Serum high-density lipoprotein cholesterol level and functional performance in an elderly Korean population

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ABSTRACT

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(Directed by Professor Hyeon Chang Kim)

INTRODUCTION:

Functional performance and cholesterol metabolism are important for elderly's health; however, their association has not been fully investigated in the general population. Thus, we investigated the association of HDL cholesterol with multiple functional performance measures in an elderly Korean population.

METHODS:

This cross-sectional analysis included 2,023 people, aged 65–95 years, who participated in baseline health examinations for the Korean Urban Rural Elderly (KURE) cohort study. Serum HDL cholesterol was measured from fasting blood samples. Functional performance was assessed by the activities of daily living (ADL) scale, instrumental activities of daily living (IADL) scale, timed up-and-go (TUG) test, and chair-rise test (CRT). The fewer seconds at TUG test and CRT and the lower ADL and IADL scores indicated better functional performance.

RESULTS:

In male elderly, higher HDL cholesterol level were significantly associated with lower ADL score (β=-0.019 per HDL cholesterol 5 mg/dL, $p<0.001$) and TUG (β=-0.133, $p=0.005$), but not with IADL (β=-0.020, $p=0.086$) and CRT (β=-0.038, $p=0.499$) when adjusted for age. When additionally adjusted for body mass index, total cholesterol, diabetes, blood pressure, smoking, alcohol consumption, and history of cardiovascular disease, the inverse association was statistically significant only for ADL (β=-0.018, $p=0.002$). In female elderly, HDL cholesterol was independently associated only with CRT (β=-0.085, $p=0.044$), but not with ADL (β=-0.003, $p=0.263$), IADL (β=-0.002, $p=0.640$) and TUG (β=-0.003, $p=0.945$) when adjusted for age. This inverse association between HDL cholesterol and CRT remained significant after additional adjustment (β=-0.090, $p=0.048$).

CONCLUSION:

Higher HDL cholesterol level was associated with better functional performance in our elderly Korean population. In addition, gender may influence this association.

Keywords: HDL cholesterol, functional performance, physical function, elderly

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I. INTRODUCTION

1. Background

A growing body of evidence has demonstrated that high-density lipoprotein (HDL) cholesterol is a marker of frailty and predictor of poor prognosis among the elderly (Arai, and Hirose 2004, 246). HDL cholesterol has generally been called the “good cholesterol” because a higher level of HDL cholesterol in the blood is associated with a lower risk of atherosclerotic cardiovascular disease (Cannon 2011, 2153-2155). More recently, HDL cholesterol has been suggested as a risk factor for all-cause mortality, especially among the elderly (Cannon 2011, 2153-2155, Weverling-Rijnsburger et al. 2003, 1549-1554), and strong findings in this field have been accumulating (Arai, and Hirose 2004, 246).

The assessment of functional status and disability among the elderly is important, since elderly people tend to experience a decline in functional performance (Guralnik, and Simonsick 1993, 3-10). Functional status defined as daily behaviors necessary to maintain daily life and including areas of physical, cognitive, and social functioning, which is important to health outcomes of the elderly (Inouye et al. 1998, 1187-1193). Evaluation of functional performance is a significant factor for maintaining an independent life (Brach et al. 2002, 320-328), in the ability of older adults to participate in activities, and prediction include items related to a specific characteristic in older to forecast another trait (Bonder, and Dal Bello-Haas 2008).

2. Objective

Although previous research has begun to discuss the growing importance of functional performance and cholesterol metabolism, their association between blood cholesterol profile and functional performance has not been fully investigated in the elderly. This study hypothesized that elderly Korean population who have elevated level of serum HDL cholesterol also have superior functional performance. Thus, the aim of this study was to investigate the association of HDL cholesterol with multiple functional performance measures among community-dwelling elderly Koreans. This study evaluated the association of serum HDL cholesterol level with multiple functional performance measures including activities of daily living (ADL), instrumental activities of daily living (IADL), timed up-and-go (TUG) test, and chair rise test (CRT).

II. METHODS

1. Study population

This study used data from the Korean Urban Rural Elderly (KURE) study, an ongoing community-based cohort study (Lee et al. 2014, 33). Over the course of 12 years, the KURE study plans to recruit more than 4,000 participants aged 65 years or order from urban and rural communities of South Korea. The KURE study enrolled 2,025 participants aged 65 years or older in 2012 and 2013 baseline examinations. Participants were recruited from three urban communities (Seodaemun-gu, Eunpyeong-gu, and Mapo-gu, Seoul, n=1,656) and one rural community (Gangwha-gun, Incheon, n=369).

The current cross-sectional analysis was conducted for a total of 2,023 participants, after excluding 2 individuals who did not complete questionnaire. Final sample for the analyses of this study were outlined in Figure 1. The association between HDL cholesterol and TUG was analyzed for 2,017 participants after excluding 6 people unable to complete TUG test. The association between HDL cholesterol and CRT was analyzed for 1,968 participants after excluding 55 people unable to complete CRT. All participants provided written informed consent, and the Institutional Review Board of Severance Hospital, Yonsei University College of Medicine, approved the study protocol.

