

## ORIGINAL ARTICLE

# Is systolic blood pressure sufficient for classification of blood pressure and determination of hypertension based on JNC-VI in an Iranian adult population? Tehran lipid and glucose study (TLGS)

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The purpose of this study was to determine if systolic blood pressure (SBP) by itself is sufficient for the JNC-VI (Sixth Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure)-based classification of blood pressure of Tehranian adult population. Clinically, SBP and diastolic blood pressure (DBP) are sometimes at different stages in the same individual and the higher stage is considered to classify blood pressure level. The prevalence of disparate levels of SBP and DBP has only recently been noticed. Some researches have reported the importance of SBP level, and not DBP, in determining the appropriate classification of hypertension even in those undergoing treatment. Data were collected for 3823 men and 5159 women aged 20–69 years who were not using antihypertensive medication, in the Tehran Lipid and Glucose Study (TLGS), a cross-sectional phase of a large epidemiological study first established in 1999. The study used the mean of two separate blood

pressure measurements in each individual. High blood pressure is defined according to the highest level of SBP or DBP. In 86.3% of the subjects, blood pressure stage was determined according to SBP and in 90.0% of them according to DBP. In 77.4% of the subjects (75.7% of men and 78.7% of women), SBP determined blood pressure in the same stage as DBP did. The role of SBP was the most prominent in age groups 20–29 and 60–69 years (91.4 and 90.8%, respectively) and the least in age group 40–49 years (80.4% of the subjects). DBP had a more prominent role in younger ages and the least significance in older ages. In conclusion, SBP has a more prominent role than DBP in determining blood pressure stage according to JNC-VI only in the 60–69-year-old group. The role of DBP is more prominent in other age groups.

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## Introduction

According to the Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-VI), blood pressure classification is based on the highest stage of systolic blood pressure (SBP) or diastolic blood pressure (DBP).<sup>1</sup> Clinically, SBP and DBP are sometimes in different stages in the same individual and the higher stage is considered to classify blood pressure level.<sup>2</sup> The prevalence of disparate levels of SBP and DBP has come to attention only recently.

Lloyd-Jones *et al*<sup>2</sup> and Pogue *et al*<sup>3</sup> have reported the importance of SBP level, and not DBP, in determining the appropriate classification of hypertension even in those undergoing treatment.<sup>4</sup> Moreover, on the basis of the wealth of currently available evidence, the JNC recommends a major paradigm shift in urging that SBP become the major criterion for diagnosis, staging, and therapeutic management of hypertension, particularly in middle-aged and older Americans.<sup>5</sup> Framingham Heart Study<sup>6</sup> and MRFIT<sup>7</sup> even more convincingly demonstrated the pre-eminent value of SBP in the risk prediction of cardiovascular diseases. This phenomenon is also recently emphasised by Dustan.<sup>8</sup>

In this article, we report our experience employing JNC-VI classification in blood pressure survey

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in inhabitants of Tehran City who participated in the Tehran Lipid and Glucose Study (TLGS) in 1999–2000.<sup>9</sup>

## Methods

### TLGS design and sample

TLGS is a longitudinal study in which the first phase is a cross-sectional study or a baseline examination survey. It has been designed to estimate the prevalence of cardiovascular risk factors including lipid and glucose disorders, obesity, smoking, and hypertension for a representative sample of Iranian urban population in Tehran, No. 13 district. The first phase of this study was performed in the years 1999 and 2000.<sup>9</sup>

Individuals aged 3–69 years who were under coverage of medical health centres of Lailatolghadr, Mohammadian, and Salavati and were sampled through a random multistage stratified cluster sampling were invited to participate in this study. The crude response rate was approximately 57.5%, and the reasons for nonresponse are now being investigated as to whether there is any essential difference between respondents and nonrespondents.

The data are collected by means of interviews and a questionnaire for demographic data and physical examination for blood pressure, pulse rate and anthropometrical measurements, thyroid examination, and laboratory measurements for lipid profiles, fasting blood sugar (FBS), 2 h post 75 gm glucose test (2 h PG), and serum thyroid hormone measurement. An electrocardiogram is taken for those over 30 years of age. Data are directly stored in Computer-Assisted System software.<sup>10</sup> All the procedures mentioned above are conducted at a research unit of the TLGS unit.

