



Contents lists available at ScienceDirect

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## Original Article

## Impact of body mass index and waist circumference on blood pressure: A cross-sectional survey in a population living in the Vietnam northern mountainous



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## ARTICLE INFO

## Article history:

Received 26 January 2019

Accepted 4 February 2019

## Keywords:

Body mass index  
Waist circumference  
Blood pressure  
Vietnam

## ABSTRACT

**Aims:** Several epidemiological studies have indicated that elevated blood pressure (BP) is associated with the surfeit of body weight. Body fat accumulation is considered as be a significant factor contributing to the nexus between obesity and hypertension. Two of the most common indicators used to characterize the associations of BP are body mass index (BMI) and waist circumference (WC). This study was aimed to describe the differences in some characteristics among people aged 20 and above in three communes of a district in Vietnam and analyze the correlation between BMI and WC, and BP.

**Materials and methods:** We conducted a survey with a cross-sectional design of 734 subjects in three communes in Chiem Hoa district of the Vietnam northern mountainous region.

**Results:** It was found that except for BMI, there were significant differences in some physical characteristics between genders ( $p < 0.05$ ). Particularly, the effects on Systolic Blood Pressure (SBP) or Diastolic Blood Pressure (DBP) of WC were more significant than that of BMI in genders. The impacts of WC on SBP as well as DBP were also stronger than that of BMI in age groups with the cut-off point 60 than BMI.

**Conclusions:** This study provides the science evidence in support of public and preventive health interventions to the locals residing in studied area. We recommend the existing correlations in subjects belonging to different ethnicities and continents.

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## 1. Introduction

The previous studies have reported that there were associations between obesity and heart disease [1–7]. The available evidence has also demonstrated that the risk of developing hypertension is much higher in obese people than that in lean ones [8–10], as well as the relationship of excess body weight and high BP has been proved [11,12]. As was shown in the previous studies, the fat distribution of body was known as an important factor which contributes to the relationship between obesity and high BP [13,14]. Researchers have long recognized the relationship between fat

accumulation for abdominal organs and chronic diseases in general, and high BP in particular. As a result, the life quality of communities has dramatically reduced due to the burdens in the socio-economy as well as in the medicine [15]. The common used indicators including BMI and WC are applicable to describe this association of BP and obesity. For World Health Organization (WHO), the BMI usage is to assess the degree of skin or fat through the prescribed classification [16]. It was pointed out that the previous evidence of abdominal obesity, assessed by WC, predicts obesity-related health risks [17–20] and there are documents report that WC in combination with BMI has the ability to predict better health risk than independent BMI [19,21–23].

The previous studies show that WC is considered as the best anthropometric index correlating with BP [24]. The positive relationships between BMI and systolic blood pressure (SBP) as well as diastolic blood pressure (DBP) were pointed out across three populations in Africa and Asia [25]. In Vietnam, one of the few similar studies that has been conducted which has shown that obesity by WC increases the risk of hypertension by 4.32 times; by BMI was 5.9 times and BMI is the best risk measure for high BP [6]. Due to the diversity of ethnic groups and the socio-economy, the surveys in different communities on the health status and related characteristics indicate the specific perspectives in the correlation between BMI, WC and BP. The present study is aimed to consolidate available information that helps to clearly understand the patterns of BMI and WC on BP among a population living in the Vietnam's Northern mountainous area where the poverty status among residents is high. Such information would thus be relevant to recommend the public and preventive health policies in this area. Thus, here we characterized the differences of some characteristics among a population in three communes in studied area and analyze the correlation between BMI and WC, and BP.

## 2. Materials and methods

### 2.1. Study design

A cross-sectional study design was employed to survey in three communes located in Chiem Hoa district, Tuyen Quang province. Study population was established by people aged 20 and above residing in these communes from June 2017 to March 2018. Sample size formula for quantitative variable was as follow.

$$n = Z_{(1-\alpha/2)}^2 \frac{SD^2}{d^2}$$

Here,  $Z_{(1-\alpha/2)} = 1.96$  with  $\alpha = 0.05$ ;  $SD = 26$  mmHg;  $d = 2$  mmHg. Sample size based on the formula was 649. A real total of 734 subjects was included in our study. A simple random sampling technique was utilized to ensure the representation of people living in these communes of Northern mountainous region in Tuyen Quang province. In the first stage, all the locals residing in Kim Binh, Binh Phu and Xuan Quang communes were listed. The second stage consisted of randomly selecting 734 subjects from the list. In the third stage, the appointment of health check invitations was sent in order to exam and collect variables and indexes.

