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Original Article

Trends in Body Mass Index and Associations With Physical Activity Among Career Soldiers in South Korea

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Objective: This study was designed to describe the trends in body mass index (BMI) during 6 years (2002-2008) and to identify associations between these trends and the amount of physical activity of South Korean career soldiers.
Method: This study targeted the 40 993 (38 857 men and 2136 women) of the 58 657 career soldiers who had undergone four (2002, 2004, 2006, and 2008) biennial medical examinations conducted by the National Health Insurance Corporation; 17 664 soldiers with missing data on height, weight, and physical activity were excluded. A linear mixed-regression model was used to categorize changes in BMI due to age versus those due to amount of physical activity.
Results: Career soldiers experienced significant increases in BMI compared with baseline data gathered in 2002. The increases in each age group were as follows: men aged 20-29: 1.16, men aged 30-39: 0.61, men aged 40-49: 0.05, women aged 20-29: 0.35, women aged 30-39: 0.30, women aged 40-49: 0.26, and women aged 50-59: 0.21. However, men aged 50 or older showed significant decreases (as high as 0.5) in BMI compared with baseline data obtained in 2002. They also experienced significant decreases in BMI compared with those who reported no physical activity. The differences between baseline and final BMIs were: 0.02 for men exercising 1-2 times per week, -0.07 for men exercising 3-4 times per week, -0.19 for men exercising 5-6 times per week, -0.21 for men exercising seven times per week, -0.05 for women exercising 1-2 times per week, -0.19 for women exercising 3-4 times per week, -0.30 for women exercising 5-6 times per week, and -0.30 for women exercising seven times per week.
Conclusions: Obesity in South Korean career soldiers increased markedly between 2002 and 2008, and our data showed that the amount of physical activity was inversely related to increases in BMI. Policies to prevent obesity are needed to reduce this trend.

Key words: Obesity, BMI, Trend, Career soldier, Physical activity, Exercise
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INTRODUCTION

As South Korea's economic status has rapidly improved, its diet and various environmental factors such as transportation and housing have evolved in a way that has decreased the need for physical activity, leading to an increase in the prevalence of obesity [1]. As a result, diseases such as cancer, diabetes, hypertension, and cardiovascular disorders are also more widespread. The socioeconomic cost related to these diseases was 1.8715 trillion won in 2003, and it has been estimated that about 0.6212 trillion won was directly attributable to obesity [2]. Additionally, obesity-related mortality has also been increasing [3].

According to the Korea National Health and Nutrition Examination Survey (KNHANES) conducted in 2008 among those 19 years of age or older, the prevalence of all types of obesity (body mass index [BMI] ≥25) was 25.1% among Korean men and 26.2% among Korean women in 1998. However, the rate of obesity increased to 36.2% among men in 2007 and showed only a very slight decrease to 35.3% in 2008. The prevalence of obesity among women increased to 27.4% in 2001, but decreased to 25.2% in 2008 [1]. US standards, however, define BMIs of 25-29 as overweight and those of 30 or greater as obese. The prevalence of all types of obesity (BMI ≥25) among Korean men was lower than the prevalence of overweight status, 72.3% (confidence interval [CI], 70.4 to 74.1), plus that of obesity, 32.2% (CI, 29.5 to 35.0), among American men 20 years of age and older according to the 2007-2008 KNHANES. The prevalence of all types of obesity in female Koreans was also lower than the prevalence of overweight status, 64.1% (CI, 61.3 to 66.9), plus that of obesity, 35.5% (CI, 33.2 to 37.7), among American women [4].

Data for 1997-2007 from the Korean National Health Insurance Corporation's (NHIC) health examination showed that the rates of obesity among men and women

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were 21.6% and 17.2%, respectively, in 1997. However, the proportion of low-weight and normal-weight adults decreased, whereas that of overweight and obese people increased during the subsequent 10 years. In 2007, the prevalence of obesity increased to 33.4% and 23.6% in men and women, respectively, with a notably greater increase in men [5].

