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Factors Associated with Metabolic Abnormalities in None-Obese and Obese Postmenopausal Women

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비(非)비만 및 비만 폐경 여성의 대사이상 관련 요인

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Abstract This study aimed to identify factors associated with metabolic abnormalities in non-obese and obese postmenopausal women based on biopsychosocial model. Secondary data analysis was conducted using data from 5,335 postmenopausal women who participated in the Korean National Health and Nutrition Examination Survey (2015-2021). According to logistic analysis with applying a complex simple analysis in SPSS 26.0, biomedical (increased age; a family history of hypertension, type 2 diabetes, dyslipidemia, and cardiovascular diseases) and biosocial factors (low educational level) were associated with 1-2 metabolic abnormalities and metabolic syndrome, regardless of adiposity. Additionally, low familial socioeconomic status and prolonged sedentary behaviors were the biosocial and psychosocial factors associated with metabolic syndrome regardless of adiposity. Finally, insufficient physical activity was associated with metabolic syndrome in obese postmenopausal women. Based on these results, tailored strategies should be developed considering the significant factors associated with metabolic abnormalities and adiposity in postmenopausal women.

Key Words : Metabolic syndrome, Adiposity, Postmenopause, Women, Biopsychosocial model

요 약 본 연구의 목적은 생물심리사회 모델을 기반으로 비(非)비만 및 비만 폐경 여성의 대사이상과 관련된 요인을 확인하는 것이다. 국민건강영양조사(2015~2021)에 참여한 우리나라 폐경 여성 5,335명의 통계 자료를 이용해 이차 자료분석을 실시하였다. 폐경 여성의 비만도와 대상이상의 수준을 고려하여, 다음의 4개 그룹으로 구분하였다. 1) 비(非)비만이며 1-2개 대사이상 요인을 갖고 있는 그룹, 2) 비(非)비만이며 대사증후군(3-5개 대사이상 요인)을 갖고 있는 그룹, 3) 비만이며 1-2개 대사이상 요인을 갖고 있는 그룹, 4) 비만이며 대사증후군을 갖고 있는 그룹. 통계분석을 위해 SPSS 26.0 프로그램의 복합표본 로지스틱 회귀분석을 이용하여 각 그룹 별 생물학적, 심리적, 사회적 관련요인을 탐색하였다. 본 연구 결과, 비만도와 무관하게 생물의학적 요인(연령 증가, 고혈압, 제2형 당뇨병, 이상지질혈증, 및 심혈관 질환 가족력)과 생물사회적 요인(낮은 교육수준)이 1-2개의 대사이상 및 대사증후군과 관련이 있었다. 또한 비만도와 무관하게 생물사회적 요인인 가계의 낮은 사회경제적 수준과 심리사회적 요인인 장시간의 좌식행동이 대사증후군과 관련이 있었다. 불충분한 신체 활동은 비만 폐경기 여성의 대사증후군과 관련이 있었다. 본 연구의 결과를 바탕으로 폐경 여성의 비만도와 대사이상과 관련된 다양한 요인을 고려한 맞춤형 전략 개발의 필요성을 제언한다. 이를 통해 폐경 여성의 비만도에 따라 수정 가능한 요인(좌식 행동 및 신체 활동)을 조기에 식별하고 중재할 수 있을 것이다.

키워드 : 대사증후군, 비만도, 폐경, 여성, 생물심리사회 모델

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1. Introduction

Postmenopausal women experience symptoms associated with decreased ovarian function [1]. Particularly, due to decreased estradiol levels, postmenopausal women seem to have increased metabolic abnormalities including abdominal obesity, high blood pressure, and impaired lipid metabolism and glucose tolerance, which are components of metabolic syndrome (MS) [2]. The prevalence of MS among postmenopausal women exhibits notable variation across different countries and ethnicities, with estimates ranging from 32% to 58%. This rate significantly exceeds that observed in premenopausal women [3]. Additionally, among individuals in the middle-aged and older adults, women exhibited a higher prevalence of MS compared to men of similar age groups, predominantly attributed to the onset of menopause [4]. Furthermore, metabolic abnormalities, including MS, result in various complications such as cardiovascular diseases (CVDs) and cancers (e.g., breast, colorectal, and endometrial cancers) in postmenopausal women [5-7]. Thus, postmenopausal women may be vulnerable group with high risk for metabolic abnormalities and their complications. In these contexts, the early prevention and management of metabolic abnormalities are important for health promotion in postmenopausal women.

Regardless of adiposity, metabolic abnormalities might develop in non-obese and obese individuals due to aging, unhealthy lifestyle, and positive energy balance [8]. Additionally, in normal-weight and obese postmenopausal women, MS is associated with an increased likelihood of CVDs [5]. Additionally, in both normal-weight and obese individuals, more than two metabolic abnormalities are associated with increased CVD mortality compared to less than one metabolic abnormality [9]. Further, in both non-obese and obese postmenopausal women, MS and more than one or two metabolic abnormalities are associated with an increased likelihood of breast or colon cancer [10-12]. Thus, Kikuchi et al.[13] emphasized the prevention of metabolic abnormalities in both non-obese and obese individuals. Many metabolic courses and adaptive processes differ according to adiposity [14]. Adiposity controls metabolic risk factors (lifestyle behaviors) in metabolic health [15]. Thus, the factors associated with metabolic abnormalities might differ according to the adiposity of individuals (non-obese and obese). The identification of factors associated with metabolic abnormalities (1–2 metabolic abnormalities and MS of 3–5 metabolic abnormalities) in non-obese and obese postmenopausal women is required to develop prevention strategies focused on modifiable factors.

The development of metabolic abnormalities and obesity entails genetic, social, and lifestyle factors. Thus, there has been an emphasis on the necessity for frameworks to comprehend these multivariate factors [16]. In this connection, Hoffman and Driscoll [16] proposed a biopsychosocial model to identify factors associated with metabolic abnormalities, including biomedical (biological processes and genetics), biosocial (sex, education, and socioeconomic status), and psychosocial (emotional status and health-related behaviors) factors. According to a literature review, the biomedical factors age; family history of hypertension, type 2 diabetes, dyslipidemia, CVDs; and breastfeeding experience are associated with metabolic abnormalities [17-19]. The biosocial factors educational level; socioeconomic status of family; and employment status are associated with metabolic abnormalities [20,21]. Finally, stress, depression, skipping breakfast, eating out, smoking status, current binge alcohol consumption, physical activity, sedentary behavior, and sleep duration are the psychosocial factors associated metabolic abnormalities [18, 22-27]. This study aimed to identify the factors associated with metabolic abnormalities (1–2 metabolic abnormalities and MS of 3–5 metabolic abnormalities) in non-obese and obese Korean postmenopausal women based on a biopsychosocial model.

