Clustering of four major lifestyle risk factors among Korean adults with metabolic syndrome

Shin Ha[1,2], Hui Ran Choi[3], Yo Han Lee[4]*

1 Department of Public Health, Graduate school of Korea University, Seoul, South Korea, 2 Services Department, Medical Library, Korea University, Seoul, South Korea, 3 Division of Family Medicine, Seoul National University Graduate School of Medicine, Seoul, South Korea, 4 Department of Preventive Medicine, Konyang University College of Medicine, Daejeon, South Korea

* vionic@konyang.ac.kr

Abstract

The purpose of this study was to investigate the clustering pattern of four major lifestyle risk factors—smoking, heavy drinking, poor diet, and physical inactivity—among people with metabolic syndrome in South Korea. There were 2,469 adults with metabolic syndrome aged 30 years or older available with the 5th Korean National Health and Nutrition Examination Survey dataset. We calculated the ratio of the observed to expected (O/E) prevalence for the 16 different combinations and the prevalence odds ratios (POR) of four lifestyle risk factors. The four lifestyle risk factors tended to cluster in specific multiple combinations. Smoking and heavy drinking was clustered (POR: 1.86 for male, 4.46 for female), heavy drinking and poor diet were clustered (POR: 1.38 for male, 1.74 for female), and smoking and physical inactivity were also clustered (POR: 1.48 for male). Those who were male, younger, low-educated and living alone were much more likely to have a higher number of lifestyle risk factors. Some helpful implications can be drawn from the knowledge on clustering pattern of lifestyle risk factors for more effective intervention program targeting metabolic syndrome.

Introduction

Metabolic syndrome is a clustering of cardio-metabolic risk factors. People with metabolic syndrome are much more likely to have cardiovascular disease (CVD) and type 2 diabetes, respectively than people without metabolic syndrome [1–3]. The prevalence of metabolic syndrome has steadily increased and is now a serious public health concern in developed countries [4,5].

There is definite epidemiological evidence that major four lifestyle risk factors such as smoking, heavy drinking, poor diet, and physical inactivity contribute to the development of metabolic syndrome and chronic diseases [6,7]. Researches also suggest that these lifestyle risk factors are not randomly distributed, but that they tend to cluster with other unhealthy behaviors within individuals [8,9]. In other words, certain combinations of lifestyle risk factors is

more prevalent than can be expected based on the prevalence of individual lifestyle risk factors.

Although there have been several studies on the clustering of multiple lifestyle risk factors in the general population [8–10], very little efforts for obtaining relevant information on people with metabolic syndrome had been done. Knowledge on unhealthy behavior pattern of people with metabolic syndrome is considered crucial for creating a tailored lifestyle intervention program and a tailored regimen might help patients with metabolic syndrome to be motivated to change unhealthy behaviors [11,12]. The purpose of this study was to investigate the clustering pattern of four major lifestyle risk factors—smoking, heavy drinking, poor diet, and physical inactivity—among people with metabolic syndrome in South Korea.

Methods

Study population

Data for this study were drawn from the population-based, nationwide cross-sectional study of the 5th Korean National Health and Nutrition Examination Survey (KNHANES) 2010–2012, which was conducted by the Korea Centers for Disease Control and Prevention (KCDC). A multistage, stratified, probability sampling approach was used with selections made from sampling units based on gender, age group and geographical area using household registries. The methods have already been detailed in previous articles [13,14].

There were 2,918 adults with metabolic syndrome aged 30 years or older available with the 5th KNHANES dataset. We excluded 449 subjects who had missing data for any of four lifestyle risk factors. Finally, 2,469 participants were included in the analyses. The American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement defined the criteria for metabolic syndrome in Asians as follows and the criteria was applied for this study [1]. Subjects with 3 or more of the following 5 metabolic derangements were defined as having metabolic syndrome: abdominal obesity more than 90 cm in men and more than 80 cm in women, blood pressure more than 130/85 mm Hg or the use of an antihypertensive drug, fasting glucose more than 100 mg/dL or the use of an antidiabetic drug, an high-density lipoprotein cholesterol level less than 40 mg/dL in men and 50 mg/dL in women or the use of an antidyslipidemic drug, and a high-density lipoprotein cholesterol level more than 150 mg/dL or use of an antidyslipidemic drug.