As shown above, the prevalence of obesity among men is obviously increasing, and that of women differs among studies. However, most previous studies involved general populations rather than specific occupational groups such as career soldiers, who serve in the military for periods of time longer than the compulsory period of service and live an organized life that includes regular exercise and training. Thus, career soldiers are often excluded from obesity research. Additionally, career soldiers live apart from their family, which leads to irregular meals, frequent dinner engagements related to their duties, and work shifts that last from morning to night-factors that expose them to a high risk of obesity [6].

According to the Ministry of National Defense (MND) analysis of the 2006 Korean NHIC study, 27.7% of career soldiers aged 19-59 were overweight (BMI 23-24.9), and 38.2% were obese (BMI $\geq$25) [7]. A survey of American soldiers older than 19 years of age that used US standards showed that the proportion of overweight individuals (BMI 25-29.9) increased from 51.2% in 1995 to 62% in 2008 and that of obese individuals (BMI $\geq$30) increased from 5.1% to 13% during the same period [8]. Given that Korea is the only geographically isolated nation in the world that is facing the enemy directly and therefore maintains a standing army of over 600 000 soldiers, the resemblance between the prevalence of obesity among officers and non-commissioned officers (NCOs) and that of civilians and foreign armies constitutes a serious problem. However, no understanding of the current situation exists because no research on the prevalence and causes of obesity among career soldiers exists. Thus, the government cannot develop and implement an active and systematic response to the problem of obesity.

Because obesity is influenced by social, cultural, psychological, and biological factors, investigation of the major causes of this problem remains complex [9]. Ordinarily, however, it is thought that an individual who exercises regularly is less likely to gain weight than is an individual who does not. However, even studies about the relationship between increased physical exercise and weight loss have been conducted only during a short time period or within a small sample. Additionally, most prospective studies have not considered individual differences such as occupation, food intake, or lifestyle. Therefore, current recommendations about the amount of physical activity required to avoid weight gain are subject to limitations [10].

Most career soldiers in South Korea live under harsh conditions and according to a strict schedule. Because they have a paying job, they may be considered to be less affected by external factors, to be economically stable, and to be similar to those in other occupational groups. Additionally, because they engage in regular training and exercise they may constitute the optimal sample for an examination of the relationship between the amount of physical activity and weight [11]. Thus, this study investigated trends in the BMI of South Korean career soldiers and the association between BMI and amount of physical activity.

METHODS

I. Resources

Historically, officers and NCOs, excluding private soldiers, have received physical examinations conducted by the NHIC once every 2 years; since 2007, this population has been categorized as blue-collar workers and has received these examinations annually [12]. Although the examination data are managed by the NHIC, which is not a military institution, the data remain subject to severe restrictions with respect to access and analysis. Indeed, only data showing the annual prevalence of diseases are made available, which strictly limits research on the database. Through the cooperation of the MND and the NHIC, the author received data from self-administrated questionnaires and categorical health examinations conducted from 2002 to 2008 after the NHIC assumed the task in 2001. Due to privacy considerations, personal data were excluded, and numbers were used for purposes of identification. These data reflect unusually high response rates because health examinations serve as prerequisites for promotion among career soldiers; thus, 82.95% of career soldiers were examined in 2002, 85.76% in 2004, 84.54% in 2006, and 90.76% in 2008 [13-16]. Moreover, due to the standardization of the process, including the medical examinations, confidence in the data is very high. An additional advantage of this dataset is the status of the sample as a large cohort given that the examinations have been conducted among the same group over the course of 6 years.

II. Research Subjects

The subjects in this study consisted of officers and NCOs aged 20-59 who received health examinations conducted by the NHIC. However, because no specific code distinguished career from short-term soldiers, the 58 657 (males: 55 890, females: 2767) soldiers who received the four health examinations every 2 years during the 6 years between 2002 to 2008 were defined as career soldiers. We excluded the 17 664 soldiers whose height, weight, and amount of physical activity were not clearly specified, yielding a final sample of 40 993 (males: 38 857, females: 2136).

