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Research Article

Effects of A Body Shape Index, Body Mass Index and Waist Circumference in Predicting Cardiovascular Disease Risk Factors in Korean Middle-Aged and Older Adults

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Abstract

Objective: This study investigated a comparative analysis of ABSI (a body shape index), BMI (body mass index) and waist circumference (WC) regarding their relationships with CVD (cardiovascular disease) risk factors in Korean middle-aged and older adults. **Materials and Methods:** The raw data of the sixth KNHNES were utilized. Data of 2,464 respondents were extracted for analysis regarding anthropometry, blood testing and blood pressure. Data were analyzed using SPSS software. **Results:** The study found that ABSI, BMI and WC have significant relationships with blood lipid levels, blood pressure and fasting blood glucose in Korean middle-aged and older adults. Specifically, WC was found to be significantly related with triglycerides, fasting blood glucose and HDL cholesterol. BMI and ABSI were found to have a significant relationship with blood pressure. Therefore, this study showed that each anthropometric factor has different effects on CVD risk factors in Korean middle-aged and older adults. **Conclusion:** Based on the study results, it was concluded that healthcare professionals should not rely on a single anthropometric measurement in CVD risk management.

Key words: ABSI , BMI, waist circumference, blood lipids, blood glucose, blood pressure

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

As the number-one cause of death worldwide, cardiovascular disease (CVD), which includes diseases of the heart and major arteries (e.g., myocardial infarction, stroke, etc.), has a major impact on healthy life expectancy. The World Health Organization (WHO) reported that in 2015, approximately 17.7 million people, 31% of all deaths worldwide, died of CVD and noted an expected further increase in the mortality from CVD in the future.[1]

Risk factors for CVD include hypertension, smoking, diabetes, physical inactivity, dyslipidemia and obesity[2]. Among them, obesity is a major risk factor for both CVD and other CVD risk factors[3]. Therefore, prevention of CVD must be accompanied by obesity management, which is possible using anthropometric measurements with health implications.

Anthropometric measurements commonly used in healthcare include body mass index (BMI) and waist circumference: (WC) is an indicator of the degree of obesity estimated with height and weight and it is known to be correlated with the risk of premature death as well as diseases such as CVD[4]. However, due to its limitation in indicating the distribution of fat, some researchers have argued against placing too much emphasis on BMI in relation to CVD. Rather, abdominal fat poses a greater risk for CVD onset and worsening than the simple ratio of height and weight[5].

Waist circumference (WC) is an indicator of the visceral fat of the abdomen that complements the limitation of BMI and is closely related to diseases such as hypertension, diabetes, hyperlipidemia and CVD[6,7]. It has been found in large-scale epidemiological studies that the distribution of body fat is more closely associated with the prevalence and mortality of CVD than BMI[8]. Cerhan *et al.*[5] also stressed the importance of waist circumference, maintaining that an excessive waist circumference (i.e., abdominal obesity) is likely to increase the prevalence of CVD and the risk of premature death even when BMI is within a normal range.

However, the point has also been raised that while abdominal obesity clearly increases the risk of CVD, both height and waist circumference needs to be considered for accurate prediction. Addressing the limitations of predicting CVD with BMI and WC, a body shape index (ABSI), a new anthropometric measure, was developed by Krakauer and Krakauer[9].

In a large-scale study in the U.S., Krakauer and Krakauer[9], demonstrated that ABSI is a better predictor of risk of premature death than BMI. The research findings that ABSI is significantly associated with blood pressure also lend support for the potential utility of ABSI as a predictor of CVD risk[10,11].

However, it is premature to conclude that ABSI can be universally applicable in the prediction and management of CVD, since ABSI research is still in the early stage. A series of studies pointed out the limitations of ABSI as a universal indicator for healthcare. Cheung[12] maintained that ABSI had a weaker association with incident hypertension than BMI[12]. In a study on the predictive power of ABSI of the risk for metabolic syndrome and CVD, Haghighatdoost *et al.*[13] reported that ABSI was ineffective in predicting CVD[13]. These studies present evidence that has casts doubts on the unrestricted wide use of ABSI as a health indicator for use in CVD prediction. To address this issue, the objective utility of ABSI needs to be evaluated through a comparison with commonly available anthropometric measures.