### 2.2. Measurements

BP was recorded three times in the right arm of each participant; BP measurement was done using the Omron HBP-1300 Professional Portable BP Monitor. Before the BP measurement, all subjects were requested to not use tobacco or tea/coffee at least 30 min and to take a rest at least five minutes in a quiet room. BP measurement was done when the subjects comfortably sat in the chair. The mean

SBPs and DBPs of the last two readings were utilized in the analyses.

We measured the height of subjects with a measuring tape. All subjects are asked to (i) take off the socks and shoes; measure height when they are barefoot, (ii) remove anything from their head; (iii) keep their hair flat and stand against the wall and close feet together; stand up as straight as possible with the head, shoulders, back and heels all touching the wall; tuck in the chin and look straight ahead [26,27]. Weight was measured by Tanita weighing instrument with a tolerance of 0.1 kg.

Measurement of WC with a flexible metric measuring tape was conducted around the belly at the level of the navel and taken to the nearest 0.1 cm [28].

### 2.3. Definitions

We took weight (kilogram) and height (meter) to calculate BMI as previous described [29]. The tertile of BMI was defined as distribution into three parts with equal number of observations. The 50th percentile of WC was defined as distribution into two parts with equal number of observations.

### 2.4. Research ethics

Permission to enter three communes was obtained from the People's Committee of communes and the respondents provided with informed consent. All co-researchers were briefed and trained before data collection.

### 2.5. Statistical analysis

The analysis of all data was analyzed using Stata<sup>®</sup>12. The descriptive analyses used for continuous variables were mean and standard deviation (SD). The Kruskal-wallis test (non-parametric method) was applied to determine the difference in the age variable between male and female. The *t*-test (parametric method) was used to determine the differences of the remaining variables (weight, height, BMI, WC, SBP and DBP) between two genders. Pearson correlation coefficient (*r*) was appropriately chosen to determine the univariate associations between BMI, and WC and either DBP or SBP. To assess the more specific influence of BMI and WC to SBP and DBP, we created DBP and SBP values according to the 50th percentile of WC and tertiles of BMI. We set the level of statistical significance at 0.05.

## 3. Results

Table 1 presents the characteristics of 231 males and 503 females. The average age was higher in male gender than in female gender, at  $59.75 \pm 14.63$  and  $55.34 \pm 15.87$  years respectively. In both genders, the mean BMI was about 22 kg/m<sup>2</sup>, while the mean

**Table 1**  
The differences of some characteristics between men and women.

Characteristics	Men (n = 231)	Women (n = 503)	p
Age (years)	59.75 ± 14.63	55.34 ± 15.87	<0.0002**
Weight (kg)	54.12 ± 10.06	48.72 ± 8.32	<0.0000***
Height (cm)	158.83 ± 8.30	149.87 ± 6.79	<0.0000***
BMI (kg/m <sup>2</sup> )	21.52 ± 4.49	21.65 ± 3.21	0.2297
WC (cm)	79.70 ± 9.39	77.35 ± 9.22	<0.0032*
SBP (mmHg)	137.36 ± 20.96	131.36 ± 23.43	<0.0001**
DBP (mmHg)	84.55 ± 12.92	80.08 ± 13.37	<0.0000***

Values are means ± SD.

\*, \*\*, \*\*\*: Statistically significant at 0.01, 0.001 and 0.0001, respectively.

**Table 2**  
Correlations between BMI, and WC and DBP or SBP in two genders.

	SBP (mmHg)		DBP (mmHg)	
	Men	Women	Men	Women
BMI	-0.05	0.17*	0.04	0.16*
WC	0.23*	0.28*	0.22*	0.24*

\*: Statistically significant at 0.05.

WC were  $79.70 \pm 9.39$  cm in men and  $77.35 \pm 9.22$  cm in women. There were 55.30% of men and 43.45% of women with hypertension (>140/90 mmHg) or using antihypertensive medications. All above differences were statistically significant ( $p < 0.05$ ).