2. Materials and Methods

2.1 Study design and sample population

This cross-sectional study was a secondary data analysis study using the 2015-2021 Korean National Health and Nutrition Examination Survey (KNHNES). Among the 28,171 Korean women who participated in the survey, 17,535 were aged over 40 years. Among them, 11,328 women experienced menopause. The majority of Korean women experience natural menopause after 40 [28]. Thus, among postmenopausal women over 40, the data from 5,335 women with metabolic abnormalities (1,765 non-obese women, 3,570 obese women) who responded to a questionnaire and underwent a physical examination were analyzed. A total of 5,993 premenopausal women and women who did not respond to the questionnaire, undergo the examination, or have not metabolic abnormalities were excluded from analysis.

2.2 Variables and Measurements

2.2.1 Outcome variables

Considering the metabolic abnormalities according to adiposity, the outcome variables were classified into four groups: 1) 1–2 metabolic abnormalities without obesity, 2) MS (3–5 metabolic abnormalities) without obesity, 3) 1–2 metabolic abnormalities with obesity, and 4) MS (3–5 metabolic abnormalities) with obesity. The methods for measuring metabolic abnormalities and adiposity were as follows.

Metabolic abnormalities

In this study, five metabolic abnormalities were included in MS: abdominal obesity, high blood pressure, low high-density lipoprotein (HDL) cholesterol, high triglyceride levels, and high fasting glucose. MS was defined as the presence of three to five of these metabolic abnormalities. Abdominal obesity was defined based on the criteria proposed by the Korean Society for the Study of Obesity [29]. High blood pressure, low HDL cholesterol, high triglyceride, and high fasting glucose levels were defined based on the criteria proposed by the American Heart Association and the National Heart, Lung, and Blood Institute [30]. Specifically, the diagnostic criteria were: i) abdominal obesity: ≥85 cm waist circumference, ii) high blood pressure: ≥130/85 mmHg or taking medication to treat hypertension, iii) low HDL cholesterol: <50 mg/dL or taking medication for the treatment of low HDL; iv) high triglycerides: ≥150 mg/dL or taking medication to treat high triglycerides, and v) high fasting glucose: ≥100 mg/dL or taking medication to treat hyperglycemia.

Adiposity

The body mass index (BMI) was evaluated using objectively measured height (m^2) and weight (kg). Then, according to the criteria proposed by Kim et al. [31], adiposity was classified into four groups based on BMI; underweight (<18.5 kg/m^2); normal weight (≥18.5 kg/m^2 and <23 kg/m^2); overweight (≥ 23 kg/m^2 and <25 kg/m^2), and obese (≥25 kg/m^2). Finally, for data analysis, adiposity was classified into two groups: non-obese (underweight and normal weight) and obese (overweight and obese).

2.2.2 Independent variables

Biomedical factors

Age was stratified into two groups (40–64 years and ≥65 years), with the classification of individuals aged 65 and older as seniors being based on the Elderly Welfare Act of South Korea. Family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs was evaluated using a single yes or no question about whether any of the participants' direct family members had a history of these conditions. Breastfeeding experience was evaluated using a single, yes or no question regarding whether the participant had more than one month total of breastfeeding experience.

Biosocial factors

Educational levels were categorized as: lower than middle school education, graduated high school, and college education or above. Socioeconomic status of family was evaluated based on their income quantile. The four quantile groups were: first quantile (lowest)–fourth quantile (highest). Employment status was categorized as either employed or unemployed.

Psychosocial factors

Stress was evaluated with a single yes or no question about usual emotional stress in daily life. Responses were categorized as "yes (with stress)" or "no (without stress)". Depression was evaluated using a single yes or no question about whether the participant had been diagnosed with depression by a psychiatrist. Skipping breakfast was evaluated with a single question about the frequency of having breakfast over the preceding week. Responses were categorized as ≤2 days/week, 3–6 days/week, and every day (7 days/week). Eating out was evaluated with a single question about average frequency of eating out over the preceding year. Responses were classified as ≤3 times/month, 1–6 times/week, and ≥1 time/day.

Smoking status was evaluated using a single yes or no question regarding current and past smoking. Current binge alcohol consumption was evaluated using three questions about the amount and frequency of alcohol consumption and the frequency of heavy alcohol drinking from the Alcohol Use Disorders Identification Test (AUDIT) Questions. Each question had four possible responses, scored from 0 to 4. The lowest and highest possible scores were 0 and 12 points, respectively. We defined binge alcohol consumption (yes or no) as a score of more than 6 according to the criteria suggested by Woo et al. [32]. Physical activity included activities during work, transportation, and recreation. Physical activity was quantified as the Metabolic Equivalent of Task (MET) minutes following the analysis guidelines proposed by the Global Physical Activity Questionnaire (GPAQ, version 2.0) [33]. Then it was classified into sufficient (≥600 MET-min a week) and insufficient (〈600 MET-min a week) physical activity following the 2019 World Health Organization guidelines [33]. Sedentary behavior was evaluated using a single question about the total hours spent sitting and lying in a day. Self-reported hours of sedentary behavior were categorized into prolonged (≥8 hours a day) and appropriate sedentary behavior (〈8 hours a day), following the guidelines proposed by the United Kingdom Chief Medical Officers [34]. Sleep duration was categorized into insufficient (〈7 hours a day) and sufficient (≥7 hours a day) based on a meta-analysis study [35].

2.3 Ethical Considerations

As this study used data from the KNHANES for secondary data analysis, the Institutional Review Board exempted the study from having to obtain ethical approval or patient consent (202310-SB-183-01).

2.4 Statistical Analysis

Following the analysis guidelines proposed by the KNHNES, complex simple analysis was applied using SPSS 26.0 (IBM, Armonk, NY, USA). The frequencies and percentages of metabolic abnormalities (1–2 metabolic abnormalities and MS) according to adiposity (non-obesity and obesity) and biomedical, biosocial, and psychosocial factors were analyzed in a descriptive study. Factors associated with metabolic abnormalities in non-obese and obese postmenopausal women were analyzed using logistic regression.

