INTRODUCTION

Cardiovascular disease encompasses a vast range of diseases of the heart and blood vessels. Cardiovascular disease is one of the three main causes of death in Korea, according to the National Statistical Office reports in 2017. According to the report, the cause of death due to three major disease is 46.4%, and the cause of death from heart disease takes 10.8%. The types of cardiovascular disease in this research are ischemic cardiovascular disease such as angina pectoris and myocardial infarction. In particular, the older people have a high death rate of circulatory system disease, the rate accelerates after age 70 [1-3]. One disease of the circulatory system, cardiovascular disease is caused by coronary artery contraction, which can be caused by smoking, hypertension, hyperlipidemia, diabetes, obesity, advanced age, and family history [4-6].

The core function of riboflavin is that of coenzyme
for metabolism, and riboflavin is closely related to fat metabolism. Deficiency of riboflavin lowers fat acid oxidation and accumulates triglycerides [7-9]. Niacin contributes to reducing the cholesterol rate and to decreasing the incidence of cardiovascular disease of the coronary artery [10-12]. In particular, one-third of Korean adults showed inadequate riboflavin status [13]. On the basis of these functions, checked that the two nutrients are related to cardiovascular disease.

This research aims to confirm the correlation between physiological factors such as hypertension and cholesterol rate with cardiovascular disease from results of Korean National Health and Nutrition Examination reports (2013~2017) and to further explore other physiological factors and their correlation. In addition, the study also investigates the influence of riboflavin and niacin intake and relevance to reducing prevalence of cardiovascular disease.

**MATERIALS AND METHODS**

1. **Subjects**

The Korean National Health and Nutrition Examination is a nation-wide nutrition and health examination based on Section 16 of the National Health Promotion Act that was issued in 1995 [14]. It combines the former separately conducted studies: National Nutrition Examination and National Health Examination. The National Health Examination covers public health, behaviors concerning health, and food and nutrition intake on a national scale with city-unit significance. It is both a survey and health examination that has both validity and reliability. This study quotes the 11,958 men and women who were over 50 years old and who did not answer “unaware” or “no reply” to the 2013~2017 (sixth and seventh) Korean National Health and Nutrition Examination reports (2013-07CON-03-4C and 2013-12EXP-03-5C).

2. **Measurement items**

The content includes age, sex, cardiovascular disease including myocardial infarction or angina), hypertension, hyperglycemia, waist size, triglyceride, HDL, LDL, total cholesterol and other contents such as riboflavin, and niacin consumption. Intake of riboflavin and niacin from individual dish consumed by each subject was calculated. Among them, LDL was excluded due to unknown value. Myocardial infarction and angina were measured with a doctor’s diagnosis. Total cholesterol was measured with normal rate, with >200 mg/dL indicated as abnormal (Diagnostic criteria of dyslipidemia The Korean Society of Lipid and Atherosclerosis). As for hypertension, hyperglycemia, waist size, hypertriglyceridemia, low HDL-cholesterol are an important factor in metabolic syndrome. Thus, table of metabolic syndrome was used as indicators. If the rate was higher than 130/85 mmHg, “hypertension” was indicated: if the fasting blood sugar level was above 100 mg/dL or taking diabetic medication, “hyperglycemia” was indicated: As for waist size, men above 90 cm and women above 85 cm were indicated as “abnormal”, the triglyceride rate above 150 mg/dL was marked as “hypertriglyceridemia”, and a low HDL-cholesterol level of below 40 mg/dL for men, and 50 mg/dL for women was indicated [15]. Intake standard of riboflavin and niacin was based on 2015 dietary reference intakes for Koreans: riboflavin intake for men of 1.5 mg/day, for women of 1.2 mg/day, and niacin intake for men of 16 mg NE/day, and for women 14 mg NE/day. If the intake was above the standard level, it was indicated as being “satisfactory,” and if below, the level was indicated as “unsatisfactory” [16].

3. **Statistical analysis**

Correlation was confirmed by cross-analysis on cardiovascular disease and physiological factors. Hazard ration estimation was detected by logistic regression analysis. People with cardiovascular disease have a higher population of older people, and to control the study, the survey target was set to age 50 and above because there is few people with the disease below age 50. Other physiological factors and nutri-
tional research cross-examination and logistic regression analysis were methods to identify the most closely related nutrition. Finally, the correlation between riboflavin and niacin intake and cardiovascular disease was determined with cross-analysis and then checked prevalence rate and risks with logistic regression analysis. This study was conducted with SPSS Statistics 25 with a significance level of $P<0.05$.