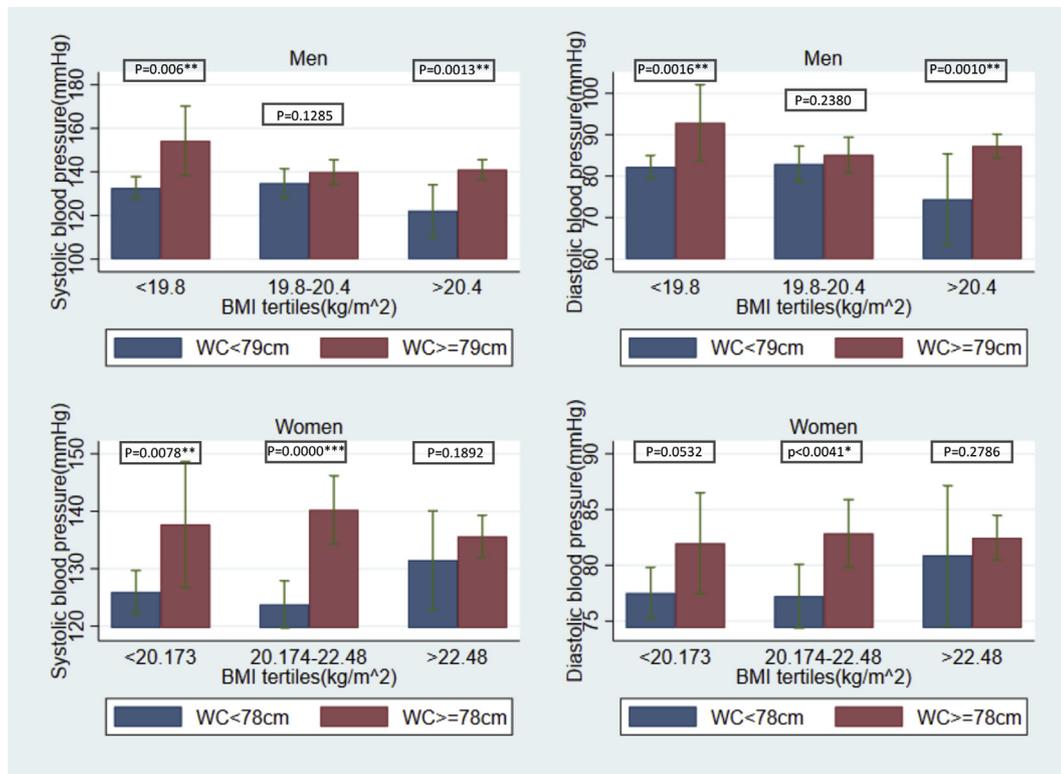
Correlations between BMI, and WC and either DBP or SBP are pointed out in Table 2. There were positive relationships between WC and SBP or DBP in both genders ( $p < 0.05$ ), whereas no significant associations were found between BMI and SBP or DBP in male gender ( $p > 0.05$ ). Weak positive relationships were found between BMI and SBP or DBP in women. The highest correlation with SBP was obtained in female gender with WC ( $r = 0.28$ ).

Fig. 1 shows that DBP and SBP values according to the 50th percentile of WC and tertiles of BMI among male and female, respectively. BMI values does not seem to affect much SBP and DBP in both genders. WC has great effect on SBP as well as DBP in both genders, in particular, in female. Among men, the highest SBP was obtained for people in the lower tertile of BMI (<19.75 kg/m<sup>2</sup>) and specialized in an elevated WC ( $\geq 80$  cm). The highest DBP was recorded in men belong to the lower tertile of BMI and experienced an elevated WC. Women in the middle tertile of BMI (20.17–22.48 kg/m<sup>2</sup>) with abdominal obesity ( $\geq 78$  cm) were characterized by an elevation in SBP and DBP. In men, the

significant differences of BP between 50th percentile of WC groups were observed for who in the lower tertile of BMI and higher. In women, the statistically significant differences of SBP between 50th percentile of WC groups were observed for who in the lower tertile of BMI and middle, while the statistically significant difference of DBP between 50th percentile of WC groups was observed for who in the middle tertile of BMI.

As was given in Table 3, weak positive associations between WC and SBP or DBP in both age groups were observed, correlation coefficient value at around 0.23. Except for no significant relationship between BMI and DBP in less than 60 group ( $p > 0.05$ ), weak positive relationships of BMI to SBP or DBP in both age groups were found. The highest correlation with DBP was obtained in the elderly with WC ( $r = 0.24$ ).