III. Defining the Variables

The variables included in this study were year of examination, sex, age, amount of physical activity, and height and weight measured during the physical examinations. The amount of physical activity was measured by a self-administrated question: "How frequently do you work out each week to the point that you start sweating?" Answers included "never," "1-2 times," "3-4 times", "5-6 times," and "almost every day." Height and weight were measured in cm and kg without decimals by a skilled nurse while the subject was wearing light clothing without shoes. BMI was calculated by dividing the weight by the squared height in meters (kg/m^2). The WHO Asian-Pacific obesity standards, which classify BMIs lower than 18.5 kg/m^2 as "low weight", those between 18.5 and 22.9 kg/m^2 as "normal weight," those between 23 and 24.9 kg/m^2 as "overweight," those between 25 and 29.9 kg/m^2 as "obese I," and those over 30 kg/m^2 as "obese II", were used [17].

IV. Research Method

The unit of analysis used in this study was the individual, the level of statistical significance was set at 0.05, and SAS version 9.1 (SAS Inc., Cary, NC, USA) was used for statistical analyses. Associations between BMI and year of examination, sex, age, and amount of physical activity were analyzed by *t*-tests and *chi*-square tests. A linear test of the categorical variables that were measured on an ordinal scale was conducted to compare the BMI values between variables. The average value of each variable each year was measured, and the differences between the averages of variables were assessed by paired *t*-tests (Table 1). To measure the distribution of BMI in each age group according to time differences, excluding the effect of age, the age at each examination was simplified into the age at the first examination, and the distribution of BMI in each year was measured. A *chi*-square test was used to measure the differences between BMI categories according to year (Table 2). To show annual overall changes in BMI between 2002 and 2008, yearly BMI categories and changes are given as percentages (Table 3).

To construct a longitudinal model that could detect overall BMI changes according to the results of regular examinations, we used a repeated-measures regression approach (PROC MIXED SAS, Mixed-effects Model). This technique changed the structure of the data from a multivariate structure of BMI per examination year to a univariate structure of examination year and BMI [18]. The age at each examination was standardized to the age at first examination, which adjusted for BMI changes attributable to aging. Because the data were gathered at regular intervals, the order of the data could not be randomized; for this reason, we used the REPEATED statement in SAS. Additionally, although the TYPE=TOEP model was appropriate because of the strong tendency for measurements of the same subject taken close in time to be more highly associated than measurements taken farther apart in time and because the period between examinations was regular (2 years), the model suitability test, which compared AIC, AICc, and BIC values, showed that the TYPE=UN model had the smallest value, so it was selected as the model for the final analysis [19]. The changes in BMI due to time leading to the adjustment in age, the interaction between time and age, the amount of physical activity, and age are reported with a 95% confidence interval (Table 4). The AIC, AICc, and BIC measured by the TYPE=UN and the TYPE=TOEP models were similar.

The primary model regressed the BMI at each examination (the dependent variables) on the year of examination, amount of physical activity, age at first examination, and interaction between year of examination and age at first examination.

Algebraically, the regression equation for BMI was as follows:

$$BMI(t) = \alpha + \tau_t + P_i + \beta \times Age + \gamma_t \times Age + e$$

(t = 1, 2, 3, 4 i = 1, 2, 3, 4, 5)
α : intercept
t : year of examination (1 = 2002, 2 = 2004, 3 = 2006, 4 = 2008)

i : frequency of exercising per week (1 = 0, 2 = 1 - 2, 3 = 3 - 4, 4 = 5 - 6, 5 = 7)
τ_t : the effect of time at point t
P_i : change in BMI due to the frequency of exercise
β : change in BMI due to baseline age
γ_t : change in BMI due to the interaction of year of examination and baseline age
e: individual error
BMI: body mass index.

τ_t shows the period effect on BMI, reflecting the rate of change in the BMI at point t, considering both age and frequency of exercise. β represents the BMI change related to year of examination and exercise frequency, which reflects the change in BMI from the age at first examination. γ_t shows the effect of period on change due to age. P_i shows the change in BMI due to the frequency of exercise.

The average BMI per year and for each age group, adjusted for age at first examination, amount of physical activity, and interaction between age at first examination and year of examination, was calculated by using the LSMEANS statement, and the changes in averages between 2002 and 2008 were calculated by the ESTIMATE statement (Table 5).