Written informed consent was provided by all participants, and the protocol for the survey was approved by the Institutional Review Board of the KCDC (2010-02CON-21-C, 2011-02CON-06-C, 2012-01EXP-01-2C). The current study did not require additional ethical approval because the KNHANES dataset is publicly available.

Measurements

Data on smoking status, alcohol intake, dietary intake and physical activity were self-reported. Smoking status was divided into two categories: current smoker and ex- or never-smoker. Heavy drinking was defined as alcohol intake $\geq$ 5 glasses for male and $\geq$ 4 glasses for female subjects on one occasion $\geq$ once a week. The definition of physical inactivity was adapted from the International Physical Activity Questionnaire (IPAQ) category 1 in which no activity is reported or some activity is reported but not enough to meet an equivalent of 30 min of at least moderate intensity physical activity on >3 days per week [15,16]. Dietary intake was assessed by the 24-h dietary recall method. Poor dietary patterns were defined as having one or two of the following two components: fat intake exceeding 30% of the total number of calories, and sodium intake exceeding 30% of the average daily intake of Koreans. Socioeconomic factors such as income, education level, marital status and job state were used for analysis.

Statistical analyses

The analyses in this study consisted of three parts. First, we calculated the ratio of the observed to expected (O/E) prevalence for the 16 different combinations of four lifestyle risk factors. O/E ratio presents both the magnitude and direction of the association, with values above 1 meaning positive association and below 1 an inverse association [17]. The more the ratio deviates from 1, the stronger the behaviors are associated. In other words, clustering exists when the observed prevalence of a certain combination of lifestyle risk factors exceeds the expected prevalence of the combination.

Second, we examined the associations between sets of two lifestyle risk factors by calculating the prevalence odds ratios (POR) and statistically tested by Chi-square tests. If the 95% confidence interval of the POR does not include 1, it indicates clustering between the two lifestyle risk factors. The POR was calculated as follows: POR = (number of respondents without with both risk factors) ÷ (number of respondents with the one risk factor × number of respondents with the other risk factor). Analyses were performed separately for male and female subjects for the former two parts of analyses because the prevalence of smoking, heavy drinking, and poor diet were substantially different for male and female subjects.

Third, we examined the sociodemographic patterns in the presence of multiple lifestyle risk factors. Multinomial logistic regression model was used to evaluate the association between sociodemographic variables and the dependent variable, the number of lifestyle risk factors, ranging from 0 to 4. The model allows us to estimate the probability that a respondent has a certain number of lifestyle risk factors (1, 2, 3, and 4) compared to the reference groups of having no risk factors. All analyses were carried out using Stata 11.1 (StataCorp, College Station, TX, USA).

Results

Table 1 shows the characteristics of the study population. Compared with male subjects, females tended to be older, in the lower income, less educated, living alone, and not employed. Males were highly likely to be smokers, heavy drinkers, and to have poor diet than female subjects, whereas the prevalence of physical inactivity was similar in both sexes. Of the males, 11% had no lifestyle risk factor, 26% had one, 37% had two, and 26% had simultaneously three or more lifestyle risk factors. Meanwhile, more than 80% of female participants had nothing or only one lifestyle risk factor.

Table 2 shows the observed and expected prevalence of all 16 possible combinations of the four lifestyle risk factors. In males, clustering was found at both ends of the lifestyle spectrum. In other words, the observed prevalence of having no, and having all four lifestyle risk factors was higher than could have been expected (O/E ratio 1.45 and 1.35, respectively) on the basis of the individual probabilities of the four risk factors alone. The observed prevalence of specific combinations such as smoking + heavy drinking + poor diet or smoking + heavy drinking + physical inactivity was higher than could have been expected. Since about 80% of the female participants had one or no risk factors, the prevalence of the majority of combinations were very low, and thus this made it difficult to interpret the O/E ratios for female subjects.

Table 3 shows the POR of combinations of two lifestyle risk factors. The overall pattern of clustering was similar for males and females. Clustering of smoking with heavy drinking was observed (POR 1.86 for male and 4.46 for female subjects). In addition, heavy drinking and poor diet were clustered in both sexes. In other words, the participants who smoke are more likely have heavy drinking, and the participants who drink heavily are more likely have poor diet. In male participants, smoking and physical inactivity were also clustered showing POR with 1.48.

Table 1. Characteristics of the study population, n (%).

