

Predictors of Central Blood Pressure in Older Adults

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ABSTRACT

Purpose: To investigate the predictors of central blood pressure (BP) in older adults, which is suggested as an emerging marker of future cardiovascular diseases, independent of peripheral BP. **Methods:** This cross-sectional study included 304 older adults aged ≥ 65 years (mean age 72). Central and peripheral BP were measured using Uscom BP+ while seated. Demographic (age, sex), lifestyle (smoking, alcohol intake), body composition by DXA (body weight and fatness), cardiometabolic (peripheral BP, resting heart rate [RHR], blood glucose and lipids), and physical activity (PA) (sitting time, daily steps) and fitness variables (cardiorespiratory fitness [CRF], handgrip strength) were identified as potentially predictive of central BP and included in the prediction model. **Results:** Univariate regression revealed that age ($p < 0.001$), body weight ($p = 0.041$), percent body fat (%BF) ($p = 0.049$), total cholesterol (TC) ($p = 0.042$), fasting glucose ($p = 0.014$), CRF ($p = 0.004$) and peripheral systolic BP (PSBP) ($p < 0.001$) were significant for central systolic BP (CSBP). Body weight ($p < 0.001$), %BF ($p < 0.001$), TC ($p = 0.005$), RHR ($p = 0.002$) and peripheral diastolic BP (PDBP) ($p < 0.001$) were significant for central diastolic BP (CDBP). Stepwise multivariate linear regressions with $p < 0.2$ for entry and $p < 0.05$ for staying in the model were used to identify significant predictors of central BP. In the multivariate regression model, PSBP ($\beta = 0.89$, $p < 0.001$) and male sex ($\beta = -1.94$, $p < 0.001$) were identified as significant predictors for CSBP, and PDBP ($\beta = 0.99$, $p < 0.001$) and TC ($\beta = 0.01$, $p < 0.011$) for CDBP. These set of predictors accounted for 91.6% and 93.5% of the total variance in CSBP and CDBP, respectively. When stratified for BP medication, PSBP and PDBP remained significant in participants both with (33%) and without (67%) BP medication, but sex and TC remained significant only in participants without BP medication, suggesting a possible effect modification by BP medication. When stratified by PA and CRF by 400m walk test, the CSBP model was stronger for the active group ($\geq 5,000$ steps/day; $R^2 = 0.97$) than the inactive ($R^2 = 0.89$) and stronger for the high (upper third; $R^2 = 0.95$) CRF than moderate (middle third; $R^2 = 0.91$) or low (lower third; $R^2 = 0.90$). **Conclusion:** The results suggest that peripheral BP is the strongest predictor of CBP for older adults.

INTRODUCTION

Central blood pressure (CBP) has been shown to assess the hemodynamic load on the cardiovascular system and predict CVD events better than peripheral blood pressure (1). However, more information about CBP is needed before it is used in the clinical setting. Therefore, the purpose of this study was to examine a wide range of potential CBP predictors and compare their relative importance.

1. Carmel M, McEniery, John R, Cockcroft, Mary J, Roman, Stanley S, Franklin, Ian B, Wilkinson. Central blood pressure: current evidence and clinical importance. *European Heart Journal*, Volume 35, Issue 26, 7 July 2014, Pages 1719–1725, <https://doi.org/10.1093/eurheartj/ehf565>

METHODS

Study Design: Cross-sectional study

Participants: 304 older adults, ≥ 65 years (mean age 72, range 65-95 years).

LIFESTYLE

- **Smoking Status:** Self-reported smoking habits
- **Heavy Alcohol Intake:** Self-reported number of daily drinks of beer (12oz.), wine (5oz.), and liquor (1.5oz.) being >14 per week for men and >7 per week for women

BODY COMPOSITION

- **Weight:** Measured using a digital scale
- **Percent Body Fat:** Dual-energy X-ray Absorptiometry (DXA)

CARDIOMETABOLIC

- **Total Cholesterol, Fasting Glucose:** 5ml blood draw after 12-hour fast
- **Peripheral Blood Pressure, Resting Heart Rate:** Automatic blood pressure machine

FITNESS:

- **Cardiorespiratory Fitness:** 400m walk test
- **Grip Strength:** Handheld dynamometer (Jamar Plus+)

PHYSICAL ACTIVITY

- **Steps per day:** Accelerometer-based pedometer (Omron HJ-321 tri-axis pedometer) worn during waking hours for 7 days, providing daily step count.
- **Sitting Time:** Self-reported using survey

CENTRAL BLOOD PRESSURE

- Uscom BP+ Central Blood Pressure Monitor (Uscom Ltd., Sydney, Australia)

METHODS

STATISTICAL ANALYSIS: Univariate regression and stepwise multivariate linear regression ($p < 0.2$ for entry and $p < 0.05$ for staying in the model). Model selected by stepwise multivariate linear regression was then stratified by blood pressure medication, physical activity, then cardiorespiratory fitness by 400m walk test.