Fig. 2 shows that DBP and SBP according to the 50th percentile of WC and tertiles of BMI among two different age groups, respectively. BMI values did not seem to affect SBP and DBP as much as WC values. WC had strong impacts on SBP as well as DBP in age groups. Among people less than 60 years, the highest SBP and DBP were obtained for the individuals in the lower tertile of BMI (<20.33kg/m<sup>2</sup>) and with an elevated WC. The similarity was seen among people above the age of 60 years, the highest SBP and DBP were concentrate among subjects in the lower tertile of BMI (<19.71kg/m<sup>2</sup>) and existing an elevated WC. Among people aged 60 years and older, the statistically significant differences of SBP between 50th percentile of WC groups were observed for who in the lower tertile of BMI and middle, while the statistically significant difference of DBP between 50th percentile of WC groups was only observed for who in the lower tertile of BMI. Among people aged under 60 years, the significant differences of BP between 50th percentile of WC groups were observed for who in the lower tertile of BMI.



\*, \*\*, \*\*\*: Statistically significant at 0.01, 0.001 and 0.0001, respectively

Fig. 1. DBP and SBP according to WC and BMI among male and female.

**Table 3**  
Correlations between BMI, and WC and DBP or SBP in two age groups.

	SBP (mmHg)		DBP (mmHg)	
	Less than 60	≥60	Less than 60	≥60
BMI	0.12*	0.12*	0.09	0.15*
WC	0.23*	0.23*	0.18*	0.24*

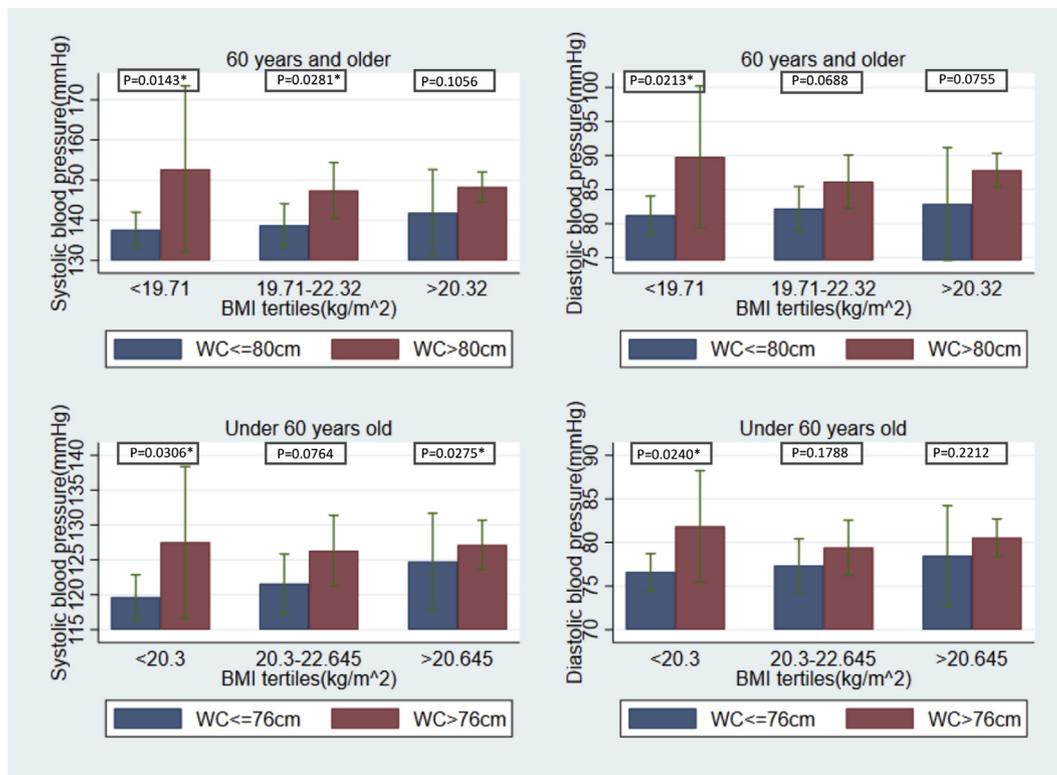
\*: Statistically significant at 0.05.

