Metabolic Syndrome and Cardio-Cerebrovascular Risk Disparities Between Pilots and Aircraft Mechanics

Myeong-Bo Kim; Hyun-Jin Kim; Soo-Hyeon Kim; Suk-Ho Lee; Se-Ho Lee; Won-Ju Park

INTRODUCTION: In the Republic of Korea Air Force, the health of pilots is strictly supervised, but there is comparatively not enough interest in aircraft mechanics' health. Among mechanics, who are heavily involved in military aircraft maintenance, the occurrence of sudden cardio-cerebrovascular diseases (CCVDs) is a possible risk factor during the maintenance process, which should be performed perfectly.

METHODS: We performed health examinations on 2123 male aircraft pilots and 1271 aircraft mechanics over 30 yr of age and determined the prevalence of metabolic syndrome (MetS), an important risk factor for CCVDs.

RESULTS: The prevalence of MetS in the aircraft mechanics (21.3%) was significantly higher than in the pilots (12.6%), and the gap in prevalence tended to grow as age increased. Among aircraft mechanics in their 30s and 40s, the prevalence of MetS was lower than in the general population. However, the prevalence of MetS among aircraft mechanics in their 50s (36.0%) was similar to that in the general population (35.7%).

CONCLUSIONS: Systematic health management is needed for aircraft mechanics for aviation safety and for the maintenance of military strength via the prevention of CCVDs.

KEYWORDS: health promotion, health status disparities, military personnel.

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Metabolic syndrome (MetS), a state of insulin resistance, is a syndrome that is accompanied by abdominal obesity, lipidosis, impaired glucose tolerance, and high blood pressure.[5] MetS is a multiplex risk factor for cardiovascular and cerebrovascular disease.[6] Cardiovascular disease was the second leading cause of death in Korea in 2014.[9] The third leading cause was cerebrovascular disease.[15] According to the Korean National Health and Nutrition Examination Survey, the prevalence of MetS significantly increased from 24.9 to 31.3% between 1998 and 2007.[17]

For high-performance aircraft operation, the physical health of pilots is very important. In the Air Force medical unit, the health of pilots is managed systematically by professional medical staff with strict standards. For aviation safety, the physical health of aircraft mechanics is important, too. Among mechanics, who are heavily involved in military aircraft maintenance, the occurrence of sudden cardio-cerebrovascular diseases (CCVDs) is a possible risk factor during the maintenance process, which should be performed perfectly. This study was intended to determine the prevalence of MetS in pilots and aircraft mechanics, and to ascertain the necessity of health promotion programs for aircraft mechanics, in whom researchers have shown less interest than in pilots in the Republic of Korea Air Force (ROKAF).

METHODS

In the ROKAF, pilots must have a strict aviation medical examination every year to keep their pilot qualification and aircraft mechanics must take a special health examination every year in accordance with the Korea Occupational Health and Safety Act.

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All of the health examinations are conducted in the Aerospace Medical Center, ROKAF. From January 2013 to November 2013, we performed a cross-sectional study of 2155 male pilots and 1338 male aircraft mechanics over 30 yr of age who came to the Aerospace Medical Center, ROKAF, for their health examinations. From these, we excluded 32 pilots and 67 aircraft mechanics whose inquiry information and test results were missing and selected 2123 pilots and 1271 aircraft mechanics as the final subjects.

The subjects were asked about their alcohol consumption, smoking, past medical history, and exercise habits through a structured questionnaire. Information about their height, weight, waist circumference, and blood pressure were collected by physical measurements and blood tests. A drinker was defined as an individual who drinks more than 20 grams of alcohol more than once a week. Exercise was defined as performing regular exercise for greater than 30 min per day more than twice a week. Blood pressure was measured with an electronic sphygmomanometer under stable conditions. The blood tests measured their fasting blood glucose, triglycerides, and high-density lipoprotein cholesterol after 12 h of fasting. MetS was diagnosed by the Asian guidelines from the National Cholesterol Education Program Adult Treatment Panel III when the results met three or more of these five metabolic disorder criteria: 1) waist circumference $\geq$ 90 cm in men; 2) triglycerides $\geq$ 150 mg $\cdot$ dL^{-1} or drug treatment for hyperlipidemia; 3) high-density lipoprotein cholesterol $<$ 40 mg $\cdot$ dL^{-1} in men; 4) systolic blood pressure $\geq$ 130 mmHg, diastolic blood pressure $\geq$ 85 mmHg or drug treatment for hypertension; or 5) fasting blood glucose $\geq$ 100 mg $\cdot$ dL^{-1} or drug treatment for diabetes mellitus.[10,18]

The Pearson's Chi-squared test, Student *t*-test, and analysis of variance (ANOVA) were used for the analysis of general characteristics, physical measurements, MetS, and laboratory test findings of these subjects. The odds ratio and 95% confidence intervals (CI) for the prevalence of MetS with job types and age were calculated by multiple logistic regression analysis. SPSS version 23.0 was used to analyze the data (SPSS Inc, Chicago, IL). Statistical significance was defined as $P < 0.05$. The study protocol was approved by the Institutional Review Boards of Medical Division Headquarters, ROKAF (ASMC-14-IRB-002). In addition, each subject provided written, informed consent before participating.