Table 1. Participant Characteristics

Characteristics	All
	n=304
Age	74.2 (5.8)
Sex (% Male)	127 (41.8)
Weight (kg)	76.9 (16.6)
Percent Body Fat	39.8 (7.7)
Total Cholesterol (mg/dL)	187 (36)
Fasting Glucose (mg/dL)	99 (16)
Peripheral Blood Pressure	
Systolic (mmHg)	124 (18)
Diastolic (mmHg)	73 (7)
Central Blood Pressure	
Systolic (mmHg)	118 (16)
Diastolic (mmHg)	74 (8)
Resting Heart Rate (beats/min)	66 (10)
Current Smoking Status (%)	
No	300 (99)
Yes	3 (1)
Heavy Drinker (%)	31 (10)
Average Sitting Time (hours/day)	11.9 (5.0)
Cardiorespiratory Fitness (400m walk time, minutes)	4.5 (0.8)
Average Grip Strength (kg)	26.97 (9.56)
Physical Activity (steps/day)	4980 (2804)

Values are means (SD) for continuous variables or number (%) for categorical variables.

Table 2. Stepwise Multivariate Regression on Central Systolic and Diastolic Blood Pressure

Variable	Central Systolic Blood Pressure		Central Diastolic Blood Pressure		P Value	Model R ²
	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error		
Systolic						0.916
Intercept	8.58	1.93	8.58	1.93	<0.001	
Male Sex	-1.94	0.56	-0.96	0.28	<0.001	
Peripheral systolic BP (mmHg)	0.89	0.02	15.83	0.28	<0.001	
Diastolic						0.935
Intercept	0.57	1.20	0.57	1.20	0.632	
Total cholesterol (mg/dL)	0.01	0.003	0.29	0.11	0.011	
Peripheral diastolic BP (mmHg)	0.99	0.02	7.37	0.11	<0.001	

Table 3. Univariate Regression on Central Systolic and Diastolic Blood Pressure

Variable	Central Systolic Blood Pressure		Central Diastolic Blood Pressure		Pr > t
	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	
Age (years)	0.54	0.16	3.16	0.94	<0.001
Male Sex	1.31	1.92	0.65	0.95	0.495
Heavy Alcohol Consumption (heavy drinker, yes or no; >14 drinks/week for men, >7 drinks/week for women)	0.78	3.12	0.24	0.95	0.802
Smoking (current, yes or no)	5.18	9.56	0.51	0.95	0.589
Weight (kg)	0.12	0.06	1.93	0.94	0.041
Percent Body Fat (%)	0.24	0.12	1.86	0.94	0.049
Total Cholesterol (mg/dl)	0.05	0.03	1.93	0.94	0.042
Fasting Glucose (mg/dl)	0.15	0.06	2.32	0.94	0.014
Resting Heart Rate (beats/min)	-0.15	0.09	-1.56	0.96	0.104
Steps per day (per 1000 steps)	-0.63	0.34	-1.78	0.95	0.061
Cardiorespiratory Fitness: 400m walk (minutes)	3.39	1.18	2.70	0.94	0.004
Grip Strength (per 5kg)	-0.70	0.50	-1.34	0.95	0.158
Self-reported Sitting Time (hours/day)	0.20	0.19	1.02	0.95	0.285
Peripheral Systolic Blood Pressure (mmHg)	0.88	0.02	15.73	0.28	<0.001
	Parameter Estimate	Standard Error	Parameter Estimate	Standard Error	Pr > t
Age (years)	-0.05	0.08	-0.28	0.45	0.533
Male Sex	0.94	0.89	0.47	0.44	0.292
Heavy Alcohol Consumption (heavy drinker, yes or no; >14 drinks/week for men, >7 drinks/week for women)	0.27	1.46	0.08	0.44	0.853
Smoking (current, yes or no)	-1.18	4.45	-0.12	0.44	0.791
Weight (kg)	0.12	0.03	1.92	0.43	<0.001
Percent Body Fat (%)	0.20	0.06	1.54	0.43	<0.001
Total Cholesterol (mg/dl)	0.03	0.01	1.25	0.44	0.005
Fasting Glucose (mg/dl)	0.04	0.03	0.70	0.44	0.114
Resting Heart Rate (beats/min)	0.14	0.04	1.42	0.44	0.002
Steps per day (per 1000 steps)	-0.21	0.16	-0.58	0.44	0.192
Cardiorespiratory Fitness: 400m walk (minutes)	0.74	0.56	0.59	0.44	0.185
Grip Strength (per 5kg)	0.14	0.23	0.27	0.44	0.545
Self-reported Sitting Time (hours/day)	0.13	0.09	0.67	0.44	0.129
Peripheral Diastolic Blood Pressure (mmHg)	0.99	0.02	7.40	0.11	<0.001

CONCLUSIONS

The results suggest that peripheral blood pressure is the strongest predictor of central blood pressure for older adults.

Stepwise multivariate regression:

- Significant predictors central Systolic BP: male sex and peripheral systolic BP
- Significant predictors central Diastolic BP: total cholesterol and peripheral diastolic BP

Limitations:

- Cross-sectional analysis
- Overall somewhat active and healthy population of older adults.

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