**4. Discussion**

The present study indicated that the average age was significantly higher in male gender than in female gender, at  $59.75 \pm 14.63$  and  $55.34 \pm 15.87$  years respectively ( $p < 0.001$ ). As was reported in CIA World Factbook in the early 2018, the median age was 30.5. It was found that the average age of people residing in selected locations was much higher than that of Vietnam population (31 years old in 2018). This suggests that most individuals in three communes of the northern mountainous are nearly at the age of older adults which was considered as 60 years or over according to the regulations of the Vietnamese government. In the present study, the mean BMI value was about  $22\text{kg}/\text{m}^2$  in both genders, when the values of the average WC corresponded to  $79.70 \pm 9.39$  cm in men and  $77.35 \pm 9.22$  cm in women ( $p < 0.01$ ). This result clearly noted that both the average BMI and the average WC in the study population are still within the normal range despite the very old mean age. Our results of the mean WC values were similar to a reported study of Paul Poirier et al. in the Quebec province [30], however, the average BMI in the Quebec survey reported to be in the overweight group. The previous results of Paul Poirier et al. was reported that the average BMI in the population

was approximately  $25\text{kg}/\text{m}^2$ , while the values of the mean WC were  $89.7 \pm 11.1$  cm in male gender and  $77.3 \pm 12.1$  cm in female gender. We also considered the prevalence for hypertension in the study population, 55.3% in men and 43.45% in women, remarkably higher than that in Quebec survey (4.8% and 8% each). It is probably because the present study is conducted on the far elder population, therefore, people at this age experienced with the accumulation of factors related to hypertension over the years. Another explanation might be that people are not fully aware of the dangerous risks of hypertension and access to healthcare services for hypertension diagnosis and prevention is limited. As well as in three mountainous communes of Vietnam, this is an area with many socio-economic difficulties in taking approach to health services.

There is a global growth in the prevalence of increasing body mass and that is a favorable condition for high blood pressure. Many studies have been conducted to detect the essence of the associations between BMI and SBP as well as DBP. As was shown in present study, we found that the very weak positive relationships were significant between BMI and SBP or DBP in the female population ( $r$  values: 0.17 and 0.16 respectively). This result was consistent with reported result of Tesfaye F in three study populations locating across Africa and Asia including Vietnam as the correlation coefficient value between BMI and SBP for female populations varied between 0.07 and 0.20, while this figure for DBP varied between 0.10 and 0.24 [25]. We did not observe significant associations between BMI and SBP or DBP in male gender residing study communes. All of above correlation coefficient values in both genders were lower than estimated figures in previous study in Tanzania, in the range of 0.313–0.388 ( $p < 0.0001$ ) [31]. As was reported in a Nigeria study, BMI was statistically significantly correlated to SBP ( $r$ : 0.142) and DBP ( $r$ : 0.142 and 0.149 respectively) in male gender, and the similar relationships were also observed in



\*, \*\*, \*\*\*: Statistically significant at 0.01, 0.001 and 0.0001, respectively

**Fig. 2.** DBP and SBP according to WC and BMI in two age groups.

female gender ( $r$ : 0.1501 and 0.1569 respectively) [32]. Our result was similar to the result in Nigeria study of correlation coefficient values in female gender, whereas our figures were lower in male gender. Human-related characteristics in different continents may have contributed to this difference. In general, present results and Nigeria's were significantly lower correlations between BMI and BP than Tanzania's. An appropriate explanation may be because Tanzania was known as a low-income country, the living conditions of people here faced many difficulties, therefore, perhaps the related factors having clear impact on the relationships between BMI and BP.

Numerous epidemiologic studies have indicated that anthropometric induce of abdominal adiposity/body fat distribution, as WC, is better variable than BMI to estimate cardio-metabolic risk relating to BP. We found that there were weak positive associations between WC and SBP or DBP in both two genders in the  $r$  value range of 0.22–0.28 ( $p < 0.05$ ). This suggested that the effect on BP of WC is stronger than that of BMI. These results were consistent with previous studies [30,33] which pointed out the fact that WC was regarded as a major contribution to values of SBP and DBP in 413 normoglycemic Chinese [33]. In Quebec study, WC was also reported to be a main determinant of BP, which was greater impact on BP than BMI [30].