RESULTS

The mean ages of the groups were 41.4 $\pm$ 7.2 and 38.6 $\pm$ 7.1 yr, and age was significantly higher in the aircraft mechanics [$t(3,392) = -11.094$, $P < 0.001$]. The aircraft mechanics showed lower values for height [$t(3,392) = 8.652$, $P < 0.001$] and high-density lipoprotein cholesterol [$t(3,392) = 9.233$, $P < 0.001$] than the pilots and higher values for weight [$t(3,392) = -2.666$, $P < 0.001$], waist circumference [$t(3,392) = -4.622$, $P < 0.001$], systolic blood pressure [$t(3,392) = -7.090$, $P < 0.001$], diastolic blood pressure [$t(3,392) = 5.171$, $P < 0.001$], fasting blood glucose [$t(3,392) = -5.972$, $P < 0.001$], and triglycerides [$t(3,392) = -6.559$, $P < 0.001$]. These differences were statistically significant ($P < 0.001$). The prevalence of current smokers was significantly higher in the aircraft mechanics than in the pilots ($\chi^2 = 66.934$, df = 1, $P < 0.001$). The differences in the prevalence of regular drinkers ($\chi^2 = 0.133$, df = 1, $P = 0.723$) and exercise habits ($\chi^2 = 0.065$, df = 1, $P = 0.826$) were not statistically significant (**Table I**). The prevalence of MetS was 12.6% among pilots and 21.3% among aircraft mechanics (**Table II**). The prevalence of MetS was higher when the age ($\chi^2 = 74.0603$, df = 1, $P < 0.001$) increased or when the subjects drank ($\chi^2 = 4.070$, df = 1, $P = 0.048$) or smoked ($\chi^2 = 98.290$, df = 1, $P < 0.001$), whereas it was significantly lower when they did regular exercise ($\chi^2 = 10.668$, df = 1, $P = 0.001$) (**Table III**).

The odds ratio of the aircraft mechanics' prevalence of MetS to the pilots', without adjustment, was 1.88 (95% CI: 1.565–2.268); with only age adjustment, 1.66 (95% CI: 1.369–2.001); and with age and lifestyle factors adjustment, 1.49 (95% CI: 1.224–1.804), and were significantly

Table I. General Characteristics of the Subjects.

VARIABLES	PILOTS (*N* = 2123)	AIRCRAFT MECHANICS (*N* = 1271)	*P*-VALUE*
Age group			< 0.001
30–39	1324 (62.4)	558 (43.9)	
40–49	584 (27.5)	516 (40.6)	
50–59	215 (10.1)	197 (15.5)	
Age (yr)	38.6 ± 7.1	41.4 ± 7.2	< 0.001
Height (cm)	173.9 ± 5.0	172.3 ± 5.4	< 0.001
Weight (kg)	73.9 ± 8.4	74.8 ± 9.4	< 0.001
BMI (kg $\cdot$ m^{-2})	24.4 ± 2.4	25.2 ± 2.7	< 0.001
WC (cm)	85.5 ± 6.9	86.6 ± 7.3	< 0.001
SBP (mmHg)	122.1 ± 9.5	124.7 ± 10.8	< 0.001
DBP (mmHg)	74.0 ± 7.1	75.6 ± 9.6	< 0.001
FBG (mg $\cdot$ dL^{-1})	94.0 ± 10.9	97.2 ± 16.8	< 0.001
Triglyceride (mg $\cdot$ dL^{-1})	124.5 ± 81.8	150.5 ± 126.2	< 0.001
HDL-cholesterol (mg $\cdot$ dL^{-1})	52.2 ± 11.1	48.7 ± 10.0	< 0.001
Current smoking			< 0.001
Yes	515 (24.3)	476 (37.5)	
No	1608 (75.7)	795 (62.5)	
Regular drinking			0.723
Yes	607 (28.6)	356 (28.0)	
No	1516 (71.4)	915 (72.0)	
Regular exercise			0.826
Yes	791 (37.3)	468 (36.8)	
No	1332 (62.7)	803 (63.2)	

Data represent number (%), arithmetic mean ± SD, or *P*-value. BMI = body mass index; WC = waist circumference; SBP = systolic blood pressure; DBP = diastolic blood pressure; FBG = fasting blood glucose; HDL = high density lipoprotein.
* Comparison by Student *t*-test, analysis of variance (ANOVA), or Pearson Chi-squared test.