	Men (n = 1,197)	Women (n = 1,272)	p-value
Age group			<0.001
30s	179 (15.0)	91 (7.2)	
40s	278 (23.2)	205 (16.1)	
50s	360 (30.1)	414 (32.6)	
60s	380 (31.8)	562 (44.2)	
Smoking	504 (42.1)	51 (4.0)	<0.001
Heavy drinking	512 (42.8)	100 (7.9)	<0.001
Poor diet	551 (46.0)	272 (21.4)	<0.001
Physical inactivity	641 (53.6)	724 (56.9)	0.100
Number of lifestyle risk factors			<0.001
4	77 (6.4)	3 (0.2)	
3	238 (19.9)	24 (1.9)	
2	438 (36.6)	202 (15.9)	
1	310 (25.9)	659 (51.8)	
0	134 (11.2)	384 (30.2)	
Household income in quartiles			<0.001
Q1 (Lowest)	270 (22.9)	385 (30.5)	
Q2	320 (27.1)	335 (26.6)	
Q3	292 (24.8)	311 (24.6)	
Q4 (Highest)	298 (25.3)	231 (18.3)	
Education			<0.001
Primary school	188 (15.7)	599 (47.2)	
Middle school	192 (16.1)	219 (17.2)	
High School	404 (33.8)	326 (25.7)	
College or more	411 (34.4)	125 (9.8)	
Married status			<0.001
Living alone	121 (10.1)	266 (20.9)	
Living with partner	1,074 (89.9)	1,004 (79.1)	
Economic status			<0.001
Active	978 (82.4)	620 (48.9)	
Inactive	209 (17.6)	649 (51.1)	

Table 4 presents the results of the multinomial logistic regression model, with the number of lifestyle risk factors as the dependent variable. The table shows that male and younger age groups were much more likely to have a higher number of lifestyle risk factors. Those who were low educated or living alone were also more likely to have multiple lifestyle risk factors, while other important socioeconomic factors such as income and economic status were not significantly associated with the number of lifestyle risk factors.

Discussion

In the present study we investigated the clustering of these four major lifestyle risk factors such as smoking, heavy drinking, poor diet, and physical inactivity among a representative sample of adult Korean population with metabolic syndrome. Most previous studies on clustering of risk factors have examined the clustering of metabolic risk factors [18–25] and not lifestyle risk factors.

Table 2. Prevalence of combinations of four lifestyle risk factors.

No.	S	A	D	P	Men, n = 1,197			Women, n = 1,272		
					N	O (%)	O/E	N	O (%)	O/E
4	+	+	+	+	77	6.43	1.45	3	0.24	6.24
3	+	+	+	-	56	4.68	1.22	2	0.16	5.49
	+	+	-	+	80	6.68	1.28	3	0.24	1.70
	+	-	+	+	51	4.26	0.72	3	0.24	0.54
	-	+	+	+	51	4.26	0.70	16	1.26	1.36
2	+	+	-	-	47	3.93	0.87	5	0.39	3.64
	+	-	+	-	50	4.18	0.81	6	0.47	1.38
	+	-	-	+	90	7.52	1.08	18	1.42	0.86
	-	+	+	-	75	6.27	1.19	10	0.79	1.13
	-	+	-	+	76	6.35	0.89	30	2.36	0.70
	-	-	+	+	100	8.35	1.02	133	10.46	0.97
1	+	-	-	-	53	4.43	0.73	11	0.86	0.69
	-	+	-	-	50	4.18	0.67	31	2.44	0.95
	-	-	+	-	91	7.60	1.08	99	7.78	0.95
	-	-	-	+	116	9.69	1.01	518	40.72	1.03
0	-	-	-	-	134	11.19	1.35	384	30.19	1.01

Note: S, smoking; A, heavy drinking; D, poor diet; P, physical inactivity; O, observed; E, expected.

This study shows that the four lifestyle risk factors tended to cluster in specific multiple combinations. Smoking and heavy drinking was clustered, heavy drinking and poor diet were clustered, and smoking and physical inactivity were also clustered. These clustering patterns were extensively reported earlier for general population [8,9,26]. But this study failed to show the clustering of heavy drinking and high physical inactivity in the metabolic syndrome patients, like earlier reports for general population which showed clustering of heavy drinking and high physical activity [8,9].