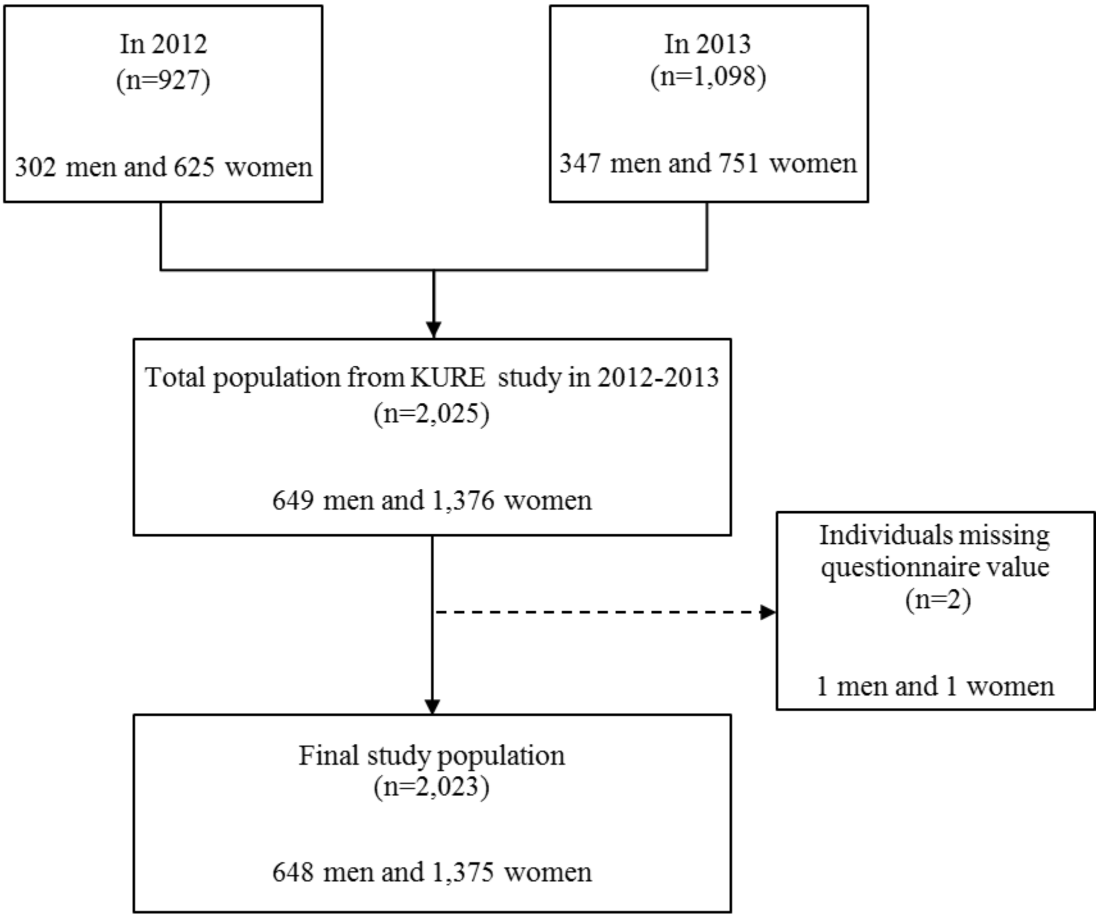

Figure 1. Flowchart of the selection criteria for the final study population

2. *Measurements*

1) Questionnaire

A face-to-face interview was conducted to evaluate participants' socio-demographic characteristics; previously known diseases including diabetes mellitus, depression, myocardial infarction, and stroke; medication use; and health behaviors such as cigarette smoking, alcohol intake, and physical activity. Participants were categorized as current smokers or current nonsmokers and current drinkers or current nondrinkers. Cognitive function was assessed using the Korean version of the Mini Mental State Examination for dementia screening (Kang, Na, and Hahn 1997, 300-308).

2) Physical examinations

Standing height was measured to the nearest 0.1 cm on a stadiometer (DS-102, JENIX, Seoul, Korea) and body weight was measured to the nearest 0.1 kg on a digital scale (DB-150, CAS, Seoul, Korea). Body mass index was calculated as body weight in kilograms divided by the square of standing height in meters. Prior to blood pressure measurement, all participants were seated for at least 5 minutes. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were repeatedly measured with 5 minutes intervals using automatic sphygmomanometer (HEM-7111, Omron Healthcare, Kyoto, Japan). Additional measurements were performed when first and second measurements differ by ≥10 mmHg either SBP or DBP, and the average of last two measurements was taken for analysis.

3) Laboratory test

Blood samples were drawn from the antecubital vein after at least eight hours fasting. Serum levels of total cholesterol, HDL cholesterol and triglycerides were measured by enzymatic methods and glucose level was measured by colorimetry method with Automatic Analyzer (ADVIA 1800, Siemens, Tarrytown, NY, USA) in an independent laboratory center. Coefficients of variation for HDL cholesterol measurement ranged from 2.0% to 2.6% in the laboratory. Diabetes mellitus was determined on the basis of fasting glucose concentration (≥126 mg/dl) or self-report of physician's diagnosis ("Diagnosis and classification of diabetes mellitus" 2011, S62-9).

4) Functional performance

Trained staff measured functional performance using ADL and IADL scores with an interviewer-assisted questionnaire, and performed TUG test and CRT. The ADL and IADL scales were developed to measure a person's independent functioning in daily life. The ADL scale is based on six levels of self-performance including dressing, eating, mobility in bed, using the toilet, bathing and personal hygiene (Lawton, and Brody 1969, 179-86). The IADL scale is based on eight levels of self-performance including shopping, doing house work, managing finances, preparation of meals, use of transportations, laundering clothes, use of the telephone and managing medications (Lawton, and Brody 1969, 179-86). Cognitive and physical functions were significantly associated with disabilities in ADL and IADL task (Brach et al. 2002, 320-328, Dodge et al. 2005, 222-30). The IADL are more complex, demanding, and requiring a higher level of personal autonomy than the ADL do (Millán-Calenti et al. 2010, 306-310). For the present analysis, a score of zero in the ADL and IADL scales indicated an independent functional status; therefore, a lower ADL score and IADL score indicated less dependent functional performance.

The TUG test is a simple, reliable way to assess mobility and falls risk because it requires balance, gait speed, and functional ability (Carter et al. 2002, 360-368, Podsiadlo, and Richardson 1991, 142). Functional mobility entails motor skills essential for independent living, such as rising from and controlling descent into a seated position, quickly walking a short distance, and changing direction while walking (Lusardi, Pellecchia, and Schulman 2003, 14-22). In this study, the participants were asked to sit down in a armless chair with their back against the chair, then they were asked to stand up and walk a 3-meter distance in their usual gait-speed, turn and walk back to the chair and sit down again (Siggeirsdottir et al. 2002, 609-616). No physical assistance was given during the test. The CRT is a complex test for lower body flexibility and recurrent falls risk requiring lower limb strength, range of motion, balance and endurance (Buatois et al. 2010, 550-560, Lord et al. 2002, M539-M543). The inability to rise from a chair without use of armrests is often used as an indicator of physical frailty (Gill, Williams, and

Tinetti 1995, 603-609). Important contributors to successful chair or bed rise include strength of hip and knee extensors, muscular endurance, and efficient postural responses for control of the center of mass during this transitional activity (Alexander et al. 2000, 526, Alexander, Schultz, and Warwick 1991, M91-M98, Lusardi, Pellecchia, and Schulman 2003, 14-22). In this study, we recorded time to perform five char rises consecutively, but only in participants who successfully completed the first chair-rise. They were asked to rise from a chair five times without armrests as quickly as possible with their arms folded across their chest (Lord et al. 2002, M539-M543). In this study, the fewer seconds it took to complete the TUG and CRT tests as well as the lower ADL and IADL scores indicated a high level of functional performance.