The difference between in the repeated-measures regression and the general linear model is the covariance, which supposes that each individual is independent and that the errors among measures for an individual at different points in time are correlated. The covariance matrix of TYPE=TOEP and TYPE=UN in this study are shown below.

$$Var(\varepsilon) = Var\begin{bmatrix}\varepsilon_1\\ \varepsilon_2\\ \varepsilon_3\\ \varepsilon_4\end{bmatrix} = \begin{bmatrix}\sigma_{11}^2 & \sigma_{12} & \sigma_{13} & \sigma_{14}\\ \sigma_{21} & \sigma_{22}^2 & \sigma_{23} & \sigma_{24}\\ \sigma_{31} & \sigma_{32} & \sigma_{33}^2 & \sigma_{34}\\ \sigma_{41} & \sigma_{42} & \sigma_{43} & \sigma_{44}^2\end{bmatrix} \qquad Var(\varepsilon) = Var\begin{bmatrix}\varepsilon_1\\ \varepsilon_2\\ \varepsilon_3\\ \varepsilon_4\end{bmatrix} = \begin{bmatrix}\sigma^2 & \sigma_1 & \sigma_2 & \sigma_3\\ \sigma_1 & \sigma^2 & \sigma_1 & \sigma_2\\ \sigma_2 & \sigma_1 & \sigma^2 & \sigma_1\\ \sigma_3 & \sigma_2 & \sigma_1 & \sigma^2\end{bmatrix}$$

RESULTS

The average age of males and females in 2002 was 34.0 and 34.8, respectively. The average weight (mean ± standard deviation [SD] kg) increased by 2.1 ± 4.7 kg in men and by 0.9 ± 4.3 kg in women during 2002-2008. Between 28.3 and 31.1% of men and between 4.5 and 6.3% of women exercised more than three times per week. The average BMI (mean ± SD kg/m²) increased by 0.7 ± 1.6 kg/m² and 0.3 ± 1.8 kg/m² in men and women, respectively, during the 6 years of the study, showing that this change was greater in men than in women (Table 1).

To adjust for increases in BMI due to aging and to observe the effect of period, each individual' s age was calibrated to the age at first examination. These data showed that the BMI increased in all age group among men and that the increase was largest among those in their 20s followed by those in their 30s and 40s. Although the increase in women was smaller than that in men, an increase in BMI could also be seen in all age groups. This increase was greatest among women in their 20s, followed by those in their 30s, 40s, and 50s (Table 2).

The annual data on obesity between 2002 and 2008 show that among men, the low-weight and normal-weight groups decreased by 0.26% and 8.7%, respectively, whereas the overweight, obese I, and obese II groups

Table 1. Characteristics of South Korean career soldiers according to NHIC data: 2002-2008

	Follow-up year	Men (n = 38 857)			Women (n = 2136)		
		Mean	SD	%	Mean	SD	%
Age (y)	2002	34.0	8.1		34.8	7.6	
Weight (kg)	2002	71.1	8.8		55.6	7.2	
	2004	71.9	9.1		55.8	7.2	
	2006	72.7	9.2		56.1	7.2	
	2008	73.2	9.3		56.4	7.3	
Frequency of physical activity (times per wk)	2002	2.0	1.7		1.1	1.6	
	2004	2.1	1.8		1.2	1.7	
	2006	1.9	1.7		1.2	1.7	
	2008	2.1	1.7		1.3	1.8	
Proportion of physical activity more than three times per week (%)	2002			28.39			4.54
	2004			30.09			4.91
	2006			27.47			5.15
	2008			31.11			6.23
BMI (kg/m²)	2002	24.1	2.7		21.9	2.7	
	2004	24.3	2.7		22.0	2.7	
	2006	24.6	2.7		22.1	2.6	
	2008	24.7	2.7		22.2	2.7	

NHIC: National Health Insurance Corporation, BMI: body mass index, SD: standard deviation.