The present study investigates the potential utility of ABSI as an indicator of CVD risk and conducts a comparative analysis of ABSI, BMI and WC regarding their effects in predicting CVD risk factors in Korean middle-aged and older adults.

MATERIALS AND METHODS

Data collection: This study used the 1st year subjects' data of the Sixth Korea National Health and Nutrition Examination Survey (2013-2015) conducted by Korea Centers for Disease Control and Prevention. The 6th KNHANES (Korea National Health and Nutrition Examination Survey) was conducted with a legal basis-the National Health Promotion Act, Article 16, of Korea-and approved by the Institutional Review Board of Korea Centers for Disease Control and Prevention. The survey consisted of a health questionnaire, health exam and nutrition survey. The health questionnaire and health exam were administered in mobile examination centers and the nutrition survey was conducted in individual interviews. The survey items of this study included subjects' gender, age, height, weight, BMI, waist circumference, blood lipids (total cholesterol, triglyceride, HDL cholesterol and LDL cholesterol), fasting blood glucose and blood pressure.

Study subject: The total number of survey participants in the 2013 KNHANES was 8,018 persons. To obtain the data for the present study, the data of 3,012 men and women aged 50 and older were initially selected. Then, after excluding 548 participants' data, which were deemed unreliable due to the inclusion of missing values and outliers, 2,464 (1,064 men and 1,400 women) persons were selected as the final subjects. The physical characteristics of the final subjects are shown in Table 1.

Measurement and analysis methods

BMI, waist circumference and ABSI: BMI was calculated using the equation, {weight(kg)/height(m)^2} and WC (waist circumference) was measured when participants were exhaling with their feet 25-30 cm apart by aligning the midpoint between the inferior margin of the last rib and the highest points of the pelvis (iliac crest) with a tape measure[14]. Finally, ABSI was calculated using the equation with height, weight and waist circumference values shown below[9]:

$$\text{ABSI} = \frac{\text{WC}}{\text{BMI}^{2/3}\,\text{Height}^{1/2}}$$

Where:
ABSI = A body shape index
BMI = Body mass index
WC = Waist circumference

Blood pressure: Systolic and diastolic blood pressures were measured by the nurses in charge of blood pressure measurement in the survey implementation team of Korea Centers for Disease Control and Prevention; the adjusted blood pressure adjusting the error values induced by the difference of height of the arm was also used[15].

Blood test: Blood lipids (total cholesterol, triglycerides, HDL cholesterol and LDL cholesterol) and fasting blood glucose were measured using an automatic biochemical analyzer (Hitachi, Japan).

Statistical analysis: The collected data were analyzed using SPSS software (version 18.0 for Windows; SPSS Inc., Chicago, IL). Descriptive statistics were obtained on participants' physical characteristics. The gender difference in ABSI, BMI, WC and CVD risk factors was tested using an analysis of variance and the effects of ABSI, BMI and WC in predicting CVD risk factors were tested using a multiple regression analysis[16]. In all analyses, the statistical significant level was set at .05.

Table 1: Physical characteristics of study subjects

	Men (n = 1064)	Women (n = 1400)
Height (cm)	167.08±6.05	153.99±5.99
Age (year)	62.86±8.64	62.44±8.79
Weight (kg)	66.97±9.69	58.00±8.61
BMI (kg m^{-2})	23.94±2.86	24.44±3.25
WC (cm)	84.71±8.37	81.41±9.13
ABSI	0.079±0.0035	0.0770±0.0053

ABSI: A body shape index, BMI: Body mass index and WC: Waist circumference
Mean±SD

RESULTS

Gender difference in CVD risk factors in Korean middle-aged and older adults: The results on gender difference in CVD risk factors in Korean middle-aged and older adults (Table 2) showed statistically significant differences in all measures except systolic blood pressure, total cholesterol, HDL cholesterol, LDL cholesterol, triglycerides, fasting blood glucose and diastolic blood pressure. Specifically, men showed higher levels of triglycerides, fasting blood glucose and diastolic blood pressure than women and women showed higher total cholesterol, HDL cholesterol and LDL cholesterol than men.