3. Results

3.1 Prevalence of biopsychosocial factors

Table 1 presents the prevalence of biopsychosocial factors according to metabolic abnormal-

Table 1. Prevalence of biopsychosocial factors

Variables	Categories	Non-obesity		Obesity	
		1 – 2 metabolic abnormalities (n=1,149)	Metabolic syndrome (n=616)	1 – 2 metabolic abnormalities (n=1,198)	Metabolic syndrome (n=2,372)
		n (%)			
Biomedical factors					
Age (years old)	40–64	795 (75.0)	279 (52.4)	831 (75.1)	1,139 (54.6)
	≥65	354 (25.0)	337 (47.6)	367 (24.9)	1,233 (45.4)
Family history of hypertension, type 2 diabetes, dyslipidemia, and cardiovascular diseases	Yes	723 (64.0)	443 (73.5)	761 (65.8)	1,648 (69.8)
	No	426 (36.0)	173 (26.5)	437 (34.2)	724 (30.2)
Breastfeeding experience	Yes	979 (82.3)	550 (87.8)	1,071 (88.4)	2,150 (88.8)
	No	170 (17.7)	66 (12.2)	127 (11.6)	222 (11.2)
Biosocial factors					
Educational level	≤Middle school education	523 (41.2)	374 (56.3)	645 (49.4)	1,626 (64.0)
	Graduated high school	389 (36.7)	165 (29.8)	385 (35.4)	525 (25.6)
	≥College education	237 (22.1)	77 (13.9)	168 (15.2)	221 (10.4)
Socioeconomic status of family (income quintile)	1st	257 (19.5)	185 (26.0)	240 (17.6)	755 (28.5)
	2nd	257 (20.5)	156 (25.7)	345 (27.6)	703 (29.2)
	3rd	285 (27.2)	158 (28.0)	289 (25.6)	493 (22.2)
	4th	350 (32.8)	117 (20.3)	324 (29.2)	421 (20.1)
Employment status	Employed	581 (50.6)	228 (38.2)	646 (53.9)	1,041 (44.5)
	Unemployed	568 (49.4)	388 (61.8)	552 (46.1)	1,331 (55.5)
Psychosocial factors					
Stress	Yes	954 (83.1)	481 (79.1)	991 (83.4)	1,875 (79.6)
	No	195 (16.9)	135 (20.9)	207 (16.6)	497 (20.4)
depression	Yes	100 (8.4)	55 (8.4)	92 (6.9)	225 (8.9)
	No	1,049 (91.6)	561 (91.6)	1,106 (93.1)	2,147 (91.1)
Skipping breakfast (days a week)	7	87 (9.0)	24 (4.8)	95 (8.9)	166 (8.3)
	3–6	123 (12.7)	42 (7.4)	166 (15.1)	260 (12.6)
	≤2	939 (78.3)	550 (87.8)	937 (76.0)	1,946 (79.1)
Eating out	≥1 time/day.	99 (9.3)	29 (4.9)	118 (10.4)	139 (6.8)
	1–6 times/week	558 (49.1)	262 (44.6)	557 (48.6)	1,000 (43.9)
	≤3 times/month	492 (41.6)	325 (50.5)	523 (41.0)	1233 (49.3)
Current and past smoking experience	Yes	97 (8.2)	53 (8.5)	77 (6.9)	197 (8.1)
	No	1,052 (91.8)	563 (91.5)	1,121 (93.1)	2,175 (91.9)
Current binge alcohol consumption	Yes	1,054 (90.9)	578 (93.9)	1,090 (89.6)	2,179 (91.2)
	No	95 (9.1)	38 (6.1)	108 (10.4)	193 (8.8)
Physical activity	Insufficient	663 (57.0)	394 (61.2)	722 (57.9)	1,611 (66.7)
	Sufficient	486 (43.0)	222 (38.8)	476 (42.1)	761 (33.3)
Sedentary behavior (hours a day)	≥8	537 (47.4)	331 (52.6)	553 (45.2)	1,343 (57.4)
	〈8	612 (52.6)	285 (47.4)	645 (54.8)	1,029 (42.6)
Sleep duration (hours a day)	≥7	663 (57.2)	323 (51.8)	692 (57.7)	1,290 (54.0)
	〈7	486 (42.8)	293 (48.2)	506 (42.3)	1,082 (46.0)

N=5.335
n,unweighted; %, weighted

ities in non-obese and obese participants in the four groups (1–2 metabolic abnormalities with non-obesity or obesity and metabolic syndrome with non-obesity or obesity).

3.2 Factors associated with metabolic abnormalities

Table 2 presents factors associated with metabolic abnormalities in non-obese and obese postmenopausal women. In non-obese postmenopausal