3. Statistical analysis

This study performed statistical analyses on the total population as well as men and women separately because we found significant gender differences in HDL cholesterol level as well as functional performance. For analytical purpose, three groups were created based of HDL cholesterol concentration: <40, 40 to <50, and ≥50 mg/dL. The distributions of continuous variables were described as means with standard deviations and compared using the one-way analysis of variance. Categorical variables were reported as observed numbers and percentages and compared using the chi-square test. A general linear model using contrast coefficients for linear trend analysis was used in continuous variables, and Cochran-Armitage test and Mantel-Haenszel test were used for categorical variables. Multiple linear regression models were performed to assess the independent association between HDL cholesterol and functional performance. Sex, age, body mass index, total cholesterol, diabetes mellitus, systolic blood pressure, smoking status, alcohol consumption, and a past History of Heart disease and/or stroke were considered as covariates in the model. All statistical analyses were performed using SAS software (version 9.2, SAS, Cary, NC, USA), and statistical significance was defined as a two-sided p-value less than 0.05.

III. RESULTS

1. Characteristics of study populations by HDL cholesterol level

General characteristics of male and female populations according to the categories of HDL cholesterol level are presented in Table 1 (men) and Table 2 (women). Serum HDL cholesterol status of study population divided into three groups: <40, 40 to <50, and ≥50 mg/dL. Both in men and women, lower HDL cholesterol concentration group was associated with more obese, higher fasting glucose, total cholesterol and triglycerides, and frequent alcohol consumption. There were no significant differences according to systolic blood pressure, history of depression, stroke, cataract and cancer, and cigarette smoking. Among men (Table 1), individuals with lower HDL cholesterol level were more likely to perform TUG test slower, and had a higher frequency of ADL dependency. However, among women (Table 2), individuals with lower HDL cholesterol level were more likely to have a lower diastolic blood pressure, perform CRT slower, have a lower frequency of previous myocardial infarction, and tended to exercise less regularly, and had a higher frequency of IADL dependency.

Table 1. Characteristics of 648 men by HDL cholesterol level

Variables	Men (n=648)			
	<40 (n=171)	40-49 (n=252)	≥50 (n=225)	*p*
Age (years)	73.0 ± 4.4	72.9 ± 5.2	72.9 ± 4.5	0.954
Height (cm)	164.8 ± 5.1	164.7 ± 5.7	164.8 ± 5.3	0.933
Weight (kg)	67.8 ± 7.8	65.5 ± 9.1	61.9 ± 8.8	**<0.001**
Body mass index (kg/m²)	24.9 ± 2.3	24.1 ± 2.8	22.8 ± 2.9	**<0.001**
Fasting glucose (mg/dl)	97.8 ± 16.2	101.4 ± 24.4	95.6 ± 18.3	**0.008**
Total cholesterol (mg/dl)	160.5 ± 33.1	169.6 ± 32.1	181.9 ± 30.6	**<0.001**
HDL cholesterol (mg/dl)	34.8 ± 3.2	44.6 ± 2.8	59.7 ± 9.6	**<0.001**
Triglycerides (mg/dl)	163.8 ± 91.0	123.5 ± 55.1	102.4 ± 46.0	**<0.001**
SBP (mmHg)	128.5 ± 13.5	130.5 ± 14.6	130.0 ± 15.3	0.372
DBP (mmHg)	72.7 ± 7.7	74.1 ± 8.5	74.3 ± 9.4	0.147
TUG (sec) *	11.1 ± 3.9	10.3 ± 2.3	10.4 ± 2.8	**0.021**
CRT (sec) ‡	10.1 ± 3.3	10.2 ± 3.3	10.3 ± 3.8	0.942
Antihypertensive treatment	97 (15.0)	130 (20.1)	96 (14.8)	**0.005**
Diabetes mellitus	47 (7.3)	74 (11.4)	36 (5.6)	**0.005**
History of Depression	7 (1.1)	8 (1.2)	3 (0.5)	0.091
History of Heart disease	16 (2.5)	27 (4.2)	22 (3.4)	0.922
History of Stroke	11 (1.7)	22 (3.4)	7 (1.1)	0.124
History of Cataract	47 (7.3)	95 (14.7)	75 (11.6)	0.288
History of Cancer	18 (2.8)	21 (3.2)	26 (4.0)	0.664
Current drinker	40 (6.2)	106 (16.4)	102 (15.8)	**<0.001**
Current smoker	29 (4.5)	44 (6.8)	36 (5.6)	0.778
Regular exercise	98 (15.1)	152 (23.5)	129 (19.9)	0.952
Dependent ADL	16 (2.5)	9 (1.4)	6 (0.9)	**0.003**
Dependent IADL	78 (12.0)	111 (17.1)	100 (15.4)	0.832
ADL score	0.15 ± 0.5	0.04 ± 0.2	0.03 ± 0.2	**<0.001**
IADL score	0.58 ± 0.9	0.50 ± 0.7	0.48 ± 0.6	0.350

Data expressed as mean ± standard deviation or number (percent)

Abbreviations: HDL, high density lipoprotein; SBP, systolic blood pressure; DBP, diastolic blood pressure; TUG, timed up and go; CRT, chair-rise test; ADL, activities of daily living; IADL, instrumental activities of daily living;

* The TUG test was performed in only 645 men.
‡ The CRT was performed in only 633 men.