Effects of ABSI, BMI and WC on CVD risk factors in Korean middle-aged and older adults

Effects of ABSI, BMI and WC on blood cholesterol: The results on the effects of ABSI, BMI and WC in predicting blood cholesterol (total cholesterol, HDL cholesterol and LDL cholesterol) as a CVD risk factor in Korean middle-aged and older adults shown in Table 3. The regression model with the three risk factors (BMI, ABSI and WC) for each gender was statistically significant, suggesting overall significance of the model fit. Specifically, although none of the three independent variables was found to have a significant relationship with total cholesterol, HDL cholesterol, or LDL cholesterol in men, WC was found to have a significant negative relationship with serum HDL cholesterol in women.

Effects of ABSI, BMI and WC on triglycerides and fasting blood glucose: The results on the effects of ABSI, BMI and WC in predicting triglycerides and fasting blood glucose as CVD risk factors in Korean middle-aged and

Table 2: Gender difference in CVD risk factors in Korean middle-aged and older adults

	Male (Mean±SD)	Female (Mean±SD)	F	p
Total cholesterol (mg dL^{-1})	185.03±35.16	200.84±37.23	114.431	0.000
HDL cholesterol (mg dL^{-1})	44.380±10.54	48.410±10.50	88.435	0.000
LDL cholesterol (mg dL^{-1})	106.09±31.54	124.09±38.95	28.245	0.000
Triglycerides (mg dL^{-1})	150.02±97.24	139.85±86.27	7.523	0.006
Fasting blood glucose (mg dL^{-1})	106.38±22.38	102.16±21.01	23.129	0.000
Systolic blood pressure (mmHg)	124.08±17.20	124.43±17.67	0.253	0.615
Diastolic blood pressure (mmHg)	76.940±10.88	75.170±10.12	17.415	0.000

Table 3:Effects of ABSI, BMI and WC on total cholesterol, HDL cholesterol and LDL cholesterol

		CVD risk factor											
		TC				HDL cholesterol				LDL cholesterol			
Model		β	t	p	sr^2	β	t	t	sr^2	β	t	p	sr^2
Male	BMI	-0.100	-0.761	0.447	-0.023	-0.033	-0.260	0.795	-0.008	-0.070	-0.239	0.811	-0.016
	ABSI	-0.113	-1.190	0.234	-0.037	0.130	1.417	0.175	0.043	-0.058	-0.259	0.796	-0.018
	WC	0.052	0.777	0.438	0.024	-0.126	-1.946	0.052	-0.060	0.020	0.142	0.887	0.010
Female	BMI	-0.106	-0.970	0.332	-0.026	-0.001	-0.011	0.991	0.000	-0.042	-0.160	0.873	-0.011
	ABSI	-0.107	-1.432	0.152	-0.038	-0.043	-0.585	0.559	-0.016	0.033	0.177	0.860	0.012
	WC	0.039	0.642	0.521	0.017	-0.245*	-4.083*	0.000*	-0.109*	-0.028	-0.197	0.844	-0.014
		1: F = 11.24, adjusted R^2 = 0.011				1: F = 26.18, adjusted R^2 = 0.066				1: F = 10.02, adjusted R^2 = 0.014			
		2: F = 10.94, adjusted R^2 = 0.010				2: F = 24.37, adjusted R^2 = 0.048				2: F = 10.63, adjusted R^2 = 0.015			

*Statistically significant results, β: Regression coefficients, t: t-value, p: p-value, sr^2: Squared semiparital correlation coefficient