Table 2. Factors associated with metabolic abnormalities

Variables		Categories	Non-obesity						Obesity					
			1 – 2 metabolic abnormalities			Metabolic syndrome			1 – 2 metabolic abnormalities			Metabolic syndrome		
			AOR	95% CI	*p*	AOR	95% CI	*p*	AOR	95% CI	*p*	AOR	95% CI	*p*
Biomedical factors	Age (years old) (Ref. 40–64)	≥65	1.95	1.38 –2.74	<.001	4.45	2.99 –6.63	<.001	2.90	1.66 –5.06	<.001	5.27	3.13 –8.87	<.001
	Family history of hypertension, type 2 diabetes dyslipidemia, and cardiovascular diseases (Ref. No)	Yes	1.30	1.01 –1.65	.038	2.82	2.08 –3.83	<.001	1.54	1.08 –2.21	.017	1.92	1.34 –2.75	<.001
	Breastfeeding experience (Ref. Yes)	No	1.13	0.82 –1.57	.461	0.95	0.62 –1.45	.804	0.67	0.42 –1.06	.087	0.84	0.53 –1.33	.443
Biosocial factors	Educational level (Ref. ≥College education)	≤Middle school education	1.89	1.35 –2.63	<.001	2.68	1.75 –4.10	<.001	1.93	1.15 –3.24	.013	2.96	1.77 –4.94	<.001
		Gaduated high school	1.15	0.87 –1.52	.322	1.32	0.88 –1.97	.175	1.36	0.87 –2.11	.177	1.65	1.05 –2.60	.031
	Socioeconomic status of family (income quintile) (Ref. 4th)	1st	1.36	0.89 –2.08	.159	1.71	1.02 –2.85	.040	1.09	0.61 –1.95	.766	1.93	1.20 –3.10	.007
		2nd	0.89	0.63 –1.27	.529	1.56	1.07 –2.30	.022	1.28	0.81 –2.01	.287	1.65	1.04 –2.61	.033
		3rd	1.00	0.75 –1.35	.956	1.38	0.90 –2.12	.139	0.97	0.62 –1.53	.892	1.14	0.73 –1.77	.573
	Employment status (Ref. Employed)	Unemployed	1.12	0.88 –1.43	.343	0.94	0.68 –1.30	.707	0.76	0.53 –1.10	.144	0.73	0.50 –1.04	.083
Psychosocial factors	Stress (Ref. No)	Yes	0.85	0.61 –1.18	.325	0.75	0.51 –1.12	.157	1.01	0.65 –1.59	.958	0.89	0.58 –1.35	.580
	Depression (Ref. No)	Yes	0.94	0.59 –1.50	.805	1.06	0.64 –1.77	.826	1.22	0.62 –2.40	.565	1.11	0.54 –2.28	.780
	Skipping breakfast (days a week) (Ref. ≤2)	7	0.79	0.51 –1.23	.300	1.23	0.87 –1.73	.243	1.14	0.64 –2.02	.658	1.26	0.73 –2.15	.406
		3–6	0.85	0.61 –1.20	.364	1.16	0.89 –1.53	.272	1.27	0.78 –2.06	.334	1.26	0.79 –2.00	.334
	Eating out (Ref. ≤3 times/month)	≥1 time/day.	0.70	0.45 –1.09	.112	1.19	0.83 –1.18	.347	1.31	0.72 –2.39	.376	1.16	0.62 –2.14	.648
		1–6 times/week	0.88	0.68 –1.15	.350	0.82	0.59 –1.14	.231	1.14	0.79 –1.65	.491	1.01	0.69 –1.47	.974
	Current and past smoking experience (Ref. No)	Yes	0.80	0.51 –1.25	.327	0.83	0.48 –1.44	.505	1.03	0.48 –2.20	.950	1.32	0.61 –2.85	.475
	Current binge alcohol consumption (Ref. No)	Yes	1.50	0.92 –2.44	.102	1.12	0.60 –2.11	.719	1.66	0.89 –3.13	.119	1.62	0.88 –3.01	.123
	Physical activity (Ref. Sufficient)	Insufficient	1.15	0.89 –1.47	.294	1.06	0.77 –1.44	.736	1.32	0.91 –1.91	.147	1.55	1.08 –2.23	.017
	Sedentary behavior (hours a day) (Ref. 〈8)	≥8	1.24	0.99 –1.57	.067	1.51	1.12 –2.05	.007	1.38	0.96 –1.98	.084	2.22	1.54 –3.22	<.001
	Sleep duration (hours a day) (Ref. ≥7)	〈7	0.89	0.69 –1.14	.339	1.03	0.76 –1.38	.867	0.95	0.68 –1.34	.782	1.10	0.79 –1.53	.568

AOR, adjusted odds ratio; 95% CI, 95% confidence interval; Ref, reference

women, having 1–2 metabolic abnormalities were associated with the following biomedical factors: age, family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs. An age of 〉65 years was associated with 1.95-fold increased likelihood of 1–2 metabolic abnormalities compared to the 40–

64-year range (95% CI: 1.38–2.74, p <.001). Family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs was all associated with a 1.30-fold increase in the likelihood of having 1–2 metabolic abnormalities compared to participants without a family history of these conditions (95% CI: 1.01–1.65, p =.038). The only associated biosocial factor was educational level, with not having graduated middle school being associated with a 1.89-fold increase in the likelihood of 1–2 metabolic abnormalities compared to having a postgraduate education (95% CI: 1.35–2.63, p <.001).

In non-obese postmenopausal women with MS, age and family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs were biomedical factors associated with MS. Specifically, age > 65 years was associated with a 4.45-fold increase in the likelihood of MS than the 40–64 year group (95% CI: 2.99–6.63, p <.001). Family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs was associated with a 2.82-fold increased likelihood of MS compared to those without a family history of these conditions (95% CI: 2.08–3.83, p <.001). Two biosocial factors, educational level and socioeconomic status of family, were associated with MS. Not graduating from middle school was associated with a 2.68-fold increase in the likelihood of MS, compared to having a postgraduate education (95% CI: 1.75–4.10, p <.001). For family socioeconomic status, the first and second income quintiles were associated with a 1.71-fold (95% CI:1.02–2.85, p =.040) and 1.56-fold (95% CI:1.07–2.30, p =.022) increase in the likelihood of MS compared to being in the fourth income quintile, respectively. Of the psychosocial factors, only sedentary behavior was associated with MS, with prolonged sedentary behavior (≥8 hours a day) associated with a 1.51-fold increased likelihood of MS than having appropriate sedentary behavior (<8 hours a day; 95% CI: 1.12–2.05, p =.007).

In obese postmenopausal women with 1–2 metabolic abnormalities, the associated biomedical factors were age and family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs. Specifically, age >65 years was associated with a 2.90-fold increase in the likelihood of having 1–2 metabolic abnormalities than the 40–64 year range (95% CI:1.66–5.06, p <.001). Family history of hypertension, type 2 diabetes, dyslipidemia and CVDs was associated with a 1.54-fold increased likelihood of having 1–2 metabolic abnormalities than having no family history of these conditions (95% CI:1.08–2.21, p =.017). Educational level was the only associated biosocial factor, with not completing middle school associated with a 1.93-fold increased likelihood of having 1–2 metabolic abnormalities than having a postgraduate education (95% CI: 1.15–3.24, p =.013).

In obese postmenopausal women with MS, the associated biomedical factors were age and family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs. Age >65 years was associated with a 5.27-fold increase in the likelihood of MS than the 40–64 year range (95% CI:3.13–8.87, p <.001). Family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs was associated with a 1.92-fold increase in the likelihood of MS than no family history of these conditions (95% CI:1.34–2.75, p <.001). Educational level and family socioeconomic status were the biosocial factors associated with MS. Not completing middle school and only graduating high school were associated with 2.96-fold a (95% CI: 1.77–4.94, p <.001) and 1.65-fold (95% CI: 1.05–2.60, p =.031) increased likelihood of MS than postgraduate education, respectively. Regarding family socioeconomic status, the first and second income quintiles were associated with a 1.93-fold (95% CI: 1.20–3.10, p =.007) and 1.65-fold (95% CI:1.04–2.61, p =.033) increase in the likelihood of MS than the fourth income quintile. Finally, physical activity and sedentary behavior were the psychosocial factors associated with MS. Insufficient physical activity and prolonged sedentary behavior were associated with a 1.55-fold (95% CI:1.08–2.23, p =.017) and 2.22-fold (95% CI: 1.54–3.22, p <.001) increased

likelihood of MS than appropriate activity and sedentary behavior.