### Blood pressure measurement

Participants were initially told to rest for 15 min. A qualified physician then measured blood pressure twice during the physical examination in a sitting position after one more measurement for determining peak inflation level using a standard mercury sphygmomanometer calibrated by the Iranian Institute of Standards and Industrial Research. All the physicians were required to participate in a period of specialized training in the use of standardized protocol for measuring the blood pressure. After that, a qualifying exam was held to assure the quality of the procedure. Moreover, satisfactory performance during concordant measurements of blood pressure with an instructor by means of a double-headed Y-shaped stethoscope was a requirement for certification as a TLGS physician as well as retraining and requalifying in definite intervals. A digit preference score was also calculated to ascertain the quality and precision of physicians' performances.<sup>11</sup> Based on the circumference of the

participant's arm, a regular adult or large cuff was chosen. The cuff was placed on the participant's right arm, and inflated as fast as possible until the cuff pressure was 30 mmHg above the level at which the radial pulse disappeared. There was at least a 30-s interval between these two separate measurements. Thereafter, the mean of the two measurements was considered as the participant's blood pressure, which was entered into the computer. The SBP was defined as the appearance of the first sound (Korotkoff phase 1), and the DBP was defined as the disappearance of the sound (Korotkoff phase 5) during deflation of the cuff at a 2–3 mm/s decrement rate of mercury column. The participants were asked to refrain from drinking tea or coffee, physical activity, and smoking. They were also asked to empty their bladder 30 min preceding the measurement. The study used the mean of two separate BP measurements in each individual, and BP classification was carried out according to the JNC-VI criteria. However, because of low frequency of hypertension stage 3, hypertension stages 2 and 3 were combined together as hypertension stage 2 in the analysis.

The study was approved by the research committee of the Endocrine Research Center and all individuals who participated in TLGS examinations were required to sign an informed consent form.

### Statistical analysis

Subjects aged 20–69 years were initially selected and categorized based on gender and five age groups. Then the prevalence of JNC-VI-based stages of SBP and DBP by gender and age groups were calculated by means of the SPSS 9.05 statistical software package (SPSS Inc., Chicago, IL, USA). Subjects who were using any antihypertensive prescription medication were excluded.

## Results

Data for 8982 subjects (3823 men and 5159 women) over 19 years of age were included. The mean age of individuals was  $40 \pm 13$  years ( $41 \pm 14$  and  $39 \pm 13$  years for men and women, respectively). Prevalence of blood pressure stages by sex on the basis of JNC-VI criteria according to both SBP and DBP, SBP alone, and DBP alone are shown in Table 1.

Based on both SBP and DBP (the JNC-VI), 71.8% of the cases had normal BP, 13.3% high normal BP, 11.1% hypertension stage 1, and 3.8% hypertension stage  $\geq 2$ . For DBP alone, the corresponding values were 78.6, 10.2, 8.5, and 2.7%, respectively, compared with those of SBP alone (81.5, 9.6, 6.8, and 2.1%), and had less differences with values for both SBP and DBP (the JNC-VI). In 8.9% of the cases (10.0% of men and 8.1% of women), SBP was at a higher stage than DBP and it was 13.6% (14.3% of men and 13.2% of women) for DBP. In 77.4% of the cases (75.7% of men and 78.7% of women), SBP and DBP were in the same stage. This means that in