**RESULTS**

1. General characteristics of research subjects

The variables and frequency analysis for this study is shown in Table 1. The survey was conducted on 11,958 people: 5,099 men (47.4%) and 6,859 women (52.6%). The subjects were over 50 years old: 48.3% were in their 50s, 28% were in their 60s, and 23.7% were in their 70s and older. Riboflavin and niacin were divided into two categories—whether consumed or not. Riboflavin’s intake amounted to 38.8%; the non-takers were 61.2%. Niacin’s intake amounted to 38.5%; the non-takers were 61.5%. For both riboflavin and niacin, 26.1% consumed both, 25.1% took only one, and non-takers were 48.8%. For cardiovascular disease, the prevalence rate was 5%, and normal was 95%. Answers to questions on hypertension, hyperglycemia, hypertriglyceridemia, and low HDL-cholesterol were divided into yes and no based on the metabolic rate. For hypertension, 39.7% responded yes, and 60.3% responded no. For hyperglycemia, 46.7% responded yes, while 53.3% responded no. For hypertriglyceridemia, 33.6% responded yes, and 66.4% responded no. For low HDL-cholesterol, 39% responded yes, and 61% responded no. For waist size and total cholesterol level, the two categories were normal and abnormal, and for waist size, 32% of respondents were abnormal, while 68% were normal. For total cholesterol, 41.4% were abnormal, and 58.6% were normal.

| Variables | N (%) |
|-----------|-------|
| Sex       |       |
| Men       | 5,099 (47.4) |
| Women     | 6,859 (52.6) |
| Age group |       |
| 50s       | 4,345 (48.3) |
| 60s       | 4,035 (28.0) |
| 70s or older | 3,578 (23.7) |
| Riboflavin RI (<1.5 mg/day, men; <1.2 mg/day, women) |       |
| Yes       | 4,356 (38.8) |
| No        | 7,602 (61.2) |
| Niacin RI (<16 mg/day, men; <14 mg/day, women) |       |
| Yes       | 4,242 (38.5) |
| No        | 7,716 (61.5) |
| Riboflavin+Niacin RI |       |
| Both      | 2,842 (26.1) |
| One       | 2,914 (25.1) |
| None      | 6,202 (48.8) |
| Cardiovascular disease |       |
| Yes       | 599 (5) |
| No        | 11,359 (95) |
| Hypertension (>130/85 mmHg) |       |
| Yes       | 4,852 (39.7) |
| No        | 7,106 (60.3) |
| Hyperglycemia (>100 mg/mL) |       |
| Yes       | 5,577 (46.7) |
| No        | 6,381 (53.3) |
| Total cholesterol (>200 mg/mL) |       |
| Abnormal  | 4,816 (41.4) |
| Normal    | 7,142 (58.6) |
| Hypertriglyceridemia (>150 mg/mL) |       |
| Yes       | 3,921 (33.6) |
| No        | 8,037 (66.4) |
| Low HDL cholesterol (<40 mg/mL) |       |
| Yes       | 4,896 (33) |
| No        | 7,062 (61) |
| Waist measurement (>90 cm, men; >85 cm, women) |       |
| Abnormal  | 4,004 (32) |
| Normal    | 7,954 (68) |
| Total     | 11,958 (100.0) |

Abbreviations: RI, Recommended intake; HDL, High density lipoprotein.

2. Relationship of physiological factors with cardiovascular disease

1) Comparison of cardiovascular disease according to physiological factors

As for the prevalence rate, among 11,958 respondents, 599 people (5%) responded yes, while 11,359 people (95%) responded no. After a careful examination on the relationship between cardiovascular disease and numerous physiological factors with statistical analysis, hypertension, hyperglycemia, waist size, and low HDL-cholesterol showed a meaningful difference ($P <0.001$).

Assumed to be the most closely related, hypertriglyceridemia did not show a significant difference, and total cholesterol had shown a meaningful result (Table 2).