4. Discussion

This study identified the factors associated with metabolic abnormalities in non-obese and obese postmenopausal women. Increased age (≥65 years old), a family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs, and low educational level were associated with an increased incidence of 1–2 metabolic abnormalities and MS in all (none-obese and obese) postmenopausal women. Low family socioeconomic status and prolonged sedentary behavior were associated with increased MS in all postmenopausal women. Finally, physical activity was associated with increased MS risk only in obese postmenopausal women.

That is, in both non-obese and obese postmenopausal women, aging, a family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs, as well as low educational level, low family socioeconomic status, and prolonged sedentary behavior, were common factors associated with metabolic abnormalities. Aging and family history of hypertension, type 2 diabetes, dyslipidemia and CVDs, as well as menopause, are significant factors associated with metabolic abnormalities [17, 19, 36]. Older individuals commonly present with increased visceral fat (abdominal obesity), which leads to insulin resistance [37]. Additionally, aging may be associated with increased proinflammatory cytokine levels, which seem to interfere with the action of insulin, resulting in insulin resistance [38]. Thus, increased visceral fat and insulin resistance in older individuals may lead to an unhealthy metabolic status [38]. Additionally, a family history of metabolic disorders is a significant genetic factor for metabolic abnormalities in offspring; specifically, a family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs was associated with metabolic abnormalities in middle-aged Korean women [17,39]. Furthermore, menopause is associated with increased visceral fat (abdominal obesity), regardless of whether body weight is gained [40]. Thus, the proatherogenic changes in the lipid profile and apolipoproteins associated with aging might result from menopause [36].

Additionally, postmenopausal women might spend more time sitting combined with the weakened muscle strength associated with aging, augmenting the low basal metabolic rate associated with sedentary behavior, resulting in a significant decrease in their energy expenditure [41,42]. Screen-based sedentary behavior, such as watching TV, might also lead to increased consumption of snacks, resulting in increased energy intake [43]. Prolonged sedentary behavior (≥ 8 hours a day) combined with increased age and menopause results in abdominal obesity regardless of diet habits, mealtime, and physical activity [41]. Additionally, prolonged sedentary behavior increases insulin resistance in postmenopausal women as age increases [44]. With aging, increased visceral fat in postmenopausal women is associated with altered expression of adiponectin, which participates in the regulation of insulin sensitivity and results in increased insulin resistance [45]. Thus, increased age, family history of hypertension, type 2 diabetes, dyslipidemia, CVDs, and prolonged sedentary behavior in postmenopausal women are significant risk factors for metabolic abnormalities (MS), regardless of adiposity (BMI).

Furthermore, a systematic review [46] reported that low educational level and familial socioeconomic status were significant risk factors for MS in Iranian adults. This may be because individuals with low educational levels and/or low familial socioeconomic status have limited health-related resources (e.g., health care services and health-related information) and more unhealthy lifestyle behaviors, such as junk food consumption (high calories and low nutritional quality), insufficient physical activity, and prolonged sedentary behavior due

to lack of health consciousness, negative attitudes toward healthy lifestyle behaviors, and poor financial status [46,47]. Accordingly, the primary risk group for the prevention and early management of metabolic abnormalities (including MS) would be postmenopausal women with increased age, family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs, low educational level, and low familial socioeconomic status, regardless of adiposity. Furthermore, as sedentary behavior is a modifiable factor, developing strategies to decrease it is important for improving metabolic health in postmenopausal women with non-modifiable vulnerable factors associated with metabolic abnormalities, regardless of adiposity.

Furthermore, according to this study, in obese postmenopausal women, physical activity was an additional associated factor with metabolic abnormalities (MS). According to Suliga et al. [19], insufficient physical activity is associated with increased abdominal obesity, high serum glucose concentration, and blood pressure in obese, but not normal-weight adults. Similarly, high moderate and vigorous physical activity was associated with metabolic health in obese individuals aged 45– 85 years [48]. Douglas et al. [49] reported that moderate physical activity was effective in decreasing appetite and increasing appetite-regulatory hormone levels (like peptide YY and glucagon-like peptide-1) in the hours after physical activity in non-obese and obese individuals. According to Luo et al. [50], increased moderate and vigorous activity may decrease brain reactivity to high-calorie food cues after glucose consumption, particularly in obese individuals. Thus, physical activity is helpful for energy balance in obese individuals, with both decreased energy intake and increased energy expenditure, which may prevent additional weight gain, possibly improving metabolic health in obese individuals. Physical activity also has benefits for improving cardiovascular (e.g., decreased heart rate), hemodynamic (e.g., improved blood flow), metabolic (e.g., change in cholesterol composition by improved HDL-LDL (low- density lipoprotein ratio), and endocrinological (e.g., increase in catecholamines and cortisol) health [51,52]. Additionally, physical activity increases exercise-induced hormones like irisin, which might result in increased energy expenditure by transforming white into brown fat cells, possibly improving glucose homeostasis [51,53]. Similarly, physical activity is effective at decreasing serum glucose concentrations in obese women [54]. According to the WHO [55], at least 150 minutes per week of moderate to vigorous physical activity, 75 minutes per week of vigorous physical activity, or an equivalent combination of moderate and vigorous activity is required to improve health. Nilsson et al. [56] emphasized that both moderate and vigorous physical activity are necessary to prevent metabolic abnormalities. Thus, moderate and vigorous physical activity can be an important strategy for managing metabolic abnormalities and improving the metabolic health of obese postmenopausal women. Furthermore, community health providers should develop safe and effective moderate-to-vigorous and/or vigorous physical activity programs to improve metabolic health in postmenopausal women, particularly those with obesity.

This study provides evidence for the need to identify various factors associated with metabolic abnormalities in postmenopausal women based on adiposity. Additionally, our results show that the developing programs tailored to adiposity should be emphasized to prevent or manage metabolic abnormalities in postmenopausal women.

However, this study had some limitations. First, this study performed a secondary data analysis with a cross-sectional study design, which is not the strongest design for the systematic assessment of independent variables and the identification of causal relationships between outcome (metabolic abnormalities) and independent (biomedical, biosocial, and psychosocial factors) variables. Therefore, co-

hort studies using instruments with confirmed validity and reliability should be conducted to verify these causal relationships. Second, the factors associated with metabolic abnormalities in non-obese and obese postmenopausal women might differ from those in same-aged men and premenopausal women in Korea and other countries. Thus, future studies should consider ethnicity and include men and premenopausal women when identifying factors associated with metabolic abnormalities in non-obese and obese individuals.