Table 2. Characteristics of 1,375 women by HDL cholesterol level

Variables	Women (n=1,375)			
	<40 (n=187)	40-49 (n=488)	≥50 (n=700)	*p*
Age (years)	72.4 ± 4.8	71.8 ± 4.7	71.4 ± 4.6	**0.016**
Height (cm)	152.6 ± 5.6	152.5 ± 5.6	151.9 ± 5.7	0.135
Weight (kg)	57.9 ± 7.7	57.7 ± 8.0	55.5 ± 8.2	**<0.001**
Body mass index (kg/m²)	24.9 ± 2.9	24.8 ± 3.0	24.0 ± 3.1	**<0.001**
Fasting glucose (mg/dl)	97.3 ± 16.8	97.6 ± 18.1	95.1 ± 15.9	**0.022**
Total cholesterol (mg/dl)	165.8 ± 36.8	183.8 ± 34.0	196.5 ± 35.3	**<0.001**
HDL cholesterol (mg/dl)	35.4 ± 3.4	44.5 ± 2.9	61.1 ± 10.2	**<0.001**
Triglycerides (mg/dl)	173.1 ± 82.4	145.7 ± 64.6	110.7 ± 45.4	**<0.001**
SBP (mmHg)	128.2 ± 15.2	127.6 ± 15.4	128.4 ± 16.5	0.676
DBP (mmHg)	71.6 ± 8.5	72.0 ± 8.2	73.1 ± 8.8	**0.029**
TUG (sec) *	11.1 ± 3.2	11.0 ± 3.2	11.1 ± 5.2	0.915
CRT (sec) ‡	11.8 ± 3.9	11.5 ± 3.8	11.0 ± 4.2	**0.029**
Antihypertensive treatment	116 (8.4)	288 (21.0)	374 (27.2)	**0.014**
Diabetes mellitus	53 (3.9)	108 (7.9)	119 (8.7)	**<0.001**
History of Depression	18 (1.3)	43 (3.1)	50 (3.6)	0.190
History of Heart disease	34 (2.5)	45 (3.3)	54 (3.9)	**<0.001**
History of Stroke	12 (0.9)	17 (1.2)	24 (1.8)	0.126
History of Cataract	83 (6.0)	207 (15.1)	287 (20.9)	0.386
History of Cancer	12 (0.9)	40 (2.9)	56 (4.1)	0.601
Current drinker	8 (0.6)	14 (1.0)	45 (3.3)	**0.034**
Current smoker	3 (0.2)	10 (0.7)	12 (0.9)	0.926
Regular exercise	107 (7.8)	267 (19.4)	443 (32.2)	**0.016**
Dependent ADL	9 (0.7)	18 (1.3)	25 (1.8)	0.499
Dependent IADL	18 (1.3)	29 (2.1)	44 (3.2)	0.225
ADL score	0.07 ± 0.4	0.05 ± 0.3	0.04 ± 0.2	0.382
IADL score	0.18 ± 0.7	0.07 ± 0.3	0.08 ± 0.4	**0.016**

Data expressed as mean ± standard deviation or number (percent)

Abbreviations: HDL, high density lipoprotein; SBP, systolic blood pressure; DBP, diastolic blood pressure; TUG, timed up and go; CRT, chair-rise test; ADL, activities of daily living; IADL, instrumental activities of daily living;

* The TUG test was performed in only 1,372 women.
‡ The CRT was performed in only 1,335 women.

2. Characteristics of study populations

General characteristics are presented for total, male, and female participants in Table 3. The mean age of study population was 72.1 years. Compared with men, women were younger, more obese, had a higher level of total cholesterol and HDL cholesterol, and a lower frequency past history of stroke, and less often consumed alcohol and cigarette significantly. In functional performance tests, there were no significant differences in the ADL scores and the TUG test between men and women. In the IADL scores, women had a significantly better independent functional status than men. However, the CRT performance was significantly better in men compared to women.

Table 3. Characteristics of 2,023 total population

Variables	Total (n=2,023)	Men (n=648)	Women (n=1,375)	*p* for difference
Age (years)	72.1 ± 4.8	72.9 ± 4.8	71.6 ± 4.7	**<0.001**
Height (cm)	156.2 ± 8.1	164.8 ± 5.4	152.2 ± 5.6	**<0.001**
Weight (kg)	59.3 ± 9.2	64.8 ± 9.0	56.6 ± 8.1	**<0.001**
Body mass index (kg/m^2)	24.2 ± 3.0	23.9 ± 2.9	24.4 ± 3.1	**<0.001**
Fasting glucose (mg/dl)	97 ± 18.1	98.4 ± 20.5	96.3 ± 16.9	**0.021**
Total cholesterol (mg/dl)	182.6 ± 36.2	171.5 ± 32.9	187.8 ± 36.5	**<0.001**
HDL cholesterol (mg/dl)	50.3 ± 12.4	47.2 ± 11.6	51.7 ± 12.5	**<0.001**
Triglycerides (mg/dl)	130.1 ± 64.8	126.8 ± 68.2	131.6 ± 63.0	0.130
SBP (mmHg)	128.7 ± 15.5	129.8 ± 14.6	128.1 ± 16.0	**0.018**
DBP (mmHg)	72.9 ± 8.6	73.8 ± 8.6	72.5 ± 8.5	**0.002**
TUG (sec) *	10.9 ± 4.0	10.5 ± 3.0	11.1 ± 4.3	**0.001**
CRT (sec) ‡	10.9 ± 3.9	10.2 ± 3.5	11.3 ± 4.0	**<0.001**
Antihypertensive treatment	1101 (54.4)	323 (16.0)	778 (38.5)	**0.005**
Diabetes mellitus	437 (21.6)	157 (7.8)	280 (13.8)	0.056
History of Depression	129 (6.4)	18 (0.9)	111 (5.5)	**<0.001**
History of Heart disease	198 (9.8)	65 (3.2)	133 (6.6)	0.810
History of Stroke	93 (4.6)	40 (2.0)	53 (2.6)	**0.023**
History of Cataract	173 (8.6)	65 (3.2)	108 (5.3)	0.106
History of Cancer	794 (39.3)	217 (10.7)	577 (28.5)	**<0.001**
Current drinker	315 (15.6)	248 (12.3)	67 (3.3)	**<0.001**
Current smoker	134 (6.6)	109 (5.4)	25 (1.2)	**<0.001**
Regular exercise	1196 (59.1)	379 (18.7)	817 (40.4)	0.698
Dependent ADL	83 (4.1)	31 (1.5)	52 (2.6)	0.283
Dependent IADL	380 (18.8)	289 (14.3)	91 (4.5)	**<0.001**
ADL score	0.05 ± 0.3	0.06 ± 0.3	0.05 ± 0.3	0.226
IADL score	0.23 ± 0.6	0.51 ± 0.7	0.09 ± 0.4	**<0.001**

Data expressed as mean ± standard deviation or number (percent)

Abbreviations: HDL, high density lipoprotein; SBP, systolic blood pressure; DBP, diastolic blood pressure; TUG, timed up and go; CRT, chair-rise test; ADL, activities of daily living; IADL, instrumental activities of daily living;

* The TUG test was performed in only 2,017 subjects (645 men and 1,372 women).
‡ The CRT was performed in only 1,968 subjects (633 men and 1,335 women).