2) Effects of physiological factors on cardiovascular disease

To investigate the correlation between prevalence rate of cardiovascular disease and physiological
Table 2. Comparison of cardiovascular disease according to physiological factors

| Cardiovascular disease | Yes   | No    | Total | \(P\) |
|------------------------|-------|-------|-------|-------|
| Hypertension           | 264 (4.7) | 4,586 (95.3) | 4,852 (100.0) | <0.001 |
| Hyperglycemia          | 356 (5.5) | 5,221 (94.5) | 5,577 (100.0) | <0.001 |
| Total cholesterol      | 144 (2.3) | 6,657 (94.6) | 6,801 (100.0) | <0.001 |
| Hypertriglyceridemia   | 208 (4.8) | 3,713 (95.4) | 3,921 (100.0) | 0.341  |
| Low HDL cholesterol    | 290 (5.4) | 4,606 (94.6) | 4,896 (100.0) | <0.001 |
| Waist measurement      | 264 (5.8) | 3,740 (94.2) | 4,004 (100.0) | <0.001 |
| Total                  | 599 (5)  | 11,359 (95)  | 11,958 (100)  |       |

Abbreviations: See Table 1.

Table 3. Effects of physiological factors on cardiovascular disease

| Cardiovascular disease | OR   | 95% CI | \(P\) |
|------------------------|------|--------|-------|
| Hypertension           | 1.164 | 0.956  | 1.417  | 0.130 |
| Hyperglycemia          | 1.615 | 1.340  | 1.947  | <0.001 |
| Total cholesterol      | 0.331 | 0.264  | 0.416  | <0.001 |
| Hypertriglyceridemia   | 1.058 | 0.867  | 1.290  | 0.580 |
| Low HDL cholesterol    | 1.602 | 1.329  | 1.930  | <0.001 |
| Waist measurement      | 1.663 | 1.340  | 1.947  | <0.001 |

Abbreviations: See Table 1.

Factors, an odds ratio was used, and as a result, hyperglycemia, waist size and low HDL-cholesterol showed a meaningful difference \(P<0.001\). People with hypertension were 1.2 times more likely to suffer from cardiovascular disease than those who did not, and this did not and showed a significant gap (OR=1.164, \(P>0.05\)). People with hyperglycemia were 1.6 times more likely than those who did not and showed a meaningful rate (OR=1.615, \(P<0.001\)). Those who had abnormal waist size had a 1.7 times higher prevalence rate and showed an important difference (OR=1.663, \(P<0.001\)). People with hypertriglyceridemia did not show a meaningful difference (OR=1.058, \(P>0.05\)). Those with low HDL-cholesterol were 1.6 times more likely to suffer from cardiovascular disease than those who did not and show an important difference (OR=1.602, \(P<0.001\)). Total cholesterol had shown important results but also had the opposite result from expectation abnormal people had a 0.3 times lower prevalence rate of cardiovascular disease (OR=0.331, \(P<0.001\)) (Table 3).

3. Relationship of riboflavin and niacin with physiological factors

1) Comparison of physiological factors according to recommended intake of riboflavin

Among the 11,958 respondents, 4,356 people consumed riboflavin above the standard level, and
7,602 did not. The correlation between intake of standard riboflavin and other physiological factors showed an important difference for hypertension, hyperglycemia and low HDL-cholesterol \((P<0.05)\). Waist size and hypertriglyceridemia did not indicate an important difference, and total cholesterol showed an important level (Table 4).

2) Comparison of physiological factors according to recommended intake of niacin

Among the 11,958 respondents, 4,242 people consumed niacin above the standard level, and 7,716 did not. The correlation between intake of standard niacin and other physiological factors showed an important difference for hypertension, hyperglycemia, waist size and low HDL-cholesterol \((P<0.05)\). Hypertriglyceridemia and total cholesterol did not yield meaningful results (Table 5).