Table 2. Changes in average BMI by age and sex among South Korean career soldiers: 2002-2008

Sex	Age	N	%	2002		2004		2006		2008	
				Mean	SD	Mean	SD	Mean	SD	Mean	SD
Men (n=38857)	20-29	14576	37.51	23.5	2.7	24.0	2.9	24.5	2.9	24.7	3.0
	30-39	13183	33.93	24.3	2.7	24.5	2.7	24.7	2.7	24.8	2.7
	40-49	10111	26.02	24.5	2.5	24.5	2.5	24.6	2.5	24.7	2.5
	50-59	987	2.54	24.3	2.5	24.3	2.4	24.4	2.4	24.3	2.4
Women (n=2136)	20-29	640	29.96	21.3	2.5	21.4	2.6	21.5	2.6	21.6	2.6
	30-39	836	39.14	21.7	2.6	21.8	2.6	22.0	2.6	22.1	2.6
	40-49	582	27.25	22.6	2.6	22.7	2.5	22.7	2.5	22.9	2.6
	50-59	78	3.65	24.2	3.2	24.3	3.3	24.2	3.2	24.3	3.3

BMI: body mass index, SD: standard deviation.

Table 3. Changes in distributions among BMI categories by sex among career soldiers: 2002-2008

n (%)

Sex	BMI	2002 (A)	2004	2006	2008 (B)	% change (B-A)
Men (n=38857)	Underweight (< 18.5)	339 (0.87)	320 (0.82)	235 (0.60)	238 (0.61)	-0.26
	Normal (18.5-22.9)	13603 (35.01)	12205 (31.41)	10842 (27.90)	10152 (26.31)	-8.70
	Overweight (23-24.9)	11391 (29.32)	11510 (29.62)	11468 (29.51)	11404 (29.35)	0.03
	Obese I (25-29.9)	12702 (32.69)	13764 (35.42)	15046 (38.72)	15641 (40.25)	7.56
	Obesity II (≥30)	822 (2.11)	1058 (2.72)	1266 (3.26)	1422 (3.66)	1.55
Women (n=2136)	Underweight (< 18.5)	151 (7.07)	146 (6.84)	133 (6.23)	112 (5.24)	-1.83
	Normal (18.5-22.9)	1367 (64.00)	1342 (62.83)	1322 (61.89)	1297 (60.72)	-3.28
	Overweight (23-24.9)	365 (17.09)	382 (17.88)	389 (18.21)	443 (20.74)	3.65
	Obese I (25-29.9)	229 (10.72)	246 (11.52)	273 (12.78)	253 (11.84)	1.12
	Obese II (≥30)	24 (1.13)	20 (0.94)	19 (0.89)	31 (1.45)	0.32

Table 4. Trends (b) in physical activity[a] and time-age interactions[b] from linear mixed model: 2002-2008

	Men (n=38 857)				Women (n=2136)			
	b	95% CI		Pr > |t|	b	95% CI		Pr > |t|
		Lower bound	Upper bound			Lower bound	Upper bound	
Intercept	22.33	22.21	22.44	<0.01	18.73	18.21	19.25	<0.01
Examination time								
2002 vs. 2004	1.06	1.00	1.12	<0.01	0.20	-0.11	0.50	0.20
2002 vs. 2006	2.01	1.94	2.07	<0.01	0.44	0.11	0.77	<0.01
2002 vs. 2008	2.55	2.48	2.61	<0.01	0.47	0.12	0.81	<0.01
Frequency of physical activity per week								
0 vs. 1-2	0.02	0.03	0.03	0.02	-0.05	-0.16	0.02	0.18
0 vs. 3-4	-0.07	-0.08	-0.05	<0.01	-0.19	-0.29	-0.10	<0.01
0 vs. 5-6	-0.19	-0.22	-0.15	<0.01	-0.30	-0.48	-0.11	<0.01
0 vs. 7	-0.21	-0.24	-0.18	<0.01	-0.30	-0.49	-0.12	<0.01
Examination time-baseline age interaction								
2002 vs. 2004	-0.02	-0.03	-0.02	<0.01	0.00	-0.01	0.01	0.42
2002 vs. 2006	-0.04	-0.05	-0.04	<0.01	-0.01	-0.02	0.00	0.12
2002 vs. 2008	-0.06	-0.06	-0.05	<0.01	0.00	-0.01	0.01	0.35
Baseline age	0.05	0.05	0.06	<0.01	0.09	0.08	0.11	<0.01

CI: confidence interval, a: kg/m² per 2 calendar years, b: kg/m² per year of age increase.

increased by 0.03%, 7.56%, and 1.55%, respectively. Among women, the low-weight and normal-weight groups decreased by 1.83% and 3.28%, respectively, whereas the overweight, obese I, and obese II groups increased by 3.65%, 1.12%, and 0.32%, respectively. The decreases in the proportion of normal-weight males and females were small, and the increases in the proportions of obese I males and overweight females were the most significant (Table 3).

