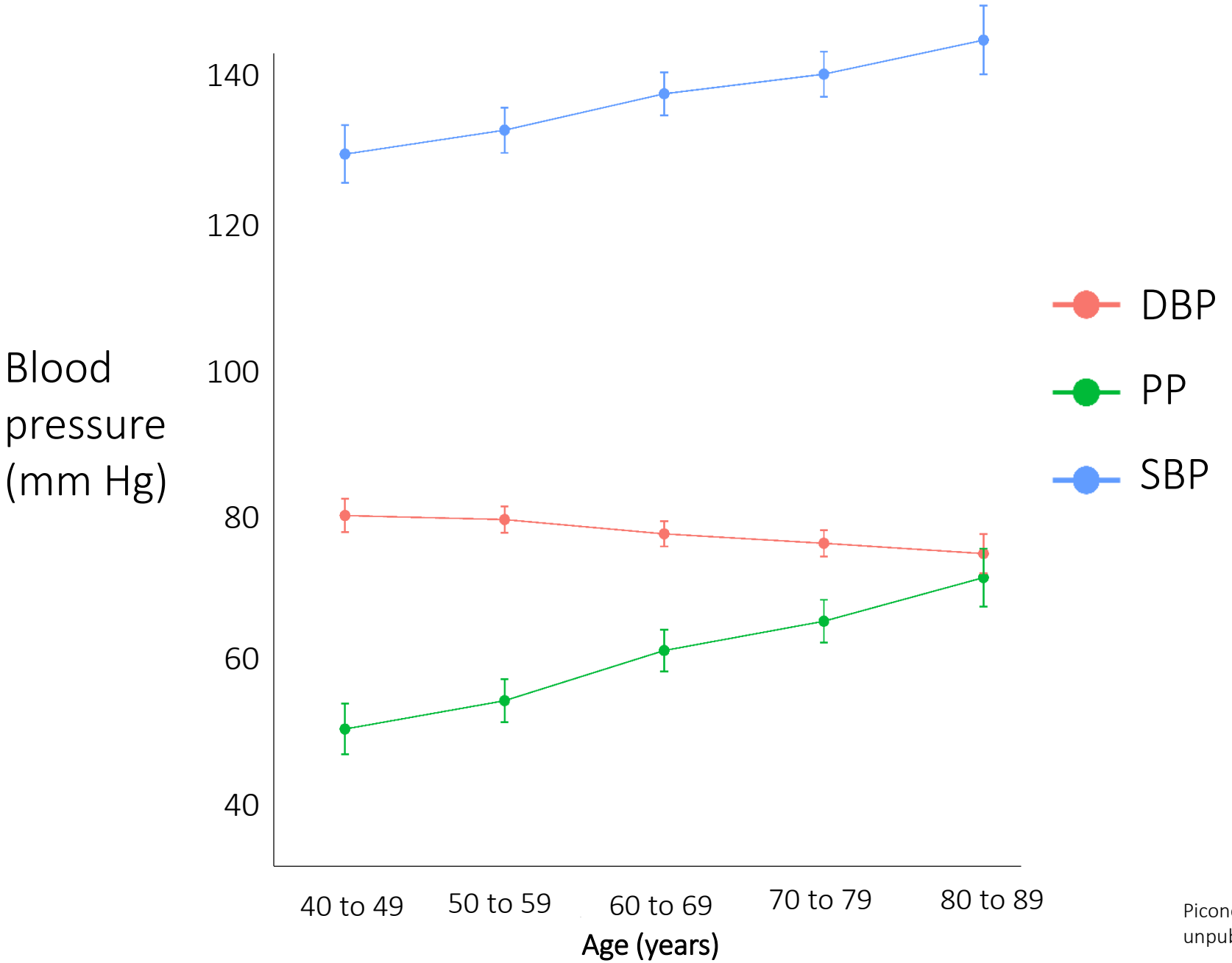
Optimal BP management thresholds

Epidemiological data on prevalence of hypertension

BP device validation protocols

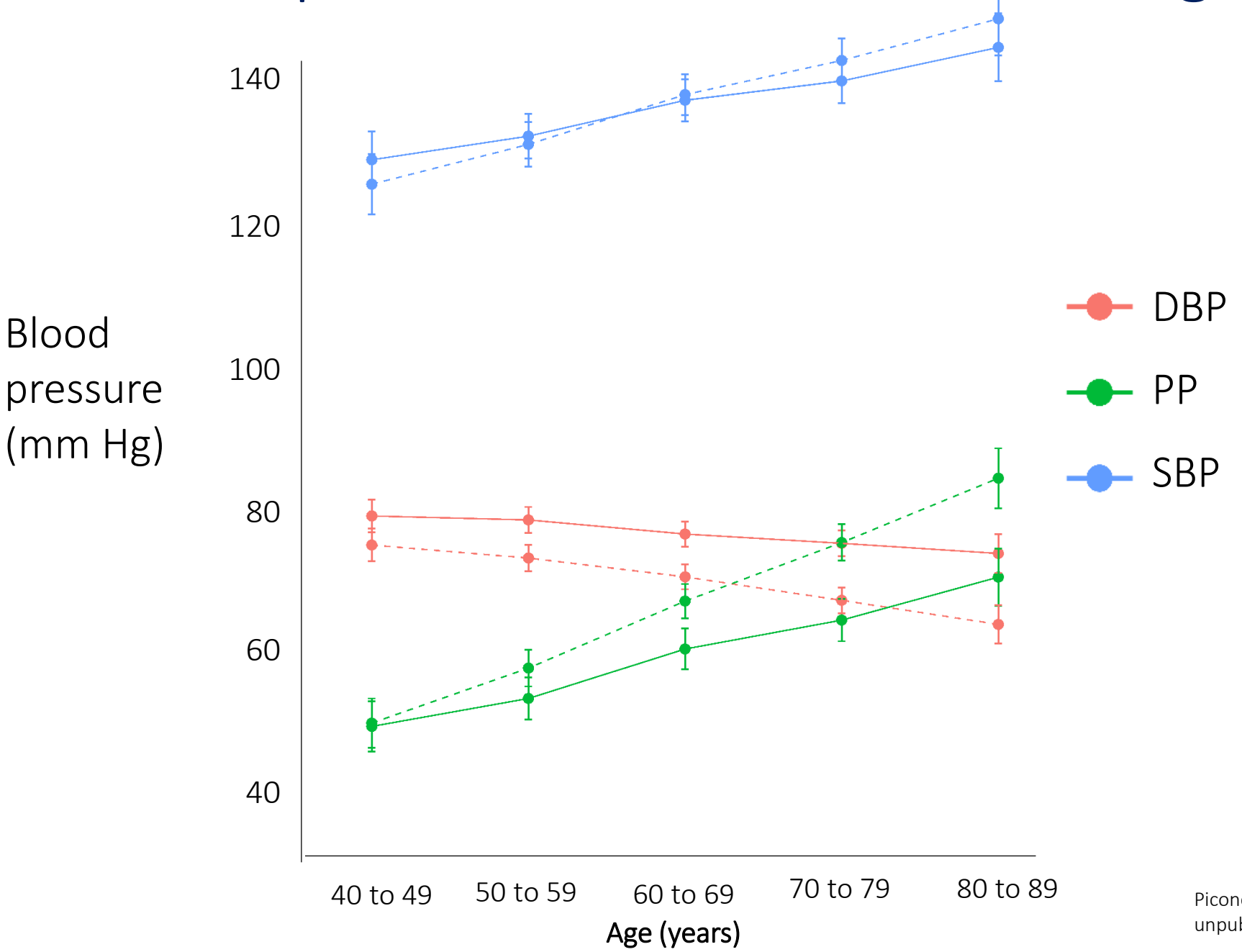
Natural history of BP with ageing

Blood pressure in middle to older age



Picone et al.
unpublished

Blood pressure in middle to older age



Picone et al. unpublished

Conclusions

Cuff BP becomes progressively more inaccurate with increasing age (systolic, diastolic, pulse pressure)

Vascular age versus chronological age ?

Expose older people to greater chance for misdiagnosis of risk related to BP

Thank you

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Broadreach Postdoctoral scholarship funding

Heart Foundation®

ARTERY
Association for Research into Arterial Structure and Physiology

UNIVERSITY of TASMANIA | MENZIES Institute for Medical Research

INSPECT

Invasive Blood Pressure Consortium

For more information or to contribute study data and join INSPECT please contact me (dean.picone@utas.edu.au) or Prof. James Sharman (james.sharman@utas.edu.au).

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