3) Comparison of physiological factors according to recommended intake of riboflavin and niacin

Among the 11,958 respondents, 2,842 people consumed both riboflavin and niacin above the standard level, while 2,914 people consumed either nutrient, and 6,202 people consumed neither. The correlation between intake of standard riboflavin and

| Table 4. Comparison of physiological factors according to recommended intake of riboflavin |
|-----------------|-----------------|-----------------|-----------------|
|                 | Riboflavin RI   |                 |                 |
|                 | Yes             | No              | Total           | \(P\)           |
| Hypertension    |                 |                 |                 |                 |
| Yes             | 1,620 (33.3)    | 3,232 (66.7)    | 4,852 (100.0)   | <0.001          |
| No              | 2,736 (38.5)    | 4,370 (61.5)    | 7,106 (100.0)   |                 |
| Hyperglycemia   |                 |                 |                 |                 |
| Yes             | 1,949 (34.9)    | 3,628 (65.1)    | 5,577 (100.0)   | 0.007           |
| No              | 2,407 (37.7)    | 3,974 (62.3)    | 6,381 (100.0)   |                 |
| Total cholesterol |               |                 |                 |                 |
| Abnormal        | 1,899 (39.4)    | 2,917 (60.6)    | 4,816 (100.0)   | <0.001          |
| Normal          | 2,457 (34.4)    | 4,685 (65.6)    | 7,142 (100.0)   |                 |
| Hypertriglyceridemia |        |                 |                 |                 |
| Yes             | 1,385 (35.3)    | 2,536 (64.6)    | 3,921 (100.0)   | 0.646           |
| No              | 2,971 (37)      | 5,066 (63)      | 8,037 (100.0)   |                 |
| Low HDL cholesterol |          |                 |                 |                 |
| Yes             | 1,648 (33.7)    | 3,248 (66.3)    | 4,896 (100.0)   | <0.001          |
| No              | 2,708 (38.3)    | 4,354 (61.7)    | 7,062 (100.0)   |                 |
| Waist measurement |            |                 |                 |                 |
| Abnormal        | 1,384 (34.6)    | 2,620 (65.4)    | 4,004 (100.0)   | 0.078           |
| Normal          | 2,972 (37.4)    | 4,982 (62.6)    | 7,954 (100.0)   |                 |
| Total           | 4,356 (36.4)    | 7,602 (63.6)    | 11,958 (100.0)  |                 |

Abbreviations: See Table 1.

| Table 5. Comparison of physiological factors according to recommended intake of niacin |
|-----------------|-----------------|-----------------|-----------------|
|                 | Niacin RI       |                 |                 |
|                 | Yes             | No              | Total           | \(P\)           |
| Hypertension    |                 |                 |                 |                 |
| Yes             | 1,605 (33.1)    | 3,247 (66.9)    | 4,852 (100.0)   | 0.017           |
| No              | 2,637 (37.1)    | 4,469 (62.9)    | 7,106 (100.0)   |                 |
| Hyperglycemia   |                 |                 |                 |                 |
| Yes             | 1,907 (34.2)    | 3,670 (65.8)    | 5,577 (100.0)   | 0.040           |
| No              | 2,335 (36.6)    | 4,046 (63.4)    | 6,381 (100.0)   |                 |
| Total cholesterol |               |                 |                 |                 |
| Abnormal        | 1,721 (35.7)    | 3,095 (64.3)    | 4,816 (100.0)   | 0.679           |
| normal          | 2,521 (35.3)    | 4,621 (64.7)    | 7,142 (100.0)   |                 |
| Hypertriglyceridemia |        |                 |                 |                 |
| Yes             | 1,336 (34.1)    | 2,585 (65.9)    | 3,921 (100.0)   | 0.519           |
| No              | 2,906 (36.2)    | 5,131 (63.8)    | 8,037 (100.0)   |                 |
| Low HDL cholesterol |          |                 |                 |                 |
| Yes             | 1,557 (31.8)    | 3,339 (68.2)    | 4,896 (100.0)   | <0.001          |
| No              | 2,685 (38)      | 4,377 (62)      | 7,062 (100.0)   |                 |
| Waist measurement |            |                 |                 |                 |
| Abnormal        | 1,302 (32.5)    | 2,702 (67.5)    | 4,004 (100.0)   | 0.001           |
| Normal          | 2,940 (37)      | 5,014 (63)      | 7,954 (100.0)   |                 |
| Total           | 4,242 (35.5)    | 7,716 (64.5)    | 11,958 (100.0)  |                 |

Abbreviations: See Table 1.
niacin and other physiological factors showed an important difference for hypertension, hyperglycemia, waist size and low HDL-cholesterol ($P<0.05$). Hypertriglyceridemia and total cholesterol did not yield meaningful results (Table 6).