It appeared that multiple lifestyle risk factors were more prevalent among men, low educated people and singles. High education may have positive effect on reducing number of having lifestyle risk factors [27,28]. Subjects educated above high school have lower possibility of having three or four risk factors than subjects with primary of middle school education. Female participants tended to be passive in terms of health behaviors in that they do not engage in smoking, heavy drinking, poor diet but as well as physical activity. About 40% of females were the case. This finding is consistent with the previous results that general Korean

Table 3. Prevalence and Prevalence Odds Ratio (POR) of combinations of two lifestyle risk factors.

	Men			Women		
	P (%)	POR	P value	P (%)	POR	P value
Smoking/Heavy drinking	260 (21.7)	1.86	<0.001	13 (1.0)	4.46	<0.001
Smoking/Poor diet	234 (19.6)	1.03	0.814	14 (1.1)	1.41	0.283
Smoking/Physical inactivity	298 (24.9)	1.48	0.001	27 (2.1)	0.85	0.559
Heavy drinking/Poor diet	259 (21.6)	1.38	0.006	331 (2.4)	1.74	0.016
Heavy drinking/Physical inactivity	284 (23.7)	1.14	0.250	52 (4.1)	0.81	0.302
Poor diet/Physical inactivity	279 (23.3)	0.80	0.062	155 (12.2)	1.00	0.980

Note: POR, prevalence odds ratio.

Table 4. Odds ratios (OR) and 95% confidence intervals (CI) of predictors of the number of lifestyle risk factors.

	1		2		3		4	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Sex (women)								
Men	1.40	1.07–1.84	6.54	4.84–8.86	27.11	16.24–45.224	73.77	21.79–249.78
Age group (60+)								
50s	1.08	0.83–1.40	1.51	1.11–2.07	2.27	1.42–3.631	6.42	2.45–16.83
40s	1.72	1.17–2.54	3.09	2.00–4.77	8.13	4.63–14.28	24.94	8.74–71.14
30s	1.36	0.81–2.28	4.31	2.52–7.40	9.07	4.64–17.73	17.75	5.47–57.56
Income (Q1)								
Q2	0.91	0.68–1.24	1.17	0.83–1.65	0.75	0.46–1.21	1.09	0.54–2.21
Q3	0.95	0.70–1.29	0.90	0.63–1.29	0.81	0.49–1.30	0.54	0.24–1.21
Q4	0.93	0.67–1.30	1.02	0.70–1.51	0.99	0.60–1.62	0.92	0.43–1.98
Education (primary)								
Middle school	0.90	0.65–1.24	1.05	0.72–1.54	0.89	0.49–1.60	0.58	0.22–1.55
High School	0.92	0.67–1.26	0.99	0.68–1.42	0.99	0.58–1.69	0.44	0.18–1.07
College or more	0.82	0.54–1.24	0.60	0.38–0.97	0.58	0.31–1.09	0.55	0.22–1.39
Married status (living with partner)								
Living alone	0.98	0.72–1.31	1.43	1.00–2.03	1.64	0.99–2.71	2.20	1.05–4.63
Economic status (active)								
Inactive	0.95	0.75–1.20	0.85	0.64–1.13	0.63	0.39–1.00	0.69	0.30–1.59

Note: Reference category for the outcome variable is "none" lifestyle risk factor. Reference group is in parenthesis.

women tended not to partake in smoking, drinking, and physical activity at the same time [26]. Likewise, male participants tended to smoke and drink heavily, also supporting existing literature [26]. Males with metabolic syndrome were much more likely than their female counterparts to engage in multiple unhealthy behaviors. This results show that there are vulnerable groups within the adult population that have more risky lifestyles.

The crucial management approach for metabolic syndrome is not drug treatment, but lifestyle change, that is to say, making healthier lifestyle behaviors. The National Cholesterol Education Panel Adult Treatment Panel recommended lifestyle change as the initial management for metabolic syndrome [1,29]. Studies have shown that short-term intensive lifestyle intervention programs are effective at controlling risk factors for metabolic syndrome. For example, diet and exercise programs significantly decrease biochemical indices of metabolic syndrome, weight, and waist circumference [30–32]. A successful lifestyle intervention for the metabolic syndrome depends much on the patient's motivation to change their unhealthy behaviors [33]. Naturally, the more closely a patient adheres an intervention program, the greater the improvement in level of his or her lifestyle risk factors [34].