3. Correlations between HDL cholesterol and functional performance

Figure 2 and Figure 3 display the relationship between HDL cholesterol level and functional performance in the total population. Figure 2 showed the association of HDL cholesterol level with the measure of ADL and IADL. According to the ADL scale, those who were more independent had higher HDL cholesterol level than those who were less independent did, and the difference was statistically significant (p=0.010). For the IADL scale, those who were more independent had a significantly higher HDL cholesterol level than those who were less independent did ($p<0.001$).

Figure 3 presented the association of HDL cholesterol level with the measure of TUG and CRT. Having a quicker TUG and CRT were associated with having a higher HDL cholesterol level than having a slower TUG and CRT were, however, this associations were not statistically significant both TUG (p=0.253) and CRT (p=0.114).

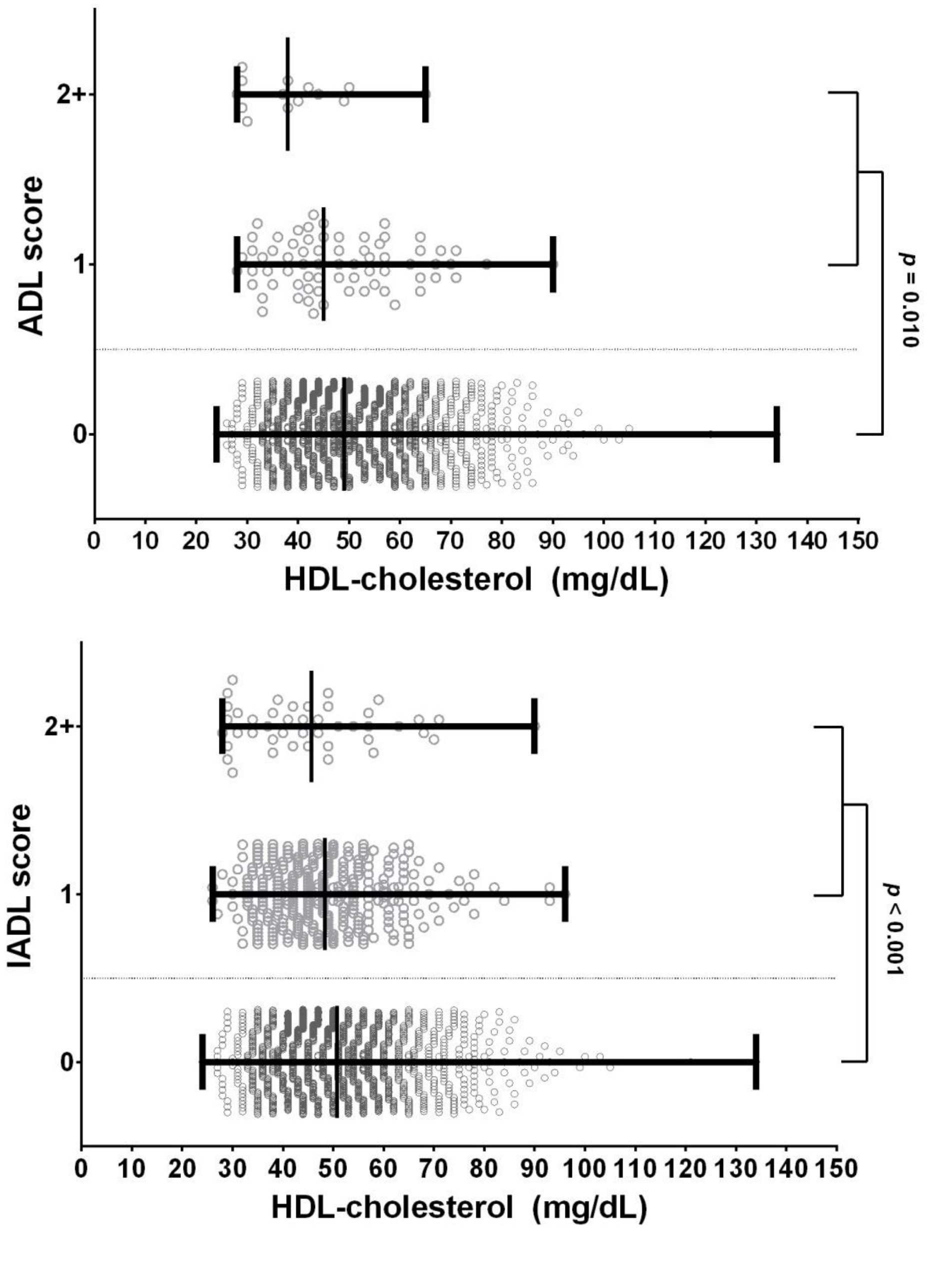

Figure 2. Association of HDL cholesterol level with the measures of ADL and IADL in the total population (n=2,023)