5. Conclusion

Based on these results, postmenopausal women with increased age; family history of hypertension, type 2 diabetes, dyslipidemia, and CVDs; low educational level; and low family socioeconomic status might be the primary population requiring prevention and early management of metabolic abnormalities, regardless of adiposity. Additionally, strategies to decrease sedentary behavior in non-obese and obese postmenopausal women and increase physical activity in obese postmenopausal women might be helpful in preventing and managing metabolic abnormalities and MS. Thus, community health care providers should develop tailored programs that focus on modifiable factors associated with metabolic abnormalities according to adiposity in postmenopausal women.

REFERENCES

[1] T. R. Silva, K. Oppermann, F. M. Reis & P. M. Spritzer. (2021). Nutrition in menopausal women: A narrative review. *Nutrients*, *13(7)*, 2149-2162. DOI : 10.3390/nu13072149

[2] M. K. Christakis, H. Hasan, L. R. De Souza & L. Shirreff. (2020). The effect of menopause on metabolic syndrome: Cross-sectional results from the Canadian Longitudinal Study on Aging. *Menopause. 27(9),* 999-1009. DOI : 10.1097/GME.0000000000001575

[3] G. Stachowiak., T. Pertyński & Pertyńska-Marczewska. M. (2015). Metabolic disorders in menopause. *Przeglad Menopauzalny, 14(1),* 59-64. DOI : 10.5114/pm.2015.50000

[4] E. Park & J. S. Kim. (2015). Gender- and age-specific prevalence of metabolic syndrome Korean Adults: Analysis of the fifth Korean National Health and Nutrition Examination Survey. *The Journal of Cardiovascular Nursing, 30(3),* 256-266. DOI : 10.1097/JCN.0000000000000142

[5] J. S. Ra. (2021). Combined effects of metabolic abnormalities and obesity on cardiovascular diseases among Korean postmenopausal women. *Healthcare*, *9(8)*, 1064-1072. DOI : 10.3390/healthcare9081064

[6] R. S. Arthur, G. C. Kabat, M. Y. Kim, R. A. Wild, A. H. Shadyab, J. Wactawski-Wende, G. Y. F. Ho, K. W. Reeves, L. H. Kuller, J. Luo, J. Beebe-Dimmer, M. S. Simon, H. Strickler, S. Wassertheil-Smoller & T. E. Rohan. (2019). Metabolic syndrome and risk of endometrial cancer in postmenopausal women: A prospective study. *Cancer Causes & Control, 30(4),* 355-363. DOI : 10.1007/s10552-019-01139-5

[7] S. Dong, Z. Wang, K. Shen & X. Chen. (2021). Metabolic syndrome and breast cancer: Prevalence, treatment response, and prognosis. *Frontiers in Oncology*, *11,* 629666. DOI : 10.3389/fonc.2021.629666

[8] N. Stefan, F. Schick & H. U. Häring. (2017). Causes, characteristics, and consequences of metabolically unhealthy normal weight in humans. *Cell Metabolism*, *26(2),* 292-300. DOI : 10.1016/j.cmet.2017.07.008

[9] A. Hamao, K. Abe & T. Hayakawa. (2013). The effect of risk factors for metabolic syndrome on cardiovascular disease mortality: From a Follow-up Survey of Basic Health Check-up Examines in Koriyama City, Fukushima Prefecture. *Health Welfare, 60(1),* 28-31. DOI : 10.1016/j.ypmed.2021.106855

[10] D. T. Dibaba, K. Ogunsina, D. Braithwaite & T. Akinyemiju. (2019). Metabolic syndrome and risk of breast cancer mortality by menopause, obesity, and subtype. *Breast Cancer Research & Treatment*, *174(1),* 209-218.

DOI : 10.1007/s10549-018-5056-8

[11] X. Liang, K. L. Margolis, M. Hendryx, T. E. Rohan, E. J. Groessl, C. A. Thomson, C. H. Kroenke, M. S. Simon, D. Lane, M. Stefanick & J. Luo. (2017). Metabolic phenotype and risk of colorectal cancer in normal-weight postmenopausal women. *Cancer Epidemiology, Biomarkers & Prevention*, *26(2),* 155-161. DOI : 10.1158/1055-9965.EPI-16-0761

[12] Y. M. Park, A. J. White, H. B. Nichols, K. M. O'Brien, C. R. Weinberg & D. P. Sandler. (2017). The association between metabolic health, obesity Phenotype and the risk of breast cancer. *International Journal of Cancer, 140(12),* 2657-2666. DOI : 10.1002/ijc.30684

[13] A. Kikuchi, T. Monma, S. Ozawa, M. Tsuchida, M. Tsuda & F. Takeda. (2021). Risk factors for multiple metabolic syndrome components in obese and non-obese Japanese individuals. *Preventive Medicine*, *153,* 106855. DOI : 10.1016/j.ypmed.2021.106855

[14] J. V. Norvik, H. M. Storhaug, K. Ytrehus, T. G. Jenssen, S. N. Zykova, B. O. Eriksen & M. D. Solbu. (2016). Overweight modifies the longitudinal association between uric acid and some components of the metabolic syndrome: The Tromsø Study. *BMC Cardiovascular Disorders, 16*, 85. DOI : 10.1186/s12872-016-0265-8

[15] L. Heath, S. A. Jebb, P. Aveyard & C. Piernas. (2022). Obesity, metabolic risk and adherence to healthy lifestyle behaviours: Prospective cohort study in the UK Biobank. *BMC Medicine, 20*, 65. DOI : 10.1186/s12916-022-02236-0

[16] M. A. Hoffman & J. M. Driscoll. (2000). Health promotion and disease prevention: A concentric biopsychosocial model of health status. In S. D. Brown & R. W. Lent (Eds.). *Handbook of counseling psychology (3rd ed).* John Wiley & Sons, Inc.