Followings are some helpful implications for more effective lifestyle intervention targeting metabolic syndrome from this study. First, multiple-behavior interventions should be provided rather than single-behavior interventions [35,36] because health behaviors are clustered. This approach can be more effective and efficient at achieving intervention goal [37]. Second, interventions need to focus on modifying smoking and heavy drinking habits. People who smoke and/or drink heavily tend to have other bad lifestyle habits. In other words, controlling for these two factors may prevent other bad habits. Third, men, younger age groups, low educated and singles should be targeted for multiple-behavior interventions because these groups appear to be relatively at high risk. Fourth, more tailored intervention should be developed for women with metabolic syndrome since most of female participants in this study have relatively

good health habits. Further study is needed to identify behavior pattern among women with metabolic syndrome more precisely.

The most important limitation in the study is that as cut-off points of lifestyle risk factors were used that are in accordance with KNHANES, it may be difficult to generalize our findings to different settings and populations. It should be noticed that the common practice of dichotomizing lifestyle factors may have implications for the findings [8,38].

Generally, prevalence ratio (PR) is regarded more appropriate measure than POR, but the reason we used POR instead of PR was that only POR has the property of reciprocity (changing reference category of a dichotomized variable will yield 'reciprocal' estimates) which is needed for our analyses [39]. In fact, previous researches with similar study design used POR, too [8–10,17].

In the present study we examined the clustering of four major lifestyle risk factors among a representative sample of adult Korean population with metabolic syndrome. This study shows that the four lifestyle risk factors clustered in specific multiple combinations and there are specific vulnerable groups that have more lifestyle risk factors. Some helpful implications can be drawn from the knowledge of clustering pattern of lifestyle risk factors for more effective intervention program targeting metabolic syndrome.

Author Contributions

Conceptualization: YHL.

Data curation: SH.

Formal analysis: HRC.

Investigation: SH HRC YHL.

Methodology: SH YHL.

Resources: YHL.

Supervision: YHL.

Writing – original draft: SH HRC.

Writing – review & editing: SH HRC YHL.

References

1. Grundy SM, Cleeman JI, Daniels SR, Donato KA, Eckel RH, Franklin BA, et al. (2005) Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. Circulation 112: 2735–2752. https://doi.org/10.1161/CIRCULATIONAHA.105.169404 PMID: 16157765

2. Ford ES (2005) Risks for all-cause mortality, cardiovascular disease, and diabetes associated with the metabolic syndrome: a summary of the evidence. Diabetes Care 28: 1769–1778. PMID: 15983333

3. Grundy SM, Brewer HB Jr., Cleeman JI, Smith SC Jr., Lenfant C, American Heart A, et al. (2004) Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. Circulation 109: 433–438. https://doi.org/10.1161/01.CIR.0000111245.75752.C6 PMID: 14744958

4. Choo J, Yoon SJ, Ryu H, Park MS, Lee HS, Park YM, et al. (2016) The Seoul Metropolitan Lifestyle Intervention Program and Metabolic Syndrome Risk: A Retrospective Database Study. Int J Environ Res Public Health 13.

5. Jahangiry L, Shojaeizadeh D, Montazeri A, Najafi M, Mohammad K, Abbasalizad Farhangi M (2014) Modifiable lifestyle risk factors and metabolic syndrome: opportunities for a web-based preventive program. J Res Health Sci 14: 303–307. PMID: 25503288

6. McGinnis JM, Foege WH (1993) Actual causes of death in the United States. JAMA 270: 2207–2212. PMID: 8411605

7. Mokdad AH, Marks JS, Stroup DF, Gerberding JL (2004) Actual causes of death in the United States, 2000. JAMA 291: 1238–1245. https://doi.org/10.1001/jama.291.10.1238 PMID: 15010446

8. Poortinga W (2007) The prevalence and clustering of four major lifestyle risk factors in an English adult population. Prev Med 44: 124–128. https://doi.org/10.1016/j.ypmed.2006.10.006 PMID: 17157369

9. Schuit AJ, van Loon AJ, Tijhuis M, Ocke M (2002) Clustering of lifestyle risk factors in a general adult population. Prev Med 35: 219–224. PMID: 12202063

10. Chou KL (2008) The prevalence and clustering of four major lifestyle risk factors in Hong Kong Chinese older adults. J Aging Health 20: 788–803. https://doi.org/10.1177/0898264308321082 PMID: 18562762