Table 4: Effects of ABSI, BMI and WC on triglycerides and fasting blood glucose

		CVD risk factor							
		Triglycerides				Fasting blood glucose			
Model		β	t	p	sr^2	β	t	p	sr^2
Male	BMI	0.019	0.149	0.882	0.005	-0.128	-0.997	0.319	-0.031
	ABSI	-0.102	-1.105	0.269	-0.034	-0.045	-0.487	0.626	-0.015
	WC	0.149*	2.294*	0.022*	0.070*	0.295*	4.513*	0.000*	0.137*
Female	BMI	0.012	0.111	0.911	0.003	0.076	0.718	0.473	0.019
	ABSI	-0.030	-0.414	0.679	-0.011	0.028	0.386	0.700	0.019
	WC	0.186*	3.093*	0.002*	0.082*	0.198*	3.331*	0.001*	0.089*
		1: F = 22.61, adjusted R^2 = 0.057				1: F = 18.37, adjusted R^2 = 0.047			
		2: F = 22.66, adjusted R^2 = 0.044				2: F = 30.12, adjusted R^2 = 0.059			

*Statistically significant results, β: Regression coefficients, t: t-value, p: p-value, sr^2: Squared semiparital correlation coefficient

Table 5: Effects of ABSI, BMI and WC on systolic and diastolic blood pressure

		CVD risk factor							
		Systolic blood pressure				Diastolic blood pressure			
Model		β	t	p	sr^2	β	t	p	sr^2
Male	BMI	0.434*	4.434*	0.001*	0.102*	0.105	0.834	0.404	0.026
	ABSI	0.287*	3.287*	0.002*	0.094*	-0.252*	-2.757*	0.006*	-0.084*
	WC	-0.043	-0.043	0.519	-0.020	-0.122	-1.888	0.059	-0.058
Female	BMI	0.442*	4.131*	0.000*	0.110*	0.098	0.904	0.366	0.024
	ABSI	0.243*	3.325*	0.001*	0.089*	-0.072	-0.975	0.330	-0.026
	WC	-0.054	-0.897	0.370	-0.024	-0.056	-0.913	0.361	-0.024
		1: F = 10.59, adjusted R^2 = 0.026				1: F = 30.21, adjusted R^2 = 0.078			
		2: F = 20.22, adjusted R^2 = 0.040				2: F = 17.87, adjusted R^2 = 0.015			

*Statistically significant results, β: Regression coefficients, t: t-value, p: p-value, sr^2: Squared semiparital correlation coefficient

older adults shown in Table 4. The regression model with the three risk factors (BMI, ABSI and WC) for each gender was statistically significant, suggesting overall significance of the model fit. Specifically, WC was found to be significantly related with triglycerides and fasting blood glucose in Korean male and female middle-aged and older adults.

Effects of ABSI, BMI and waist circumference on blood pressure: The results on the effects of ABSI, BMI and WC in predicting blood pressure (systolic and diastolic blood pressure) as a CVD risk factor in Korean middle-aged and older adults shown in Table 5. The regression model with the three risk factors (BMI, ABSI and WC) for each gender was statistically significant, suggesting overall significance of the model fit. Specifically, BMI and ABSI were found to have a significant positive relationship with systolic blood pressure in Korean male and female middle-aged and older adults. ABSI was also found to have a negative relationship with diastolic blood pressure in men.

DISCUSSION

CVD is one of the major causes of death worldwide. In Korea, the prevalence of CVD has increased sharply in the last three decades and CVD is one of the top three causes of death[17]. Thus, CVD has been a steady subject of research among clinical researchers, sports scientists and public health professionals.

The present study investigates the potential utility of ABSI as an indicator of CVD risk and conducts a comparative analysis of ABSI, BMI and WC regarding their effects in predicting CVD risk factors in Korean middle-aged and older adults. The study results showed that ABSI, BMI and WC predicted blood lipid levels, blood pressure and fasting blood glucose in Korean middle-aged and older adults. Specifically, for both men and women, waist circumference significantly predicted triglycerides and BMI and ABSI significantly predicted blood pressure.