### 4) Effects of riboflavin and niacin on physiological factors

To investigate the contributing effect of standard-level intake of riboflavin and niacin on normal and abnormal results of physiological factors, an odds ratio was used. Hypertension, hyperglycemia, and low HDL-cholesterol showed important differences ($P<0.01$). On riboflavin’s effect alone, hypertension was reduced to 80% (OR=0.808, $P<0.001$), hyperglycemia was reduced to 88% (OR=0.881, $P<0.01$), and low HDL-cholesterol was reduced to 84% and showed significant results (OR=0.840, $P<0.001$). Total cholesterol showed an important difference but increased to 120% (OR=1.212, $P<0.001$). On niacin’s effect alone, hypertension was reduced to 88% (OR=0.879, $P<0.01$), hyperglycemia was reduced to 85% (OR=0.848, $P<0.001$), abnormal waist size was reduced to 88% (OR=0.879, $P<0.01$), and low HDL-cholesterol was reduced to 84%, showing an important difference (OR=0.839, $P<0.001$). Hypertriglyceridemia (OR=0.971, $P>0.05$) and total cholesterol (OR=1.046, $P>0.05$) did not show important difference.

On both riboflavin and niacin’s effect, when both nutrients were consumed on a standard level, hypertension was reduced to 79% (OR=0.792, $P<0.001$), hyperglycemia was diminished to 81% (OR=0.813, $P<0.001$), and abnormal waist size was reduced to 84% (OR=0.844, $P<0.01$), and low HDL-cholesterol was reduced to 80% and showed a meaningful difference (OR=0.799, $P<0.001$). Hypertriglyceridemia did not show a meaningful difference (OR=0.920, $P>0.05$). Total cholesterol showed significant results, but the abnormal rate increased (OR=1.168, $P<0.01$) (Table 7).

### 4. Relationship of riboflavin and niacin with cardiovascular disease

#### 1) Comparison of cardiovascular disease according to recommended intake of riboflavin and niacin

Among the 11,958 respondents, 599 people (5%) responded yes on cardiovascular disease diagnosis, while 11,359 (95%) did not. Among those 599 people, 174 people (3.3%) consumed riboflavin, and 425 people (5%) did not. Within the prevalent 599 people, 168 people (3.3%) consumed niacin, and 431 people (4.9%) did not. If we explore both nutrients, 97 people (2.7%) consumed both nutrients, while 148 people (4.5%) consumed either of the nutrients, and 354 people (5.1%) consumed neither of the nutrients. The correlation between intake of standard riboflavin and niacin and

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**Table 6. Comparison of physiologic factors according to recommended intake of riboflavin and niacin**

|                      | Both   | One    | None   | Total  | $P$   |
|----------------------|--------|--------|--------|--------|-------|
| Hyper tension        |        |        |        |        |       |
| Yes                  | 1,035  | (21.3) | 1,155  | (23.8) | 2,662 | (54.9)| 4,852 | (100.0) | <0.001 |
| No                   | 1,807  | (25.4) | 1,759  | (24.8) | 3,540 | (50.8)| 7,106 | (100.0) |       |
| Hyperglycemia        |        |        |        |        |       |
| Yes                  | 1,249  | (22.4) | 1,358  | (24.3) | 2,970 | (53.3)| 5,577 | (100.0) | 0.010  |
| No                   | 1,593  | (25)   | 1,556  | (24.4) | 3,232 | (50.6)| 6,381 | (100.0) |       |
| Total Cholesterol    |        |        |        |        |       |
| Abnormal             | 1,210  | (25.1) | 1,200  | (24.9) | 2,406 | (50) | 4,816 | (100.0) | 0.079  |
| Normal               | 1,632  | (22.8) | 1,714  | (24)   | 3,796 | (53.2)| 7,142 | (100.0) |       |
| Hypertriglyceridemia |        |        |        |        |       |
| Yes                  | 887    | (22.6) | 947    | (24.2) | 2,087 | (53.2)| 3,921 | (100.0) | 0.815  |
| No                   | 1,953  | (25)   | 1,967  | (24.5) | 4,115 | (51.2)| 8,037 | (100.0) |       |
| Low HDL cholesterol  |        |        |        |        |       |
| Yes                  | 1,046  | (21.4) | 1,113  | (22.7) | 2,377 | (55.9)| 4,536 | (100.0) | <0.001 |
| No                   | 1,796  | (25.4) | 1,801  | (25.5) | 3,465 | (54.1)| 7,062 | (100.0) |       |
| Waist measurement    |        |        |        |        |       |
| Abnormal             | 852    | (21.3) | 982    | (24.5) | 2,170 | (54.2)| 4,004 | (100.0) | 0.006  |
| Normal               | 1,990  | (25)   | 1,932  | (24.3) | 4,032 | (50.7)| 7,954 | (100.0) |       |
| Total                | 2,842  | (23.8) | 2,914  | (24.4) | 6,202 | (51.8)| 11,958| (100.0) |       |