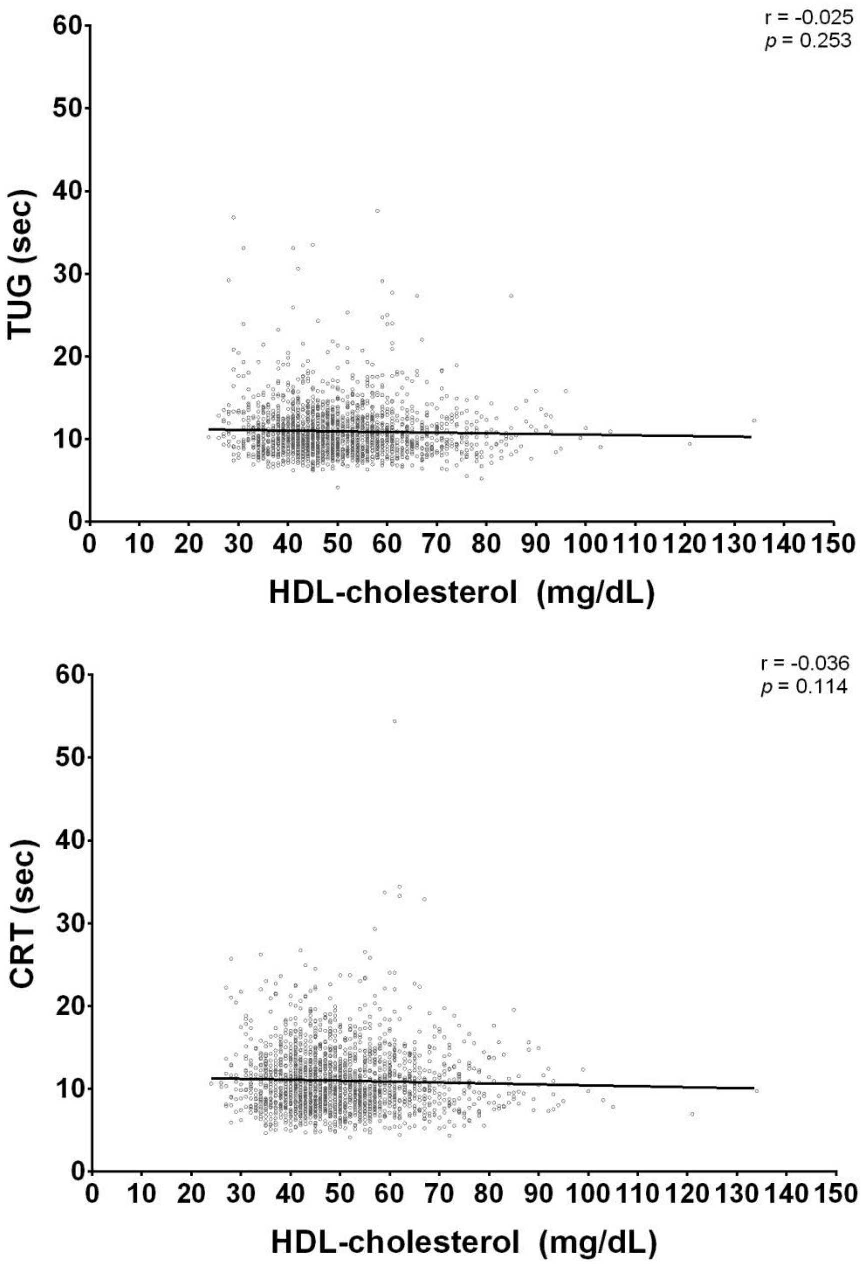

Figure 3. Association of HDL cholesterol level with the measures of TUG (n=2,017) and CRT (n=1,968) in the total population

4. Association between HDL cholesterol and functional performance

Table 4 shows the results of the multiple linear regression analysis on the association between HDL cholesterol level and functional performance. In the total population, HDL cholesterol level was significantly associated with ADL and IADL, but not with the TUG and CRT in the unadjusted model. After adjustment for all covariates, the association remained significant for ADL. Among men, HDL cholesterol was significantly and inversely associated with ADL and TUG before adjustment. After adjustment for all potential confounders, HDL cholesterol was only independently associated with ADL. Among women, HDL cholesterol was significantly and inversely associated with CRT without any covariate adjustment. After adjustment for covariates, this inverse association still remained significant among women for HDL cholesterol and CRT.

As a further analysis, this study developed multiple logistic regression models to investigate associations between categorized HDL cholesterol level, and dependency in ADL (Table 5 and Table 6) and IADL task (Table 7 and Table 8). Men with lower HDL cholesterol (less than 40 mg/dL) were significantly higher odds for having ADL dependency (Table 5), but not for IADL dependency (Table 7). In women lower HDL cholesterol category was not significantly associated with ADL dependency (Table 6) or IADL dependency (Table 8).

Table 4. Regression coefficients for the association between having a higher HDL cholesterol level (5 mg/dL) and functional performance

Measurements of functional performance	Total (n=2,023)		Men (n=648)		Women (n=1,375)	
	β	*p*	β	*p*	β	*p*
ADL (score, 0-6)						
Unadjusted	-0.009	**0.001**	-0.019	**<0.001**	-0.004	0.156
Adjusted for sex* and age	-0.008	**0.002**	-0.019	**<0.001**	-0.003	0.263
Multivariate adjustment†	-0.008	**0.003**	-0.018	**0.002**	-0.004	0.153
IADL (score, 0-8)						
Unadjusted	-0.022	**<0.001**	-0.021	0.086	-0.004	0.400
Adjusted for sex* and age	-0.007	0.142	-0.020	0.086	-0.002	0.640
Multivariate adjustment†	-0.007	0.154	-0.016	0.246	-0.005	0.318
TUG (sec)						
Unadjusted	-0.041	0.253	-0.133	**0.008**	-0.030	0.517
Adjusted for sex* and age	-0.042	0.226	-0.133	**0.005**	-0.003	0.945
Multivariate adjustment†	-0.040	0.288	-0.041	0.439	-0.035	0.467
CRT (sec)						
Unadjusted	-0.056	0.114	-0.038	0.526	-0.115	**0.009**
Adjusted for sex* and age	-0.042	0.226	-0.038	0.499	-0.085	**0.044**
Multivariate adjustment†	-0.062	0.093	0.006	0.929	-0.090	**0.048**

*Sex was adjusted only in total analysis.

†Adjusted for sex (only in total analysis), age, body mass index, total cholesterol, diabetes mellitus, systolic blood pressure, smoking, alcohol consumption, and a past History of Heart disease and/or stroke

Abbreviations: SBP, systolic blood pressure; ADL, activities of daily living; IADL, instrumental activities of daily living; TUG, time up and go; CRT, chair-rise test;

The TUG test was performed in only 2,017 subjects (645 men and 1,372 women). The CRT was performed in only 1,968 subjects (633 men and 1,335 women).