The evident impacts of BMI and WC on BP have been more apparent as assessing DBP and SBP values according to the 50th percentile of WC and the tertiles of BMI in genders. As was shown in our result, obviously BMI values did not have a far influences on SBP and DBP in both genders, whereas WC values had significantly strong effects on SBP as well as DBP in male and female subjects. These interaction suggested being extremely necessary to address the risk of disease prediction. A previous study of Michele Bombelli reported that the usage of BMI and WC together could improve the predictive ability of the development of markers with great cardiovascular importance, such as alterations of glucose metabolism, BP, and cardiac structure [34]. In particular, this study found that all of people in both genders with an elevated WC have higher SBP and DBP than people in the lower 2-quantile of WC. Among male gender, the highest SBP and DBP were recorded for the individuals in the lower tertile of BMI ( $< 19.75 \text{ kg/m}^2$ ) and with an elevated WC. Women in the middle tertile of BMI ( $20.17\text{--}22.48 \text{ kg/m}^2$ ) experiencing abdominal obesity ( $\geq 78 \text{ cm}$ ) were characterized by a SBP and DBP elevation in SBP and DBP. However, the results in Quebec were reported that women in the higher BMI tertile ( $\geq 24.8 \text{ kg/m}^2$ ) with an WC elevation ( $\geq 74 \text{ cm}$ ) have the greatest SBP and DBP, while non-obese men suffering from abdominal obesity ( $\geq 88 \text{ cm}$ ) were identified by an elevation in SBP, which was comparable to SBP values among male gender in the peak of BMI tertile ( $\geq 26.6 \text{ kg/m}^2$ ). Regarding the determination of elevated DBP, WC value had greater influence than BMI value [30]. This difference can be explained by the specific characteristics of geography, climate, ethnicity as well as lifestyle between two study areas. The present findings once again have demonstrated that the efficacy may be altered in each BMI and WC group in the world's different populations.

The indicators of SBP and DBP have been shown to correlate with increased cardiovascular mortality and stroke in elderly individuals [35–37]. Obesity which is assessed by BMI and WC has been indicated to be an independent predictor for cardiovascular mortality and a factor indirectly resulted in other health issues [38,39]. The very weak positive relationships of BMI to SBP or DBP in people aged 60 and above were also found, while no correlation between BMI and SBP or DBP in others less than 60. All correlations of BMI to SBP or DBP in our study was positive in both age groups, which completely consistent with the previous study [40,41]. As was shown in a Japan study in 80-year-old subjects, the mean SBP

and DBP rose from the 1st quintile of BMI to 5th quintiles [41]. In addition, our study showed that WC was weakly correlated to SBP and DBP in older adults, whereas a very weak relationship were found between WC and DBP in others less than 60. It clearly suggested that the impacts between WC and SBP or DBP are stronger among older adults than in others less than 60. Recent findings reported that the risk indicator might be better of WHR than of BMI for some diseases such as type 2 diabetes, heart disease, cancer and the Metabolic Syndrome [42–44]. As a consequence, this study concluded that WC has stronger influences on SBP as well as DBP in age groups with the cut-off point 60 than BMI.

Our results had the disadvantage of being only representative of the whole population of citizens in three communes of Chiem Hoa district. This survey can not have any interpretation about the causal relationship due to the cross-sectional design. Another limitation was that we have not approached the other metabolic variables associated with BP. Finally, this study was our inability to assess the cultural aspects related to the uptake of health services as well as acceptability and attitudes towards living conditions which could limit their perceive and knowledge of impact of health indicators on blood pressure.

In spite of the existing limitations, the current findings from our study have several important implications for health and social policies. First of all, the present study identified vulnerable population groups residing in the mountainous areas experienced the old age which easily affected by risk factors for their health. Secondly, based on our results, the policy makers should appropriately consider to concentrate their efforts on offering sustainable solutions for the health issues of non-communicable disease in Vietnam. Ultimately, the present data make available evidence regarding the formidable new health burden that many developing countries are experiencing.

## 5. Conclusions

We documents the very high median age in the study locations. This study indicates that there are significant differences of some physical characteristics between male and female in three communes of Tuyen Quang province, except for BMI values. Particularly our findings highlight that the effects on SBP or DBP of WC are more significant than that of BMI in both genders. The impacts of WC on SBP as well as DBP are also significantly stronger than that of BMI in age groups with the cut-off point 60 than BMI. This study provides the science evidence in support of public and preventive health interventions to the locals residing this area in Vietnam. Further studies are essential to record such a relationship in different ethnicities and continents.

## Conflicts of interest

No conflict of interest was reported by the authors.

## Funding

No funding was received in study.

## Acknowledgement

We sincerely thank the locals of living in the three communes of Chiem Hoa district for their participation in this study. We also want to acknowledge the enthusiastic support of the Hanoi Medical University. MSc. Phuong Linh Nguyen (Catholic University of Murcia, Murcia, Spain - An English editor) are acknowledged for critically reading the manuscript.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.dsx.2019.02.015>.

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