Abbreviations: See Table 1.
Table 7. Effects of riboflavin and niacin on physiological factors

| DV                    | IV             | OR       | 95% CI     | P    |
|-----------------------|----------------|----------|------------|------|
|                       |                | DV       | 95% CI     |      |
|                       |                | LL CI    | ULCI       |      |
| Hypertension          | Riboflavin RI  | Yes      | 0.808      | 0.738| 0.884| <0.001|
|                       | No             | (reference) |           |      |      |      |
|                       | Niacin RI      | Yes      | 0.879      | 0.803| 0.962| 0.005|
|                       | No             | (reference) |           |      |      |      |
|                       | Riboflavin+Niacin RI | Both | 0.792 | 0.711 | 0.882| <0.001|
|                       |               | One      | 0.889 | 0.799 | 0.989| 0.030|
|                       |               | None     | (reference) |     |      |      |
| Hyperglycemia         | Riboflavin RI  | Yes      | 0.881      | 0.808| 0.961| 0.004|
|                       | No             | (reference) |           |      |      |      |
|                       | Niacin RI      | Yes      | 0.848      | 0.774| 0.929| <0.001|
|                       | No             | (reference) |           |      |      |      |
|                       | Riboflavin+Niacin RI | Both | 0.813 | 0.731 | 0.905| <0.001|
|                       |               | One      | 0.954 | 0.862 | 1.057| 0.372|
|                       |               | None     | (reference) |     |      |      |
| Total Cholesterol     | Riboflavin RI  | Yes      | 1.212      | 1.110| 1.323| <0.001|
|                       | No             | (reference) |           |      |      |      |
|                       | Niacin RI      | Yes      | 1.046      | 0.954| 1.148| 0.337|
|                       | No             | (reference) |           |      |      |      |
|                       | Riboflavin+Niacin RI | Both | 1.168 | 1.050 | 1.300| 0.004|
|                       |               | One      | 1.129 | 1.016 | 1.253| 0.024|
|                       |               | None     | (reference) |     |      |      |
| Hypertriglyceridemia  | Riboflavin RI  | Yes      | 0.971      | 0.880| 1.071| 0.552|
|                       | No             | (reference) |           |      |      |      |
|                       | Niacin RI      | Yes      | 0.909      | 0.825| 1.002| 0.054|
|                       | No             | (reference) |           |      |      |      |
|                       | Riboflavin+Niacin RI | Both | 0.920 | 0.819 | 1.033| 0.158|
|                       |               | One      | 0.952 | 0.848 | 1.069| 0.407|
|                       |               | None     | (reference) |     |      |      |
| Low HDL cholesterol   | Riboflavin RI  | Yes      | 0.840      | 0.766| 0.921| <0.001|
|                       | No             | (reference) |           |      |      |      |
|                       | Niacin RI      | Yes      | 0.839      | 0.767| 0.918| <0.001|
|                       | No             | (reference) |           |      |      |      |
|                       | Riboflavin+Niacin RI | Both | 0.799 | 0.715 | 0.892| <0.001|
|                       |               | One      | 0.832 | 0.751 | 0.921| <0.001|
|                       |               | None     | (reference) |     |      |      |
| Waist measurement     | Riboflavin RI  | Yes      | 0.918      | 0.832| 1.012| 0.084|
|                       | No             | (reference) |           |      |      |      |
|                       | Niacin RI      | Yes      | 0.879      | 0.862| 0.785| 0.002|
|                       | No             | (reference) |           |      |      |      |
|                       | Riboflavin+Niacin RI | Both | 0.844 | 0.754 | 0.944| 0.003|
|                       |               | One      | 0.974 | 0.871 | 1.090| 0.650|
|                       |               | None     | (reference) |     |      |      |

Abbreviations: See Table 1.