11. Kandula NR, Dave S, De Chavez PJ, Bharucha H, Patel Y, Seguil P, et al. (2015) Translating a heart disease lifestyle intervention into the community: the South Asian Heart Lifestyle Intervention (SAHELI) study; a randomized control trial. BMC Public Health 15: 1064. https://doi.org/10.1186/s12889-015-2401-2 PMID: 26475629

12. Kandula NR, Patel Y, Dave S, Seguil P, Kumar S, Baker DW, et al. (2013) The South Asian Heart Life-style Intervention (SAHELI) study to improve cardiovascular risk factors in a community setting: design and methods. Contemp Clin Trials 36: 479–487. https://doi.org/10.1016/j.cct.2013.09.007 PMID: 24060673

13. Kweon S, Kim Y, Jang MJ, Kim Y, Kim K, Choi S, et al. (2014) Data resource profile: the Korea National Health and Nutrition Examination Survey (KNHANES). Int J Epidemiol 43: 69–77. https://doi.org/10.1093/ije/dyt228 PMID: 24585853

14. Kim Y (2014) The Korea National Health and Nutrition Examination Survey (KNHANES): current status and challenges. Epidemiol Health 36: e2014002. https://doi.org/10.4178/epih/e2014002 PMID: 24839580

15. Kim Y, Park I, Kang M (2013) Convergent validity of the international physical activity questionnaire (IPAQ): meta-analysis. Public Health Nutr 16: 440–452. https://doi.org/10.1017/S1368980012002996 PMID: 22874087

16. Lee PH, Macfarlane DJ, Lam TH, Stewart SM (2011) Validity of the International Physical Activity Questionnaire Short Form (IPAQ-SF): a systematic review. Int J Behav Nutr Phys Act 8: 115. https://doi.org/10.1186/1479-5868-8-115 PMID: 22018588

17. Lee Y, Back JH, Kim J, Byeon H, Kim S, Ryu M (2012) Clustering of multiple healthy lifestyles among older Korean adults living in the community. Geriatr Gerontol Int 12: 515–523. https://doi.org/10.1111/j.1447-0594.2011.00788.x PMID: 22212559

18. Chen W, Bao W, Begum S, Elkasabany A, Srinivasan SR, Berenson GS (2000) Age-related patterns of the clustering of cardiovascular risk variables of syndrome X from childhood to young adulthood in a population made up of black and white subjects: the Bogalusa Heart Study. Diabetes 49: 1042–1048. PMID: 10866058

19. Milligan RA, Thompson C, Vandongen R, Beilin LJ, Burke V (1995) Clustering of cardiovascular risk factors in Australian adolescents: association with dietary excesses and deficiencies. J Cardiovasc Risk 2: 515–523. PMID: 8665370

20. Yu Y, Song Y (2015) Three clustering patterns among metabolic syndrome risk factors and their associations with dietary factors in Korean adolescents: based on the Korea National Health and Nutrition Examination Survey of 2007–2010. Nutr Res Pract 9: 199–206. https://doi.org/10.4162/nrp.2015.9.2.199 PMID: 25861428

21. Song S, Paik HY, Song WO, Park M, Song Y (2014) Three distinct clustering patterns in metabolic syndrome abnormalities are differentially associated with dietary factors in Korean adults. Nutr Res 34: 383–390. https://doi.org/10.1016/j.nutres.2014.03.004 PMID: 24916551

22. Melka MG, Abrahamowicz M, Leonard GT, Perron M, Richer L, Veillette S, et al. (2013) Clustering of the metabolic syndrome components in adolescence: role of visceral fat. PLoS One 8: e82368. https://doi.org/10.1371/journal.pone.0082368 PMID: 24376531

23. Nazzaro P, Schirosi G, Mezzapesa D, Petruzzellis M, Pascazio L, Serio G, et al. (2013) Effect of clustering of metabolic syndrome factors on capillary and cerebrovascular impairment. Eur J Intern Med 24: 183–188. https://doi.org/10.1016/j.ejim.2012.08.017 PMID: 23041467

24. Hong TK, Trang NH, Dibley MJ (2012) Prevalence of metabolic syndrome and factor analysis of cardiovascular risk clustering among adolescents in Ho Chi Minh City, Vietnam. Prev Med 55: 409–411. https://doi.org/10.1016/j.ypmed.2012.09.002 PMID: 22975412