Abdominal obesity is closely associated with CVD and is a major risk factor for chronic non-communicable diseases in itself[18]. In the present study, WC had a significant associated with triglyceride and fasting blood glucose increment in Korean middle-aged and older adults. It was also found to be significantly related with HDL cholesterol reduction in women. This demonstrates that waist circumference is a useful indicator for managing blood lipid levels as a CVD risk factor. This result is consistent with the finding by Yun *et al.*[19] that waist circumference is significantly associated with fasting blood glucose, blood triglycerides and HDL cholesterol in the elderly. Arimura *et al.*[20] also argued that serum HDL cholesterol is unrelated to BMI but negatively related to waist circumference in the middle-aged and older adults.

Known to improve cholesterol and reduce the risk for CVD, HDL cholesterol tends to decrease with aging[21]. The prevalence of CVD caused by dyslipidemia, especially serum HDL cholesterol reduction, further increases in women after menopause as a result of aging[22]. Given the negative association between abdominal obesity and HDL cholesterol, increased abdominal obesity likely accelerates HDL cholesterol reduction in women. Therefore, maintaining serum HDL cholesterol within a normal range is likely an effective method for maintaining cardiovascular health in the elderly, which is supported by Savva *et al.*'s claim that waist circumference is an adequate predictor of HDL cholesterol[23].This suggests that middle-aged and older adults, who are required to manage blood glucose and lipid levels for CVD prevention, need to maintain a proper waist circumference.

Many epidemiological studies have listed BMI as another indicator for gauging the risk for CVD. In the present study, the results indicated a positive association between BMI and blood pressure. This finding is consistent with Chun *et al.*'s report of a positive correlation between BMI and blood pressure and Byun *et al.*'s report that blood pressure was higher when BMI was higher in older women[24,25].

In particular, BMI has been found to have a significant relationship with systolic blood pressure. Systolic blood pressure in and of itself increases the risk of CVD. Ettehad *et al.* also found that a 10-mmHg decrease in systolic blood pressure reduced the risk of major cardiovascular events by 20% in major CVD patients and by 17, 27 and 28% in patients with coronary artery disease, stroke and heart failure, respectively[26]. Moreover, given the marked elevation of systolic blood pressure over age 50 and the high prevalence of CVD in patients with geriatric hypertension[27]. BMI is expected to be an effective measure in managing blood pressure.

The present study showed that blood pressure is also affected by ABSI in middle-aged and older adults. This result is consistent with He and Chen[11] report of ABSI as a predictor of blood pressure, providing corroborative evidence for the potential utility of ABSI as a predictor of CVD risk. The result also supports the finding by Duncan *et al.*[10] that ABSI has a greater predictive power in explaining systolic and diastolic blood pressure than BMI or WC. However, further examination is warranted to conclude that ABSI is a better predictor of CVD morbidity and mortality than BMI and WC, as Krakauer and Krakauer argued[9].

While ABSI cannot be dismissed as inadequate in predicting the risk of CVD, it is also difficult to see it as a far superior measure to existing measures (i.e., waist circumference and BMI). Although this view is somewhat contradictory to the study findings in support of the claim that ABSI is a better indicator in myocardial infarction, hypertension and premature death than existing measures,[9,28] the view has been presented in several previous studies as well as the present study.

In an evaluation of ABSI as a predictor of the risks of CVD and metabolic syndrome, Haghighatdoos *et al.*[13] reported weak associations between ABSI and the risk factors for the diseases in Iranian adults. Fujita *et al.*[29] also reported that ABSI was not a better predictor of diabetes, hypertension and dyslipidemia in Japanese adults, compared with BMI and WC. Maessen *et al.*[30] found ABSI is not capable of identifying cardiovascular health status, while traditional body indices like BMI and WC are able to determine CVD risk. These reports suggest that it is difficult to conclude that ABSI is clearly superior to other measurement indicators in predicting CVD risk. Given the conflicting findings on ABSI and the fact that

chronic diseases such as CVD are caused by various factors, ABSI research needs to incorporate different populations and contexts.

This study also failed to consider the score ranges of anthropometric indicators. Therefore, further research on the effects of anthropometric indicator according to the classification based on score ranges in predicting CVD risk is needed to determine cut-off scores for CVD prevalence.