2) Effects of riboflavin and niacin on cardiovascular disease

To study the contributing effect of riboflavin and niacin’s standard-level intake on prevalence rate of cardiovascular disease, an odds ratio was conducted, which showed a significant difference (P<0.001). If those who did not take a standard level of riboflavin and niacin has a 100% likely get cardiovascular disease. On riboflavin’s effect alone, prevalence rate of cardiovascular disease was reduced to 64% (OR=0.641, P<0.001). When niacin was consumed on a standard level,
Table 8. Comparison of cardiovascular disease according to recommended intake of riboflavin and niacin

| Cardiovascular disease | Total | P     |
|------------------------|-------|-------|
|                        | Yes   | No    |
| Riboflavin RI          |       |       |
| Yes                    | 174 (3.3) | 4,182 (96.7) | 4,356 (100.0) | <0.001 |
| No                     | 425 (5.0) | 7,177 (95.0) | 7,602 (100.0) | <0.001 |
| Niacin RI              |       |       |
| Yes                    | 168 (3.3) | 4,074 (96.7) | 4,242 (100.0) | <0.001 |
| No                     | 431 (4.9) | 7,285 (95.1) | 7,716 (100.0) | <0.001 |
| Riboflavin+Niacin RI   |       |       |
| Both                   | 97 (2.7) | 2,745 (97.3) | 2,842 (100.0) | <0.001 |
| One                    | 148 (4.5) | 2,766 (95.5) | 2,914 (100.0) | <0.001 |
| No                     | 354 (5.1) | 5,848 (94.9) | 6,202 (100.0) | <0.001 |
| Total                  | 599 (5) | 11,359 (95) | 11,958 (100) | <0.001 |

Abbreviations: See Table 1.

Table 9. Effects of riboflavin and niacin on cardiovascular disease

| DV | IV    | OR       | 95% CI      | P     |
|----|-------|----------|-------------|-------|
|    | Riboflavin RI |        |             |       |
|    | Yes    | 0.641    | 0.522       | 0.786 | <0.001 |
|    | No     | (reference) |             |       |
|    | Niacin RI |        |             |       |
|    | Yes    | 0.634    | 0.513       | 0.785 | <0.001 |
|    | No     | (reference) |             |       |
|    | Riboflavin+Niacin RI | |             |       |
|    | Both   | 0.508    | 0.391       | 0.660 | <0.001 |
|    | One    | 0.857    | 0.684       | 1.073 | 0.178  |
|    | None   | (reference) |             |       |

Abbreviations: See Table 1.

prevalence rate of cardiovascular disease was reduced to 63% (OR=0.634, P<0.001). If the contributing effect of both the riboflavin and niacin is combined, while intake of one nutrient drops the prevalence rate to 85%, consuming both nutrients reduces the prevalence rate of cardiovascular disease to 50% (OR=0.508, P<0.001) (Table 9).