Table 5. Association between HDL cholesterol categories and dependency in ADL scale among men

HDL cholesterol level (mg/dL)	No	Men (n=648)				
		No (%) with dependency	Age-adjusted OR (95% CI) for dependency		Multivariate-adjusted† OR (95% CI) for dependency	
<40	171	16 (9.4)	1.00		1.00	
40-49	252	9 (3.6)	**0.34**	(0.15-0.80)	**0.25**	(0.10-0.64)
≥50	225	6 (2.7)	**0.26**	(0.10-0.69)	**0.22**	(0.07-0.65)
<40	171	16 (9.4)	**3.81**	(1.45-10.00)	**4.58**	(1.54-13.60)
40-49	252	9 (3.6)	1.30	(0.45-3.75)	1.16	(0.38-3.55)
≥50	225	6 (2.7)	1.00		1.00	

†Adjusted for age, body mass index, total cholesterol, diabetes mellitus, systolic blood pressure, smoking, alcohol consumption, and a past History of Heart disease and/or stroke

Table 6. Association between HDL cholesterol categories and dependency in ADL scale among women

HDL cholesterol level (mg/dL)	No	Women (n=1,375) No (%) with dependency	Age-adjusted OR (95% CI) for dependency		Multivariate-adjusted† OR (95% CI) for dependency	
<40	187	9 (4.8)	1.00		1.00	
40-49	488	18 (3.7)	0.83	(0.36-1.90)	0.75	(0.32-1.78)
≥50	700	25 (3.6)	**1.17**	(1.11-1.24)	0.74	(0.31-1.75)
<40	187	9 (4.8)	1.15	(0.52-2.55)	1.35	(0.57-3.19)
40-49	488	18 (3.7)	0.95	(0.51-1.78)	1.01	(0.53-1.94)
≥50	700	25 (3.6)	1.00		1.00	

†Adjusted for age, body mass index, total cholesterol, diabetes mellitus, systolic blood pressure, smoking, alcohol consumption, and a past History of Heart disease and/or stroke

Table 7. Association between HDL cholesterol categories and dependency in IADL scale among men

HDL cholesterol level (mg/dL)	No	Men (n=648)				
		No (%) with dependency	Age-adjusted OR (95% CI) for dependency		Multivariate-adjusted† OR (95% CI) for dependency	
<40	171	78 (45.6)	1.00		1.00	
40-49	252	111 (44.0)	0.95	(0.64-1.41)	0.91	(0.60-1.37)
≥50	225	100 (44.4)	0.96	(0.64-1.44)	0.92	(0.59-1.44)
<40	171	78 (45.6)	1.04	(0.69-1.56)	1.09	(0.69-1.71)
40-49	252	111 (44.0)	0.98	(0.68-1.42)	0.99	(0.67-1.45)
≥50	225	100 (44.4)	1.00		1.00	

†Adjusted for age, body mass index, total cholesterol, diabetes mellitus, systolic blood pressure, smoking, alcohol consumption, and a past History of Heart disease and/or stroke

Table 8. Association between HDL cholesterol categories and dependency in IADL scale among women

HDL cholesterol level (mg/dL)	No	Women (n=1,375)				
		No (%) with dependency	Age-adjusted OR (95% CI) for dependency		Multivariate-adjusted† OR (95% CI) for dependency	
<40	187	18 (9.6)	1.00		1.00	
40-49	488	29 (5.9)	0.63	(0.34-1.19)	0.61	(0.32-1.18)
≥50	700	44 (6.3)	0.73	(0.40-1.31)	0.68	(0.36-1.29)
<40	187	18 (9.6)	1.38	(0.76-2.48)	1.47	(0.78-2.78)
40-49	488	29 (5.9)	0.87	(0.53-1.20)	0.90	(0.54-1.50)
≥50	700	44 (6.3)	1.00		1.00	

†Adjusted for age, body mass index, total cholesterol, diabetes mellitus, systolic blood pressure, smoking, alcohol consumption, and a past History of Heart disease and/or stroke

IV. DISCUSSION

1. *Summary of findings*

The current study investigated the association between serum HDL cholesterol level and multiple functional performance measures in a Korean elderly population. This study found that older men with higher HDL cholesterol level showed better functional performance in ADL scale, and older women with higher HDL cholesterol level did better performance in CRT, even after adjusting for potential confounders. However, IADL score was not associated with HDL cholesterol level either in men or women. Performance in TUG test was associated with HDL cholesterol level among men, but the association was not independent from other covariates.

2. *Comparison with previous studies*

In general, women have been more likely to report limitations, use of assistance, and a greater degree of disability, particularly among IADL categories, than men have been because women required more help than men did with reaching and gripping (Murtagh, and Hubert 2004, 1406). However, in this study, women were generally more independent in their ADL and IADL than men were. A previous study have found that women tend to perform worse than men do in the three tests of functional capacity balance, walking, and chair-rise (Orfila et al. 2006, 2367-2380). Similarly, the mean times for women to perform the repeated CRT were significantly longer than they were for men in a Brazilian older adults study (Barbosa et al. 2005, 1177-1185). Our study also found that men have a greater functional capacity to perform the TUG and CRT than women did.

Recently, several studies have suggested that HDL cholesterol may be inversely associated with the onset of frailty in the older people (Atzmon et al. 2002, M712-M715, Formiga et al. 2012, 449-53, Landi et al. 2007, 514-520, Landi et al. 2007, 71-78, Van Exel et al. 2002, 716-721). One previous study reported that those with higher HDL cholesterol level had better ADL and IADL than those with lower HDL cholesterol level did, this relationship was significant after adjustment for covariates (Formiga et al. 2012, 449-53). Among people aged 80 years or older, higher HDL cholesterol level was associated with better physical function and survival (Landi et al. 2007, 514-520, Landi et al. 2007, 71-78), and lower HDL cholesterol level was associated with cognitive impairment and likelihood of being diagnosed with dementia (Van Exel et al. 2002, 716-721). Our findings confirm those of previous studies that have reported higher HDL cholesterol is associated with better functional performance.

However, there are important differences between this study and the previous studies investigating the role of HDL cholesterol level on functional performance.

Most of the previous studies did not investigate whether gender-specific associations existed in their study populations. However, our results differed significantly for men and women. Moreover, most previous studies have looked at the association of HDL cholesterol and functional performance among Western populations (Atzmon et al. 2002, M712-M715, Formiga et al. 2012, 449-53, Landi et al. 2007, 514-520, Landi et al. 2007, 71-78, Singh-Manoux et al. 2008, 1556-1562, Van Exel et al. 2002, 716-721); therefore, this study adds novel data on this relationship among the Asian older population.

3. Possible mechanisms

There are several possible mechanisms that may explain the association between HDL cholesterol and functional performance. First, HDL cholesterol is atheroprotective through its reverse cholesterol transport and provides anti-inflammatory, antithrombotic, and endothelial cell repair effects (Badimon, and Vilahur 2012, 18-32). Therefore, having low HDL cholesterol level predisposes people to atherosclerotic disease and stroke, peripheral vascular disease, lower-extremity amputation, and loss of kidney function (Jang et al. 2013, 316-28, Toth 2005, e89-e91). In addition, HDL cholesterol level was inversely associated with non-vascular outcomes such as chronic obstructive pulmonary disease, cancer, and mortality (Burke et al. 2001, 254-262).