CONCLUSION

This study verified that ABSI, BMI and WC have significant relationships with blood lipid levels, blood pressure and fasting blood glucose in Korean middle-aged and older adults. Based on the study results, it is expected to inform the efforts for managing CVD, a major cause of death worldwide. However, each anthropometric factor showed differences in regard to their impacts on the CVD risk factors. Therefore healthcare professionals should not rely on a single anthropometric measurement in CVD risk management.

SIGNIFICANCE STATEMENTS

This study discovers the ABSI, BMI and WC have significant relationships with blood lipid levels, blood pressure and fasting blood glucose in Korean middle-aged and older adults. Particularly, the new significance of this research is an applicability of ABSI, which has not been paid enough attention, as an indicator of CVD risk. It is expected to inform the fundamental data for management of CVD as a major cause of death for the elderly in Korea.

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REFERENCES

1. WHO., 2015. Fact sheet: Cardiovascular diseases (CVDs). World Health Organization, Geneva. http://www.who.int/mediacentre/factsheets/fs317/en/
2. Mendis, S., P. Puska and B. Norrving, 2011. Global Atlas on Cardiovascular Disease Prevention and Control. 1st Edn., World Health Organization, Geneva, ISBN-13: 9789241564373, pp: 3-18.
3. Cho, T.Y., H.C. Cho, S.Y. Hong, Y.K. Song and H.H. Lim, 2004. Correlation study between obesity and cardiovascular risk factors. J. Korean Med. Obes. Res., 4: 33-43.
4. Feng, R.N., C. Zhao, C. Wang, Y.C. Niu and K. Li *et al.*, 2012. BMI is strongly associated with hypertension and waist circumference is strongly associated with type 2 diabetes and dyslipidemia, in northern Chinese adults. J. Epidemiol., 22: 317-323.
5. Cerhan, J.R., S.C. Moore, E.J. Jacobs, C.M. Kitahara and P.S. Rosenberg *et al.*, 2014. A pooled analysis of waist circumference and mortality in 650,000 adults. Mayo Clin. Proc., 89: 335-345.
6. Feller, S., H. Boeing and T. Pischon, 2010. Body mass index, waist circumference and the risk of type 2 diabetes mellitus: Implications for routine clinical practice. Deutsches Arzteblatt Int., 107: 470-476.
7. Flint, A.J., K.M. Rexrode, F.B. Hu, R.J. Glynn and H. Caspard *et al.*, 2010. Body mass index, waist circumference and risk of coronary heart disease: A prospective study among men and women. Obes. Res. Clin. Pract., 4: e171-e181.
8. Carey D.G.P., 1998. Abdominal obesity. Curr. Opin. Lipidol., 9: 35-40.
9. Krakauer, N.Y. and J.C. Krakauer, 2012. A new body shape index predicts mortality hazard independently of body mass index. PLoS One, Vol. 7, No. 7. 10.1371/journal.pone.0039504.
10. Duncan, M.J., J. Mota, S. Vale, M.P. Santos and J.C. Ribeiro, 2013. Associations between body mass index, waist circumference and body shape index with resting blood pressure in Portuguese adolescents. Ann. Hum. Biol., 40: 163-167.
11. He, S. and X. Chen, 2013. Could the new body shape index predict the new onset of diabetes mellitus in the Chinese population? PLoS One, Vol. 8. 10.1371/journal.pone.0050573.
12. Cheung, Y.B., 2014. "A body shape index" in middle-age and older Indonesian population: Scaling exponents and association with incident hypertension. PloS One, Vol. 9. 10.1371/journal.pone.0085421.
13. Haghighatdoost, F., N. Sarrafzadegan, N. Mohammadifard, S. Asgary, M. Boshtam and L. Azadbakht, 2014. Assessing body shape index as a risk predictor for cardiovascular diseases and metabolic syndrome among Iranian adults. Nutrition, 30: 636-644.
14. WHO., 2008. Waist circumference and waist-hip ratio. Report of a WHO Expert Consultation, Geneva, 8-11 December 2008. World Health Organization, Geneva.
15. Kirkendall, W.M., A.C. Burton, F.H. Epstein and E.D. Freis, 1967. Recommendations for human blood pressure determination by sphygmomanometers. Circulation, 36: 980-988.
16. Rea, L.M. and R.A. Parker, 2005. Designing and Conducting Survey Research: A Comprehensive Guide. 3rd Edn., Jossey-Bass Inc., San Francisco, CA.
17. Statistics Korea, 2013. Statistics on the aged: 2013. Statistics Korea, Korea.