DISCUSSION

The causes of cardiovascular disease can be of different types: innate factors such as aging, family history, and sex; biological factors such as hypertension and cholesterol level; as well as environmental factors such as smoking, eating, and stress [17, 18]. The major precedence diseases to cardiovascular disease are dyslipidemia, hypertension, and diabetes [19], and to reduce the incidence, many studies are being conducted on correlation between precedence diseases and cardiovascular disease [20-22]. At first, the analysis was conducted on adults 19 years of age or older. As a result, except for the age element, there was no significant result. The reason for such result was the 0% prevalence rate of cardiovascular disease among 19 to 39 years old individuals. On the basis of such trials, the study was reexamined with subjects over 50 years old. It was able to analyze it more accurately than before, excluding the influence of age. For lipid level, the variables were total cholesterol, hypertriglyceridemia, low HDL-cholesterol, and high LDL-cholesterol, but through analysis, LDL had a high missing value and was excluded from the variables. Before executing this study, the physiological factor most correlated to cardiovascular disease was expected to be lipid level [23-25]. However, through cross-analysis, hypertriglyceridemia does not display a high correlation, and total cholesterol had an opposite result from the hypothesis. According to P value, the result of total cholesterol are significant; however, the prevalence rate of the normal people was higher than the
abnormal people. Variables on glucose and waist size showed a significant result as expected. As for total cholesterol level, it is a well-known fact that the higher the rate, the higher the likelihood of death from cardiovascular disease [26, 27], and the same is true of hypertriglyceridemia level and low HDL-cholesterol [28, 29]. Thus, the statistical results in this study raised questions about numerous articles that had been published to date. In addition, this study also checked clinical trial reports on the South Korean population. An observational study on patients hospitalized for myocardial infarction during 1993 reported that higher total cholesterol and triglyceride levels were found in the patient group (186.2 mg/dL and 131.8 mg/dL, respectively) than in the control group (145.2 mg/dL and 104.7 mg/dL, respectively) [30]. Another study on patients from 20 hospitals in South Korea showed that the risk of cardiovascular diseases increased when total cholesterol and triglyceride levels increased [31]. However, the risk of cardiovascular disease was not proportional to the gradual increase in cholesterol level in a prediction model for onset of ischemic heart disease among South Korean patients. Moreover, while the risk of cardiovascular disease increased gradually when the triglyceride level was between 100 and 299 mg/dL, the risk decreased when the triglyceride level was ≥300 mg/dL. The age of the study population was ≥50 years, whereas the age in clinical trials was mostly <60 years, while the average total cholesterol and triglyceride levels were higher than the levels reported in the Korean National Health and Nutrition Examination Survey (KNHANES) [32]. Physiologically, triglyceride levels fluctuate widely, and thus it is difficult to use a single measurement as an indicator [33]. Most studies in South Korea have the limitations of targeting clinical patients, being limited to specific communities, or not analyzing patterns of change based on long-term observation within the same population [34, 35]. Because KNHANES data are based on a questionnaire survey conducted mostly on healthy subjects, data may contain errors due to failure to check the diagnosis of each individual. Compared to clinical trials, this study divided the results simply by normal versus abnormal for comparison and included cardiovascular disease including myocardial infarction or angina. In addition, the results may differ from actual clinical results, and the results may also be based on the prediction model explained earlier. It is believed that cohort studies on cardiovascular disease associated with lipid levels among older age groups are needed in the future.

On the basis of relationship between riboflavin and niacin [7-9], the study further investigates the correlation between physiological variables and riboflavin or niacin. Total cholesterol and triglyceride, which had an unexpected correlation to cardiovascular disease, interestingly, also showed the same relationship with riboflavin and niacin. D’Andrea et al. demonstrated that cumulative evidence showed no preventive relation of niacin to therapeutic effects of cardiovascular disease in secondary prevention. It has been suggested that niacin may be useful in lipid control for secondary prevention as monotherapy [36]. Although niacin is recognized to reduce the cholesterol rate, the correlation results with total cholesterol had low significance. Finally, a study on riboflavin and niacin consumption of a standard level and the correlation to cardiovascular disease found that consuming both on a recommended level reduced the prevalence rate to 50%. Our research demonstrated that intake of riboflavin or niacin can prevent the prevalence rate of cardiovascular disease by inhibiting low HDL-cholesterol and hyperglycemia (Table 7).

Sex was another variable to conduct a frequency analysis, but was excluded from the actual research. Men averaged higher cardiovascular disease risk than women at most ages, but after age 75, the rate becomes similar [37, 38]: the body component changes over time, for both men and women as time goes by: the level of subcutaneous fat reduces; and visceral fat increases. As aging takes place, hormones that suppress fat decrease, resulting in visceral fat accumulation. On the
basis of statistics from the Korean National Health and Nutrition Examination, among a total of 11,958 subjects, 5,099 were men (47.4%), and 6,859 were women (52.6%). There were more women in a payment data of national health insurance corporation. Up to age 50, there is a higher percentage of men, but after age 60, the trend reverses, and after age 80, the percentage of women is 2.66 times higher than that of men [39]. As people grow older, the prevalence rate for women increased, and in this study, the respondents were also over 50 years old, yielding similar results. However, sex as a variable does not show great statistical difference and was excluded.

In conclusion, all the results from this research show the highest prevalence rate of cardiovascular diseases from physiological factors: hypertension, waist size, low HDL-cholesterol, and the nutrients that were related to the abnormal rate of physiological factors were riboflavin and niacin. Finally, riboflavin and niacin had a high correlation to prevalence rate of cardiovascular diseases (Figure 1). These observations indicate that riboflavin and niacin may be effective in prevention of cardiovascular disease.

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