Table II. Prevalence of Metabolic Syndrome and Its Components in Pilots and Aircraft Mechanics According to National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III) Asian Guidelines.

	PILOTS (*N* = 2123)		AIRCRAFT MECHANICS (*N* = 1271)		
VARIABLES	**NUMBER**	**%**	**NUMBER**	**%**	***P*-VALUE***
Central obesity	512	24.1	362	28.5	0.005
Hyperglycemia	521	24.5	417	32.8	< 0.001
Hypertension	597	28.1	436	34.3	< 0.001
Hypertriglyceride	505	23.8	452	35.6	< 0.001
Low HDL-cholesterol	207	9.8	233	18.3	< 0.001
Metabolic syndrome	267	12.6	271	21.3	< 0.001

* Comparison by Pearson Chi-squared test. HDL = high density lipoprotein.

high (**Table IV**). After the subjects were stratified by 10-yr intervals, when the prevalence of MetS was compared between the pilots and aircraft mechanics, the gap in the prevalence tended to grow as age increased. The age-adjusted odds ratio of MetS was 1.33 (95% CI: 0.975–1.800) for those in their 30s, 1.60 (95% CI: 1.164–2.209) for those in their 40s, 1.66 (95% CI: 1.024–2.700) for those in their 50s and beyond, and it significantly grew as their age increased (Mantel-Haenszel χ^2 test, $\chi^2 = 29.374$, df = 1, $P < 0.001$) (**Fig. 1**).

DISCUSSION

Aircraft accidents occur for several reasons, such as human errors, aircraft maintenance, weather, and technical mission-related causes.[20] Statistics vary, but aircraft accident investigators and researchers commonly report that approximately 70–80% of all aviation mishaps (and near-mishaps) involve human factors.[4] Over 60% of all aircraft accidents worldwide are caused by pilots.[20] Although much less frequent today than previously reported, mechanical failures occasionally do occur in flight.[19] Aeromedical studies of human factors have focused on the pilot and pilot error rather than on aircraft maintenance workers and maintenance error.[16] Health problems in aircraft mechanics could potentially impair job performance. Because aviation safety management cannot involve any risk factors, the physical health maintenance of aircraft mechanics is important.

Table III. Prevalence of Metabolic Syndrome by Age and Life Style Components.

	NON-METABOLIC SYNDROME (*N* = 2856)		METABOLIC SYNDROME (*N* = 538)		
VARIABLES	**NUMBER**	**%**	**NUMBER**	**%**	***P*-VALUE***
Age group					< 0.001
30–39	1663	88.4	219	11.6	
40–49	895	81.4	205	18.6	
50–59	298	72.3	114	27.7	
Current smoking					< 0.001
Yes	738	74.5	253	25.5	
No	2118	88.1	285	11.9	
Regular drinking					0.048
Yes	791	82.1	172	17.9	
No	2065	84.9	366	15.1	
Regular exercise					0.001
Yes	1093	86.8	166	13.2	
No	1763	82.6	372	17.4	

* Comparison by Pearson Chi-squared test.

An existing study showed the prevalence of MetS in Air Force pilots was ~9.9–28.5%.[3,8,12,13] In this study, the prevalence of MetS in ROKAF male pilots was 12.6%, similar to or lower than the prevalence of MetS in Air Force pilots in other countries. Also, in this study, there was a possibility that the prevalence of MetS in the pilots, who were qualified as Air Force pilots and actively fulfilled their flight duty, may have been lower. Actually, the prevalence of MetS in ROKAF pilots who fulfilled their active flight duty was lower than what this study showed (9.9%).[13] However, the pilots, being qualified, may be required to perform their duties at any given time, depending on the situation. Therefore, this study has an advantage over the existing studies because we selected all male pilots qualified in the ROKAF as subjects.

As expected, the prevalence of MetS in the aircraft mechanics was significantly higher than in the pilots; this gap tended to grow as age increased. The early difference was due to selection bias, where healthy subjects were chosen during the pilot selection process. The growing gap in the risk of MetS as the age gap between the two groups increased was owing to the healthy worker survivor effect, where unhealthy pilots were excluded from aviation. Socioeconomic factors, such as education and income, are likely to have influenced this growing gap. For other reasons, the health management program for aircraft mechanics is insufficient compared to the one for pilots. In the ROKAF, health management programs, such as those encouraging nonsmoking, moderation in drinking, proper weight management, and prevention of lifestyle diseases, are organized for pilots by each flight unit. There are many flight surgeons and special nurses for the health management of pilots. However, there are very few special personnel and health promotion programs for aircraft mechanics. In this study, among aircraft mechanics in their 30s and 40s, the prevalence of MetS was lower than that in the general population. However, the prevalence of MetS among aircraft mechanics in their 50s was higher than that in the general population, which can be grounds for supporting health promotion (**Fig. 2**).[14] Therefore, it is necessary to provide special personnel dedicated to the health management of aircraft mechanics and to run compulsory training and management programs on nonsmoking, moderation in drinking, proper weight management, and prevention of lifestyle diseases.