The repeated-measures regression showed increases of 1.06 kg/m² in 2004, 2.01 kg/m² in 2006, and 2.55 kg/m² in 2008 compared with the BMI values in 2002. The increases were smaller in women, in whom BMI values increased by 0.44 kg/m² in 2006 and by 0.47 kg/m² in 2008 compared with values in 2002.

Those who exercised 1-2 times per week showed an increase in BMI of 0.02 kg/m² compared with those not exercising at all, but those exercising 3-4, 5-6, and 7

Table 5. Actual and estimated changes in BMI adjusted by relevant variables among career soldiers: 2002-2008

Sex	Age	2002	2004	2006	2008	Estimates of change during 6 years	95% CI		Pr > |t|
							Lower bound	Upper bound	
Men (n = 38857)	20 - 29	23.54	24.01	24.45	24.70	1.16	1.14	1.18	<0.01
	30 - 39	24.05	24.29	24.53	24.66	0.61	0.60	0.62	<0.01
	40 - 49	24.57	24.57	24.61	24.63	0.05	0.03	0.08	<0.01
	50 - 59	25.09	24.85	24.69	24.59	-0.50	-0.54	-0.46	<0.01
Women (n = 2136)	20 - 29	20.90	21.01	21.15	21.25	0.35	0.23	0.47	<0.01
	30 - 39	21.83	21.90	22.01	22.13	0.30	0.23	0.38	<0.01
	40 - 49	22.76	22.80	22.87	23.02	0.26	0.13	0.38	<0.01
	50 - 59	23.69	23.70	23.73	23.91	0.21	0.00	0.42	0.05

times per week showed decreases in BMI of 0.07 kg/m^2, 0.16 kg/m^2, and 0.21 kg/m^2, respectively. The effect of physical activity was more rapid and pronounced in women, whose BMIs decreased by 0.05 kg/m^2, 0.19 kg/m^2, 0.30 kg/m^2, and 0.49 kg/m^2 for those who exercised 1-2, 3-4, 5-6, and 7 times per week, respectively.

The changes in BMI related to the interaction between year of examination and age at first examination decreased in men between 2002 and 2004, 2006, and 2008 (by 0.02 kg/m^2, 0.04 kg/m^2, and 0.06 kg/m^2, respectively), but these changes were not significant in women.

The increase in BMI according to age at first examination was 0.05 kg/m^2 in women and 0.09 kg/m^2 in men, reflecting a larger increase in males than in females (Table 4).

As shown in Table 4, the mean BMI increased in both men and women between 2002 and 2008. However, the interaction between year of examination and age at first examination and other variables were not adjusted for, and exact changes in BMI should be measured after these factors are adjusted for. The changes in BMI among men after adjustment for the interaction between year of examination and age at first examination, amount of physical activity, and age at first examination during the 6 years between 2002 to 2008 were 1.16 kg/m^2 among those in their 20s, 0.61 kg/m^2 among those in their 30s, 0.05 kg/m^2 among those their 40s, and -0.50 kg/m^2 among those in their 50s. The corresponding changes in BMI in women were 0.35 kg/m^2 among those in their 20s, 0.30 kg/m^2 among those their 30s, 0.26 kg/m^2 among those in their 40s, and 0.21 kg/m^2 among those their 50s; the results for women in their 50s did not reach significance (Table 5).

DISCUSSION

By examining the trends in BMI among South Korean career soldiers, this study highlighted the seriousness of the problem of obesity among career soldiers and thereby underscored the importance of immediately preparing an plan to remediate this problem. The study showed the need for intervention by the MND and tri-service headquarters.