[17] H. C. Chang, Y. S. Wu, W. C. Tzeng, H. Y. Wu, P. C. Lee & W. Y. Wang. (2023). Sex differences in risk factors for metabolic syndrome in middle-aged and senior hospital employees: A population-based cohort study. *BMC Public Health, 23*, 587. DOI : 10.1186/s12889-023-15491-4

[18] J. S. Ra & S. O. Kim. (2020). Beneficial effects of breastfeeding on the prevention of metabolic syndrome among postmenopausal women. *Asian Nursing Research*, *14(3),* 173-177. DOI : 10.1016/j.anr.2020.07.003

[19] E. Suliga, E. Cieśla, D. Rębak, D. Kozieł & S. Głuszek. (2018). Relationship between sitting time, physical activity, and metabolic syndrome among adults depending on body mass index (BMI). *Medical Science Monitor, 24*, 7633-7645. DOI : 10.12659/MSM.907582

[20] G. K. K. Chung, R. H. Y. Yu, J. Woo, F. T. T. Lai, R. Y. Chung, E. K. Yeoh & S. C. Ho. (2020). Accelerated progression of waist-to-hip ratio but not body mass index associated with lower socioeconomic position: A cohort study of nonobese early postmenopausal Chinese Women. *Menopause*, *27(5),* 550-558. DOI : 10.1097/GME.0000000000001503

[21] J. K. Montez, J. T. Bromberger, S. D. Harlow, H. M. Kravitz & K. A. Matthews. (2016). Life-course socioeconomic status and metabolic syndrome among midlife women. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *71(6),* 1097-1107. DOI : 10.1093/geronb/gbw014

[22] Z. H. Li, L. Xu, R. Dai, L. J. Li & H. J. Wang. (2021). Effects of regular breakfast habits on metabolic and cardiovascular diseases: A protocol for systematic review and meta-analysis. *Medicine*, *100(44),* e27629. DOI : 10.1097/MD.0000000000027629

[23] N. Kudo, R. Nishide, M. Mizutani, S. Ogawa & S. Tanimura. (2021). Association between the type of physical activity and metabolic syndrome in middle-aged and older adult residents of a semi-mountainous area in Japan. *Environmental Health and Preventive Medicine*, *26(1)*, 46-54.. DOI : 10.1186/s12199-021-00949-x

[24] J. S. Ra & H. S. Kim. (2018). Influence of physical activity on metabolic syndrome according to smoking intensity. *Journal of Korean Public Health Nursing*, *32(2),* 319-330. DOI : 10.5932/JKPHN.2018.32.2.319

[25] M. Kwaśniewska, M. Pikala, K. Kaczmarczyk-Chałas, A. Piwońska, A. Tykarski, K. Kozakiewicz, A. Pająk, T. Zdrojewski & W. Drygas. (2012).

Smoking status, the menopausal transition, and metabolic syndrome in women. *Menopause*, *19(2),* 194-201.
DOI : 10.1097/gme.0b013e3182273035

[26] E. J. Kwon, E. H. Nah, H. K. Kim, S. H. Joe & H. I. Cho. (2016). Association between metabolic syndrome and psychological characteristics in Korean postmenopausal women. *Korean Journal of Health Promotion. 16(2),* 119-26.
DOI : 10.15384/kjhp.2016.16.2.119

[27] S. A. Gaston, Y. M. Park, K. L. McWhorter, D. P. Sandler & C. L. Jackson. (2019). Multiple poor sleep characteristics and metabolic abnormalities consistent with metabolic syndrome among White, Black, and Hispanic/Latina Women: Modification by menopausal status. *Diabetology & Metabolic Syndrome*, *11,* 17.
DOI : 10.1186/s13098-019-0413-2

[28] J. H. Yeo & M. T. Kim (2023). Association of weight, smoking, and alcohol consumption with age at natural menopause. *Journal of Women & Aging*, *35(4),* 343-353.
DOI : 10.1080/08952841.2022.20501574

[29] S. Y. Lee, H. S. Park, S. M. Kim, H. S. Kwon, D. Y. Kim, D. J. Kim, G. J. Cho, J. H. Han, S. R. Kim, C. Y. Park, S. J. Oh, C. B. Lee, K. S. Kim, S. W. Oh, Y. S. Kim, W. H. Choi & H. J. Yoo. (2006). Cut-off points of waist circumference for defining abdominal obesity in the Korean population. *The Korean Journal of Obesity*, *15(1),* 1-9.

[30] S. M. Grundy, J. I. Cleeman, S. R. Daniels, K. A. Donato, R. H. Eckel, B. A. Franklin, D. J. Gordon, R. M. Krauss, P. J. Savage, S. C. Smith, Jr, J. A. Spertus & F. Costa. (2005). Diagnosis and management of the metabolic syndrome: An American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Circulation*, *112(17),* 2735-2752.
DOI : 10.1161/CIRCULATIONAHA.105.169404

[31] M. K. Kim, W. Y. Lee, J. H. Kang, J. H. Kang, B. T. Kim, S. M. Kim, E. M. Kim, S. H. Suh, H. J. Shin, K. R. Lee, K. Y. Lee, S. Y. Lee, S. Y. Lee, S. K. Lee, C. B. Lee, S. Chung, I. K. Jeong, K. Y. Hur, S. S. Kim & J. T. Woo. (2014). 2014 Clinical practice guidelines for overweight and obesity in Korea. *Endocrinology & Metabolism*, *29(4),* 405-409. DOI : 10.3803/EnM.2014.29.4.405

[32] S. M. Woo, O. J. Jang, H. K. Choi & Y. R Lee. (2017). Diagnostic availability and optimal cut off score of the Korea version of Alcohol Use Disorder Identification Test (AUDIT-K), Alcohol Consumption Questions (AUDIT-C) and Question 3 Alone (AUDIT3) for screening of hazardous drinking. *The Journal Korean Academy of Addiction Psychiatry*, *21(1),* 62-67.
DOI : 10.37122/kaap.2017.21.2.62

[33] World Health Organization (WHO). (2002). *Physical activity questionnaire (GPAQ) analysis guide (version 2.0).*
https://www.who.int/ncds/surveillance/steps/resources/GPAQ_Analysis_Guide.pdf

[34] UK Chief Medical Officers (2019). *UK Chief Medical Officers' Physical Activity Guidelines.*
https://assets.publishing.service.gov.uk/media/5d839543ed915d52428dc134/uk-chief-medical-officers-physical-activity-guidelines.pdf.