Second, HDL cholesterol is probably related to cognitive function, which appears to be important for maintaining functional status in older people (Robertson, Savva, and Kenny 2013, 840-851). HDL cholesterol, predominant lipoprotein in the human brain, may prevent the formation of amyloid-beta in senile plaques constitutes one of the defining hallmarks of Alzheimer's disease (Olesen, and Dagø 2000, 62-66). The interaction of amyloid-beta with HDL cholesterol, mainly in association with apolipoprotein-J, is not only related transport of the peptide in circulation but also blood-to-brain permeability (Koudinov et al. 1994, 1164-1171). It may also be possible that decreased HDL cholesterol level in the central nervous system linked with a risk factor for the development of neurodegeneration (Michikawa 2003, 141-146). In a group of middle-aged adults, low HDL cholesterol level was associated with poor memory in cross-sectional analysis, and decline in HDL cholesterol was associated with declines in memory function in longitudinal analysis over 5 years follow-up (Singh-Manoux et al. 2008, 1556-1562). In older people study, HDL cholesterol level was positively and significantly associated with higher cognitive function (Atzmon et al. 2002, M712-M715).

Third, another possible explanation for this relationship could be health behaviors. Those with higher HDL cholesterol level are more likely to have a healthy lifestyle than those with lower HDL cholesterol are (Toth 2005, e89-e91). In this study, both in men and women with higher HDL cholesterol group consumed alcohol more frequently, and women with higher HDL cholesterol group performed exercise more regularly. In our analysis, adjustment for potential lifestyle-related confounders did not greatly change the association between HDL cholesterol and functional performance. However, this study could not exclude the potential impact of lifestyle factors in the association.

4. Limitations

This study has some limitations to be discussed. First, this study was a cross-sectional design in which all data was collected at the same period of time. Given the study design, temporal relationship between HDL cholesterol and functional performance could not be clarified. Second, although this study controlled for numerous potential confounders in our statistical models, residual confounding effects may remain. Finally, this study population may not represent the entire Korean older population, because they were recruited from one urban community and another rural community. Our study participants might be healthier, because they could complete questionnaire interviews and functional tests.

V. CONCLUSION

The present study reports that higher HDL cholesterol level was associated with better functional performance among our community-dwelling elderly population in Korea. In men, higher HDL cholesterol level was independently associated with lower score at ADL. In women, higher HDL cholesterol level was independently associated with fewer seconds at CRT.

Serum HDL cholesterol level may be a predictor of functional decline and frailty among the older adults, and gender may influence this relationship. Further longitudinal analyses are required to understand the possible roles of HDL cholesterol in maintaining and improving functional performance among older adults.

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ABSTRACT (KOREAN)

'한국 노년 인구에서 고밀도 지질단백질 콜레스테롤과 기능수행평가 결과와의 관련성'

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연구 배경 및 목적:

최근 노년 인구에서 고밀도지질단백질 콜레스테롤이 심혈관질환의 예방인자로 작용할 뿐만 아니라, 기능수행평가 결과를 향상시킨다는 연구가 보고되고 있다. 그러나 한국 노년 인구를 대상으로 이의 관련성에 대해 수행한 연구는 아직까지 보고되지 않았다. 본 연구의 목적은 한국의 지역사회 거주 노년 인구를 대상으로 고밀도지질단백질 콜레스테롤 농도와 기능수행평가 결과와의 독립적인 관련성을 평가하는 것이다.

연구 방법:

본 연구는 지역사회기반 전향적 코호트인 Korean Urban Rural Elderly (KURE) study 의 일부로, 2012 년과 2013 년에 연구 참여에 동의하고 기반조사를 마친 65 세 이상의 성인을 대상으로 시행되었다.

고밀도지질단백질 콜레스테롤 농도는 공복 혈액에서 측정되었고, 연속형 변수와 범주형 변수로 나누어 분석하였다. 기능수행평가는 activities of daily living (ADL), instrumental activities of daily living (IADL), timed up-and-go (TUG) test, chair rise test (CRT)의 네 가지 평가방법 이용하여 측정하였다. 혼란변수로는 성, 연령, 체질량지수, 당뇨병, 수축기혈압, 흡연상태, 음주상태, 심장질환과 뇌졸중의 과거력 등을 보정하였다.

연구 결과:

남자에서는 연령을 보정했을 때 고밀도지질단백질 콜레스테롤이 ADL(β=-0.019, p<0.001)과 TUG test(β=-0.133, p=0.005)와는 통계적으로 유의한 관련성이 있었지만, IADL(β=-0.020, p=0.086)과 CRT(β=-0.038, p=0.499)와는 통계적으로 유의한 관련성을 보이지 않았다. 체질량지수, 당뇨병, 수축기혈압, 흡연상태, 음주상태, 심장질환과 뇌졸중의 과거력을

추가적으로 보정한 모델에서는 ADL (β=-0.018, *p*=0.002)에서만 독립적인 관련성이 있었다.

여자에서는 모든 혼란변수를 보정하였을 때 고밀도지질단백질 콜레스테롤과 CRT(β=-0.090, *p*=0.048)는 독립적인 관련성이 있었다. 하지만 혼란변수를 보정하기 전과 후 모두 ADL(β=-0.004, *p*=0.153), IADL(β=-0.005, *p*=0.318), TUG test(β=-0.035, *p*=0.467)와는 통계적으로 유의한 관련성을 보이지 않았다.

고찰:

본 연구에서의 지역사회 거주 한국 노년 인구에서는 높은 고밀도지질단백질 콜레스테롤을 가진 사람이 그렇지 않은 사람에 비해 더 나은 기능수행평가 결과를 나타내는 것으로 나타났으며, 성에 따라 고밀도지질단백질 콜레스테롤과 기능수행평가 결과는 차이가 있었다. 특히 고밀도지질단백질 콜레스테롤이 남자에서는 ADL 과, 여자에서는 CRT 와 독립적인 관련성이 있었다. 혈중 고밀도지질단백질 콜레스테롤 농도와 기능수행평가 결과의 인과적인 관계에 대한 평가를 위해서는 추후 전향적인 연구가 뒷받침 되어야 할 것이다.

핵심단어: 고밀도지질단백질 콜레스테롤, 기능수행, 신체기능, 노년 인구