This study showed the following changes in BMI during the 6 years between 2002 and 2008. The mean BMI of men in their 20s increased by 1.16 kg/m^2; it increased by 0.61 kg/m^2 among those in their 30s and by 0.05 kg/m^2 among those in their 40s; it decreased by 0.50 kg/m^2 among those in their 50s. The mean BMI of women in their 20s increased by 0.35 kg/m^2; it increased by 0.30 kg/m^2 among those in their 30s and by 0.26 kg/m^2 among in those in their 40s. With the exception of men in their 50s, the BMI of all age groups in both sexes increased during the period covered by this study. It is noteworthy that the increase in BMI among those between 20 and 49 years of age was highest among those in their 20s, whereas the BMI of those in their 50s decreased; this constitutes is a significant contrast to the corresponding values among civilians. The finding that the overweight or obese status of those between 20 and 39 years of age, low-level officers who constitute the majority of career soldiers, becomes more serious as a function of age may point to the major factor causing the overall increase in BMI. In this context, obesity prevention programs focused on low-level officers in their 20s may constitute the most effective approach to this problem.

It is difficult to explain why BMI decreased among high-level officers in their 50s, but it is possible that this phenomenon relates to the age at which military personnel retire. Unlike other government employees who retire when they reach an age limit, career soldiers retire according to limits on years of service combined with considerations of rank. Soldiers are discharged from the service when they reach one of three retirement criteria [20]. Of the three retirement criteria, career soldiers are most affected by rules about maximum ages, which differ according to rank. If career soldiers above the level of lieutenant colonel are not promoted to the next rank between the ages of 53 and 63, more than 50% are discharged from the military at each promotion opportunity. Given this pyramid-like structure, the decrease in BMI among career soldiers older than 50 years of age can be interpreted as the "healthy worker effect." This phenomenon may also be due to their increased socioeconomic status within the military, which enables them to exercise more frequently and reduce their work load. Unlike the case with men, the BMI of women in every age group increased as a function of age. Although women are also affected by the healthy worker effect, the hormonal changes accompanying pregnancy and menopause also contribute significantly to increases in BMI [21].

According to the 2008 KNHANES, the prevalence of obesity among men in the general population was 37.9% (19-59 years: 20s, 31%; 30s, 39.3%; 40s, 40.1%; and 50s, 40.2%) and that among women in the general population was 20.6% (19-59 years: 20s, 13.6%; 30s, 15.6%; 40s, 27.2%; and 50s, 37.8%). However, the results of the 2008 physical examinations conducted by the NHIC showed that the prevalence of obesity among male career soldiers was 43.91% (19-59 years: 20s, 38.63%; 30s, 44.66%; 40s, 45.39%; and 50s, 41.52%) and that among female career soldiers was 13.29% (19-59 years: 20s, 18.39%; 30s. 18.38%; 40s, 13.07%; and 50s, 26.52%). These data indicate that the prevalence of obesity among male career soldiers of all ages was higher than that among men in the general population. Similarly, the prevalence of obesity was higher among career female soldiers than among women in the general population in their 20s and 30s, but this pattern was reversed among women in their 40s and 50s. It is possible that career soldiers who exercise on a regular basis have more muscle than non-military males and that the failure of the BMI to distinguish between muscle and fat led to this result. However, research conducted on English soldiers that examined whether BMI was a reliable method for measuring populations such as athletes, police officers, and soldiers, who have a higher proportion of muscle than do ordinary people, showed a substantial relationship between BMI and waist circumference [22]. Although BMI does not directly indicate the amount of body fat, the correlation between BMI and body fat was 0.7-0.8, which shows that using BMI to measure obesity among a population that exercises regularly can yield reliable results [23]. However, researchers should consider measuring both waist circumferences and body fat in physical examinations to avoid involvement in this controversy.

Normally, BMI increases as people age, but more exercise is associated with decreases in BMI. However, people tend to exercise less as they age, and the BMI increase due to aging is usually larger than the BMI decrease due to exercise. On the surface, it appears that the BMI of older individuals increases but that the effect of exercise cannot be predicted because aging is a confounding factor. This pattern is reflected in the results of this research, which found that exercising more than three times per week was associated with decreased BMI in both men and women (males: -0.07 kg/m^2, females: -0.19 kg/m^2), and this decrease was greater than the increase in BMI related to aging (males: 0.05 kg/m^2, females: 0.09 kg/m^2). Thus, in 2007, the American Heart Association recommended that, at minimum, adults aged 18-65 should exercise at a moderate rate for 30 minutes five times a week or at an intense rate for 20 minutes three times a week to maintain a healthy lifestyle. Additionally, more exercise is required to prevent weight gain; moderate exercise for 10 minutes per day, such as by walking, has cumulative effects. This may represent a minimum criterion met by career soldiers who engage in physical activity on a daily basis [9]. This result is relevant to other findings suggesting that an adult should exercise at least three times per week [24] as well as to foreign studies that have analyzed the relationship between exercise and body fat or motor ability and BMI among career soldiers [25-27]. It should also be noted that when men and women engaged in the same exercise, the decrease in BMI was more rapid and greater among women.