**Table 1** Distribution of blood pressure stages in 8982 cases based on JNC-VI criteria, SBP alone, or DBP alone

Blood pressure	Sex	Blood pressure classification				Total
		Normal	High normal	HTN Stage 1	HTN Stage $\geq 2$	
SBP	Men	3044 (79.6) <sup>a</sup>	413 (10.8)	272 (7.1)	94 (2.4)	3823 (100)
	Women	4276 (82.9)	448 (8.7)	341 (6.6)	94 (1.8)	5159 (100)
	All	7320 (81.5)	861 (9.6)	613 (6.8)	188 (2.1)	8982 (100)
DBP	Men	2946 (77.1)	429 (11.2)	333 (8.7)	115 (3.0)	3823 (100)
	Women	4114 (79.7)	489 (9.5)	430 (8.3)	126 (2.4)	5159 (100)
	All	7060 (78.6)	918 (10.2)	763 (8.5)	241 (2.7)	8982 (100)
JNC-VI (SBP and DBP)	Men	2654 (69.4)	566 (14.8)	445 (11.6)	158 (4.1)	3823 (100)
	Women	3799 (73.6)	626 (12.1)	552 (10.7)	182 (3.5)	5159 (100)
	All	6453 (71.8)	1192 (13.3)	997 (11.1)	340 (3.8)	8982 (100)

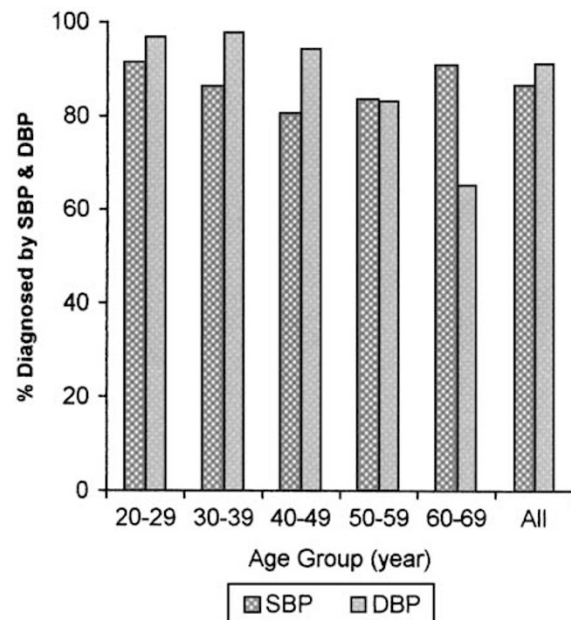
<sup>a</sup>Numbers in parenthesis represent row percent. SBP, systolic blood pressure; DBP, diastolic blood pressure; HTN, hypertension.

**Table 2** Concordance of SBP and DBP stages in various age groups

Age group (years)	No.	Comparison of blood pressure stage		
		SBP > DBP	SBP = DBP	DBP > SBP
20–29	2220	73 (3.3) <sup>a</sup>	1955 (88.1)	192 (8.6)
30–39	2574	53 (2.1)	2166 (84.1)	355 (13.8)
40–49	1886	107 (5.7)	1408 (74.7)	371 (19.7)
50–59	1309	222 (17.0)	870 (66.5)	217 (16.6)
60–69	993	347 (34.9)	555 (55.9)	91 (9.2)
All	8982	802 (8.9)	6954 (77.4)	1226 (13.6)

<sup>a</sup>See Table 1.

86.3% of the cases (85.7% of men and 86.8% of women), SBP was responsible for determining blood pressure stage and DBP alone had this responsibility in 90.0% of the cases (Table 1). The role of DBP in determining BP stage (ie DBP > SBP percent plus DBP = SBP percent in Table 2) was more prominent than SBP in all age groups, except for the 50–59 and 60–69 years age groups (Figure 1). This means that in 91.0% of the cases (90.0% of men and 91.9% of women), DBP was responsible for determining blood pressure stage and SBP alone had this responsibility in 86.3% of the cases (Table 2).



**Figure 1** Comparison of blood pressure classification based on SBP and DBP measures for age groups.

### Effect of age

Table 2 displays frequencies of blood pressure stages on the basis of SBP and DBP in different age groups. In age groups 20–29 and 60–69 years, SBP was responsible for determining blood pressure stage in 91.4 and 90.8% of the cases respectively, but in the

age group of 40–49 years blood pressure stage was determined on the basis of SBP in only 80.4% of the cases. The same pattern was seen in both gender, as shown in Figure 1. The role of SBP in determining blood pressure stage, however, was more prominent in lower and higher age groups. The role of SBP in determining blood pressure stage was the least in the middle-age group (40–49 years) in both genders (80.0 and 80.6% for men and women, respectively).

SBP tends to rise with increasing age, whereas DBP tends to have no notable change in the age group 50–59 years, when it begins to fall.