Table IV. Odds Ratio for Metabolic Syndrome Between Pilots and Aircraft Mechanics.

	ODDS RATIO	95% CI
Unadjusted		
Pilot	1.000	
Aircraft mechanic	1.884	1.565-2.268
Model 1*		
Pilot	1.000	
Aircraft mechanic	1.656	1.369-2.001
Model 2**		
Pilot	1.000	
Aircraft mechanic	1.486	1.224-1.804

CI = confidence interval.
* Adjusted for age.
** Adjusted for age and lifestyle factors (drinking, smoking, and exercise).

MetS confers a fivefold increase in the risk of type 2 diabetes mellitus and a twofold risk of developing cardiovascular disease over the next 5 to 10 yr.[1] Furthermore, patients with MetS are at a two- to fourfold increased risk of stroke, a three- to fourfold increased risk of myocardial infarction, and twofold the risk of dying from such an event compared with those without MetS, regardless of a previous history of cardiovascular events.[2,7,11] Aircraft mechanics, due to occupational characteristics, become technically proficient as their age increases. For mechanics, who take heavy responsibility for aircraft maintenance, the sudden occurrence of CCVDs may cause unpredictable aviation safety situations and become a risk factor that affects the strength of the Air Force. For aviation safety, systematic health management programs need to be introduced for aircraft mechanics in the Air Force. Through these programs, we can expect improved personal health by decreasing MetS and prevention of unexpected reductions in the Air Force's military power and decreases in socioeconomic costs.

As expected, the prevalence of MetS among aircraft mechanics was significantly higher than in pilots, and the gap tended to grow significantly as age increased. The prevalence of MetS among aircraft mechanics in their 30s and 40s was lower than in the general population, but the difference disappeared when aircraft mechanics in their 50s were studied. For aviation safety and maintenance of the Air Force's strength by prevention of CCVDs, systematic health management is needed for aircraft mechanics as well as pilots.

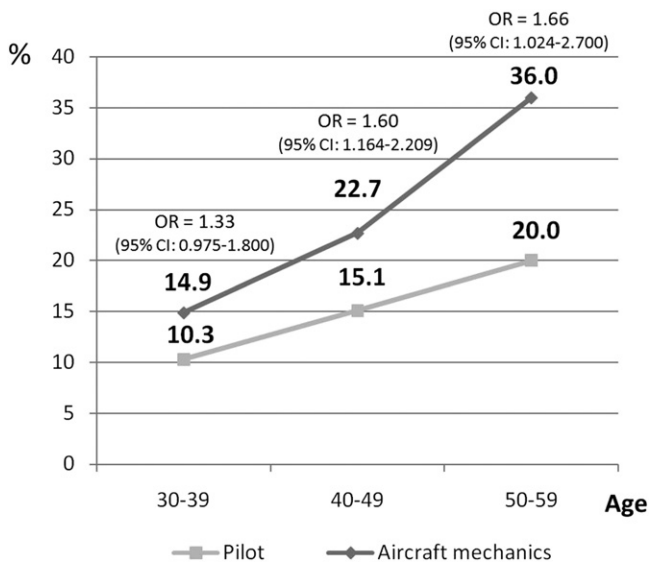

Fig. 1. Comparison of metabolic syndrome prevalence between pilots and aircraft mechanics by age.

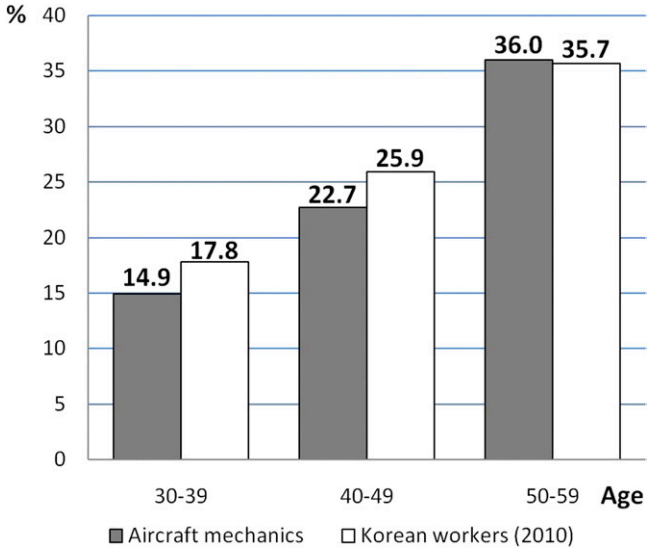

Fig. 2. Comparison of metabolic syndrome prevalence between aircraft mechanics and Korean workers by age.

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