The data collected during the physical examinations of military officers and NCOs from 2002 to 2008 showed that BMI gradually increased in every age group, except among individuals in their 50s. Policies to prevent increases in BMI are essential, but the most effective approach to increasing BMIs among military personnel involves increasing the amount of physical activity. The MND or tri-service headquarters should consider imposing measures to prevent obesity on all military officers and NCOs to produce an effect in a relatively short time. For example, the frequency with which physical strength is examined could be increased. Currently, this examination is conducted only once per year; an increase to twice per year (once every 6 months) would increase the amount of physical activity. The development of an environment that encourages exercising three times per week would be the most effective way to decrease BMI without extra cost. Additionally, career soldiers who are already obese should participate in mandatory obesity-related programs or attend a facility for the treatment of obesity. Indeed, since the mid-1980s, obese soldiers in the US have been mandated to participate in weight-control programs. If the individual fails to reach the criterion weight within 6 months, he or she is discharged from the military [28]. Potential participants in this program are initially identified as those who weigh more than the standard weight for their height and age; their body fat is then measured, and those whose body fat exceeds the standard rate are selected for the program, which consists of exercise, nutrition consultations, and medical testing [29]. As a result of this program, the overweight population within the military increased to 61.6% in 2005, whereas the obese population decreased to 12.4%, reaching the goal of "*Healthy People 2010*," which was 15% [30,31].

This research was limited by calibrating the age of subjects to their age at their first examination and by calculating changes in BMI according to the time intervals between examinations and the associated age differences. However, people age as time passes; as a follow-up study, our results would certainly reflect the aging process, irrespective of specific methodology. Additionally, because this research was conducted only among career soldiers, our results may have limited applicability to other occupational groups and may have limited generalizability among ranks, units, and military branches. We also did not have access to data on socioeconomic status, region of service, and type of job within the military. Given that socioeconomic status within the military is directly related to rank, rank constitutes an essential variable; however the absence of data on the rank of each individual precluded in-depth research in this regard. Compared with people in other occupations, career soldiers are subject to frequent moves, which vary according to their duties. This characteristic of military life is significantly related to individual behaviors such as amount of physical activity. The results of this study clearly showed that the amount of physical activity experienced by career soldiers during a 6-year time period was irregular and frequently changed substantially between examinations. However, we were unable to analyze this issue because information on the military unit and geographic region of each individual was not available. As noted about, the absence of information on membership in military branches restricted our investigation of differences between combat and combat-support branches. The question about the amount of physical activity asked only about how frequently the person exercised until the point of sweating, which prevented exact identification of the intensity and duration of exercise, rendering distinguishing between occupational physical activities and exercise during leisure time difficult and precluding more detailed research on the amount of physical activity [32].

Given these limitations, this research used data from the physical examinations of South Korean career soldiers accumulated during 2002-2008 to show that the BMI of members of every age group, except that consisting of individuals in their 50s, increased over time and that exercising at least three times per week was associated with decreased BMI.

In summary, the mean BMI of male career soldiers increased when they were in their 20s to 40s and was higher in the younger age group; the mean BMI of those in their 50s decreased. The increase was smaller among female than male career soldiers but was found in every age group, although the increase grew smaller as a function of age. Exercising at least three times per week was associated with decreased BMI, and greater decreases were associated with increased physical activity.

Our result suggests that the prevalence of obesity among career soldiers will increase if the trend toward increasing BMI continues. Hence, efforts to reverse this trend should not be confined to increasing the amount of exercise but should also include studies regarding other related factors. These data should contribute to plans to promote the health and improve the combat ability of career soldiers.

CONFLICT OF INTEREST

The authors have no conflicts of interest with the material presented in this paper.

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