18. Brenner, D.R., K. Tepylo, K.M. Eny, L.E. Cahill and E.A. Sohemy, 2010. Comparison of body mass index and waist circumference as predictors of cardiometabolic health in a population of young Canadian adults. Diabetol. Metab. Syndrome. 10.1186/1758-5996-2-28.
19. Yoon, J.H., J. Kim, S.Y. Lee, K. Kim, I.Y. Cho and Y.M. Cho, 2012. What is the most reliable obesity iindex in Korean elderly population? Korean J. Obes., 21: 140-147.
20. Arimura, S.T., B.M. Moura, G.D. Pimentel, M.E.R. Silva and M.V. Sousa, 2011. Waist circumference is better associated with high density lipoprotein (HDL-C) than with body mass index (BMI) in adults with metabolic syndrome. Nutr. Hosp., 26: 1328-1332.
21. Cremer, P., D. Nagel, H. Mann, B. Labrot, R. Muller-Berninger, H. Elster and D. Seidel, 1997. Ten-year follow-up results from the Goettingen risk, incidence and prevalence study (GRIPS). I. Risk factors for myocardial infarction in a cohort of 5790 men. Atherosclerosis, 129: 221-230.
22. Anagnostis, P., J.C. Stevenson, D. Crook, D.G. Johnston and I.F. Godsland, 2015. Effects of menopause, gender and age on lipids and high-density lipoprotein cholesterol subfractions. Maturitas, 81: 62-68.
23. Savva, S.C., M. Tornaritis, M.E. Savva, Y. Kourides and A. Panagi *et al*., 2000. Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. Int. J. Obes. Relat. Metab. Disord., 24: 1453-1458.
24. Chun, J.M., J.K. Jin and J.M. Lee, 2013. The effects of blood pressure and physical fitness by body mass index level in adult males. KSSS., 22: 1089-1097.
25. Byun, H.B., S.H. Kim and T.S. Kim, 2013. Effect of body mass index difference on body composition, cardiopulmonary, low extremity muscular functions in institutionalized older women. J. Sport Leis. Stud., 52: 789-799.
26. Ettehad, D., C.A. Emdin, A. Kiran, S.G. Anderson and T. Callender *et al*., 2016. Blood pressure lowering for prevention of cardiovascular disease and death: A systematic review and meta-analysis. Lancet, 387: 957-967.
27. Franklin, S.S. and D. Levy, 2011. Aging, blood pressure and heart failure: What are the connections? Hypertension, 58: 760-762.
28. Yusuf, S., S. Hawken, S. Ounpuu, L. Bautista and M.G. Franzosi *et al*., 2005. Obesity and the risk of myocardial infarction in 27000 participants from 52 countries: A case-control study. Lancet, 366: 1640-1649.
29. Fujita, M., Y. Sato, K. Nagashima, S. Takahashi and A. Hata, 2015. Predictive power of a body shape index for development of diabetes, hypertension and dyslipidemia in Japanese adults: A retrospective cohort study. PLoS One, Vol. 10. 10.1371/journal.pone.0128972.
30. Maessen, M.F.H., T.M.H. Eijsvogels, R.J.H.M. Verheggen, M.T.E. Hopman, A.L.M. Verbeek and F. de Vegt, 2014. Entering a new era of body indices: The feasibility of a body shape index and body roundness index to identify cardiovascular health status. PLoS One, Vol. 9. 10.1371/journal. pone. 0107212.