25. Tsai CH, Li TC, Lin CC, Tsay HS (2011) Factor analysis of modifiable cardiovascular risk factors and prevalence of metabolic syndrome in adult Taiwanese. Endocrine 40: 256–264. https://doi.org/10.1007/s12020-011-9466-1 PMID: 21499818

26. Kang K, Sung J, Kim CY (2010) [High risk groups in health behavior defined by clustering of smoking, alcohol, and exercise habits: National Heath and Nutrition Examination Survey]. J Prev Med Public Health 43: 73–83. https://doi.org/10.3961/jpmph.2010.43.1.73 PMID: 20185985

27. Chung W, Lee S, Lim SJ, Kim J (2016) Modifying effects of education on the association between life-style behaviors and the risk of obesity: evidence from South Korea. BMC Public Health 16: 1100. https://doi.org/10.1186/s12889-016-3776-4 PMID: 27765022

28. Mirowsky J, Ross CE (2015) Education, Health, and the Default American Lifestyle. J Health Soc Behav 56: 297–306. https://doi.org/10.1177/0022146515594814 PMID: 26272989

29. Grundy SM, Hansen B, Smith SC Jr., Cleeman JI, Kahn RA, American Heart A, et al. (2004) Clinical management of metabolic syndrome: report of the American Heart Association/National Heart, Lung, and Blood Institute/American Diabetes Association conference on scientific issues related to manage-ment. Circulation 109: 551–556. https://doi.org/10.1161/01.CIR.0000112379.88385.67 PMID: 14757684

30. Singh RB, Singh NK, Rastogi SS, Mani UV, Niaz MA (1993) Effects of diet and lifestyle changes on ath-erosclerotic risk factors after 24 weeks on the Indian Diet Heart Study. Am J Cardiol 71: 1283–1288. PMID: 8498367

31. Anderssen SA, Hjermann I, Urdal P, Torjesen PA, Holme I (1996) Improved carbohydrate metabolism after physical training and dietary intervention in individuals with the "atherothrombogenic syndrome". Oslo Diet and Exercise Study (ODES). A randomized trial. J Intern Med 240: 203–209. PMID: 8918511

32. Watkins LL, Sherwood A, Feinglos M, Hinderliter A, Babyak M, Gullette E, et al. (2003) Effects of exer-cise and weight loss on cardiac risk factors associated with syndrome X. Arch Intern Med 163: 1889–1895. https://doi.org/10.1001/archinte.163.16.1889 PMID: 12963561

33. Bassi N, Karagodin I, Wang S, Vassallo P, Priyanath A, Massaro E, et al. (2014) Lifestyle modification for metabolic syndrome: a systematic review. Am J Med 127: 1242 e1241–1210.

34. Fappa E, Yannakoulia M, Pitsavos C, Skoumas I, Valourdou S, Stefanadis C (2008) Lifestyle interven-tion in the management of metabolic syndrome: could we improve adherence issues? Nutrition 24: 286–291. https://doi.org/10.1016/j.nut.2007.11.008 PMID: 18201869

35. Nigg CR, Allegrante JP, Ory M (2002) Theory-comparison and multiple-behavior research: common themes advancing health behavior research. Health Educ Res 17: 670–679. PMID: 12408211

36. Goldstein MG, Whitlock EP, DePue J, Planning Committee of the Addressing Multiple Behavioral Risk Factors in Primary Care P (2004) Multiple behavioral risk factor interventions in primary care. Summary of research evidence. Am J Prev Med 27: 61–79. https://doi.org/10.1016/j.amepre.2004.04.023 PMID: 15275675

37. Atkins D, Clancy C (2004) Multiple risk factors interventions. Are we up to the challenge? Am J Prev Med 27: 102–103. https://doi.org/10.1016/j.amepre.2004.04.016 PMID: 15275678

38. MacCallum RC, Zhang S, Preacher KJ, Rucker DD (2002) On the practice of dichotomization of quanti-tative variables. Psychol Methods 7: 19–40. PMID: 11928888

39. Tamhane AR, Westfall AO, Burkholder GA, Cutter GR (2016) Prevalence odds ratio versus prevalence ratio: choice comes with consequences. Stat Med 35: 5730–5735. https://doi.org/10.1002/sim.7059 PMID: 27460748