## Discussion

There is a current inclination to consider SBP as a much more important risk factor of coronary artery disease.<sup>2–8,12–14</sup> Lloyd-Jones *et al*<sup>2</sup> stated that 64.6% of the subjects had congruent of stages of SBP and DBP; in 31.6%, SBP was at a higher stage than DBP and in 3.8%, DBP was at a higher stage than SBP. This means that SBP alone correctly classified the JNC-VI-based stage of blood pressure in nearly 96% of the cases.<sup>2</sup> They stated that among subjects >60 years old, SBP alone correctly classified 99% of the subjects, and suggested that SBP appears to play a greater role in determining blood pressure stage and eligibility for that treatment of hypertension according to the JNC-VI criteria.<sup>2</sup> Our study demonstrated a weaker role for SBP and a stronger role for DBP in this regard. When the BP was classified based on SBP alone, fewer cases were categorized into higher stages of BP than it is done based on DBP alone. The blood pressure of 91.0% of the subjects was classified according to DBP alone. SBP alone, however, correctly classified the blood pressure of 86.3% of the subjects. Therefore, in our sample DBP was a more superior determinant of blood pressure stage than SBP, compared with Western studies. A possible explanation for this finding may be the age of our study subjects. Our subjects were younger than those studied by Lloyd-Jones *et al*<sup>2</sup> (40 ± 13 vs 58 ± 13 years). To explore the effect of age, our cases were stratified into five age groups and then the analysis was repeated. In this regard, the role of SBP in determining blood pressure stage was the greatest in age groups 20–29 and 60–69 years and the least in the age group 40–49 years. In the age group 60–69 however, this role was not as prominent as it was in Lloyd-Jones *et al*'s study. The more eminent role of SBP in determining blood pressure stage is mostly because of the higher concordance of SBP and DBP in younger age groups (88.1%) and the higher prevalence of blood pressure class upstaged by SBP in older age groups (34.9%). Considering DBP, in 96.7% of the 20–29-years-old cases, it determined BP stage correctly. DBP determined BP stage correctly in 97.9, 94.4, 83.1, and 65.1% of 30–39, 40–49, 50–59, and 60–69-years-old cases, respectively. It is clear that only in those over 60 years old,

**Table 3** Mean of SBP and DBP in different age groups

Age (years)	20–29	30–39	40–49	50–59	60–69
SBP (mmHg)	110	112	117	126	133
DBP (mmHg)	73	76	79	81	80

As is clear, SBP tends to rise with increasing age and there is no significant change in DBP after 50 years old.

SBP had an advantage over DBP in determining blood pressure stage, even though this advantage was not as strong as the study by Llyod-Jones *et al*.<sup>2</sup> It is also obvious that in those who are 50–59 years old, neither SBP nor DBP can be used alone for BP staging, because in this case in almost 17% of people the staging will be wrong. In younger age groups, DBP is a good predictor of BP staging. One has to practice caution when analysing the BP measurement on those who are 40–49 years old in whom SBP alone can be used for correct staging of BP in only 80.4% of the cases, while DBP can be used in 94.4% of the cases.

Another possible explanation for a more prominent role of DBP over SBP in our subjects is the higher mean DBP level in Tehranians compared with the Western population,<sup>15</sup> especially in the younger age groups.

With increasing age, the concordance of SBP and DBP decreases and blood pressure upstaging based on SBP becomes more likely. Blood pressure upstaging based on DBP is still high until 50 years old, but it tends to decrease when SBP becomes more prominent in determining blood pressure stage in older age groups. These findings may be because of a tendency of a rise in SBP with increasing age, whereas DBP tends to have no significant change after 50 years old, and actually after 60 years old it begins to fall slightly (Table 3) as noted in other studies.<sup>15,16</sup>

In conclusion, DBP seems to be a stronger predictor of BP staging than SBP in young and middle-aged people. A higher prevalence of high SBP in older age groups renders SBP more prodigious in staging blood pressure in older people. Therefore, the role of DBP in determining blood pressure stage in adults, especially in young and middle-aged subjects, should be considered more important than SBP.

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