[35] I. H. Iftikhar, M. A. Donley, J. Mindel, A. Pleister, S. Soriano & U. J. Magalang. (2015). Sleep duration and metabolic syndrome. An updated dose-risk metaanalysis. *Annals of the American Thoracic Society*, *12(9),* 1364-1372.
DOI : 10.1513/AnnalsATS.201504-190OC

[36] C. U. Chae & C. A. Derby. (2011). The menopausal transition and cardiovascular risk. *Obstetrics and Gynecology Clinics of North America*, *38(3),* 477-488.
DOI : 10.1016/j.ogc.2011.05.005

[37] M. Varghese, J. Song & K. Singer. (2021). Age and sex: Impact on adipose tissue metabolism and inflammation. *Mechanisms of Ageing & development*, *199*, 111563.
DOI : 10.1016/j.mad.2021.111563

[38] N. Barzilai, D. M. Huffman, R. H. Muzumdar & A. Bartke. (2012). The critical role of metabolic pathways in aging. *Diabetes*, *61(6),* 1315-1322.
DOI : 10.2337/db11-1300

[39] H. Kim & Y. Cho. (2020). Factors associated with metabolic syndrome among middle-aged women in their 50s: Based on national health screening data. *International Journal of Environmental Research & Public Health, 17(9),* 3008-3020. DOI : 10.3390/ijerph17093008

[40] Ko, S. H & Jung, Y. (2021). Energy metabolism changes and dysregulated lipid metabolism in postmenopausal women. *Nutrients*, *13(12),* 4556-4567. DOI : 10.3390/nu13124556

[41] J. S. Ra & H. Kim. (2021). Combined effects of unhealthy lifestyle behaviors on metabolic syndrome among postmenopausal women. *Healthcare*, *9(7),* 848-859. DOI : 10.3390/healthcare9070848

[42] N. Rosique-Esteban, N. Babio, A. Díaz-López, D. Romaguera, J. Alfredo Martínez, V. M. Sanchez, H. Schröder, R. Estruch, J. Vidal, P. Buil-Cosiales, J. Konieczna, I. Abete & J. Salas-Salvadó. (2019). Leisure-time physical activity at moderate and high intensity is associated with parameters of body composition, muscle strength and sarcopenia in aged Adults with obesity and metabolic syndrome from the PREDIMED-Plus Study. *Clinical Nutrition*, *38(3),* 1324-1331. DOI : 10.1016/j.clnu.2018.05.023

[43] J. Kim, S. Choi, H. Kim & S. An. (2021). Binge drinking and obesity-related eating: The moderating roles of the eating broadcast viewing experience among Korean adults. *International Journal of Environmental Research & Public Health*, *18(15),* 8066-8079. DOI : 10.3390/ijerph18158066

[44] M. D. Brown, M. T. Korytkowski, J. M. Zmuda, S. D. McCole, G. E. Moore & J. M. Hagberg. (2000). Insulin sensitivity in postmenopausal women: Independent and combined associations with hormone replacement, cardiovascular fitness, and body composition. *Diabetes Care*, *23(12),* 1731-1736. DOI : 10.2337/diacare.23.12.1731

[45] U. Smith & B. B. Kahn. (2016). Adipose tissue regulates insulin sensitivity: Role of adipogenesis, de novo lipogenesis and novel lipids. *Journal of Internal Medicine*, *280(5),* 465-475. DOI : 10.1111/joim.12540

[46] K. Hajian-Tilaki. (2015). Metabolic syndrome and its associated risk factors in Iranian adults: A systematic review. *Caspian Journal of Internal Medicine, 6(2),* 51-61.

[47] G. K. Chung, F. T. T. Lai, E. K. Yeoh & R. Y. Chung. (2021). Gender-specific trends of educational inequality in diagnosed diabetes from 1999 to 2014 in Hong Kong: A serial cross-sectional study of 97,481 community-dwelling Chinese adults. *Population Health Metrics*, *19(1),* 37-45. DOI : 10.1186/s12963-021-00268-x

[48] S. M. Camhi, M. E. Waring, S. B. Sisson, L. L. Hayman & A. Must. (2013). Physical activity and screen time in metabolically healthy obese phenotypes in adolescents and adults. *Journal of Obesity*, *2013,* 984613. DOI : 10.1155/2013/984613

[49] J. A. Douglas, J. A. King, D. J. Clayton, A. P. Jackson, J. A. Sargeant, A. E. Thackray, M. J. Davies & D. J. Stensel. (2017). Acute effects of exercise on appetite, ad libitum energy intake and appetite-regulatory hormones in lean and overweight/obese men and women. *International Journal of Obesity*, *41(12),* 1737-1744. DOI : 10.1038/ijo.2017.181

[50] S. Luo, S. G. O'Connor, B. R. Belcher & K. A. Page (2018). Effects of physical activity and sedentary behavior on brain response to high-calorie food cues in young adults. *Obesity*, *26(3),* 540-546. DOI : 10.1002/oby.22107

[51] P. Boström, J. Wu, M. P. Jedrychowski, A. Korde, L. Ye, J. C. Lo, K. A. Rasbach, E. A. Boström, J. H. Choi, J. Z. Long, S. Kajimura, M. C. Zingaretti, B. F. Vind, H. Tu, S. Cinti, K. Højlund, S. P. Gygi & B. M. Spiegelman. (2012). A PGC1-*α*-dependent myokine that drives brown-fat-like development of white fat and thermogenesis. *Nature*, *481(7382),* 463-468. DOI : 10.1038/nature10777

[52] C. Malm, J. Jakobsson & A. Isaksson. (2019). Physical activity and sports-real health benefits: A review with insight into the public health of Sweden. *Sports*, *7(5),* 127-154. DOI : 10.3390/sports7050127

[53] P. Kokkinos. (2012). Physical activity, health benefits, and mortality risk. *ISRN Cardiology*, *2012,* 718789. DOI : 10.5402/2012/718789

[54] D. S. Wagmacker, J. Petto, A. S. Fraga, J. B. Matias, S. K. A. Mota, L. E. A. Rodrigues & A. M. Ladeia. (2017). Metabolic reponses to a physical exercise session in women with excess body mass: Randomized clinical trial. *Lipids in Health & Disease*, *16(1),* 249-255.

DOI : 10.1186/s12944-017-0600-9

[55] World Health Organization (WHO). (2020). *WHO guidelines on physical activity and sedentary behavior.* https://www.who.int/publications/i/item/9789240015128

[56] A. Nilsson, B. Wåhlin-Larsson & F. Kadi. (2017). Physical Activity and not sedentary time per se influences on clustered metabolic risk in elderly community-dwelling women. *PloS one*, *12(4),* e0175496. DOI : 10.1371/journal.pone.0175496

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