RCPHN
Research in Community and Public Health Nursing

Original Article

pISSN 2983-0648 · eISSN 2288-4203
Res Community Public Health Nurs 2024;35(4):375-388
https://doi.org/10.12799/rcphn.2024.00738

Social Network Analysis of Adults' Obesity-Related Health Behaviors According to Life Cycle Stage

Seung-bin Park[1], **Insoon Kang**[2]

[1]Graduate Student, College of Nursing, Pusan National University, Yangsan, Korea
[2]Professor, College of Nursing, Pusan National University, Yangsan, Korea

Purpose: This secondary data analysis study examined adults' levels and networks of obesity-related health behaviors according to the life cycle stage.
Methods: Participants included 5,203 adults aged 19–79 years who participated in the third year of the eighth Korea National Health and Nutrition Examination Survey (2021). Life cycle stages were divided into young, middle-aged, and older adult groups. Obesity status was classified based on a body mass index of 25 kg/m^2. Selected obesity-related health behaviors included alcohol abstinence, not smoking, proper sleep, eating breakfast, fruit intake, vegetable intake, not eating out, aerobic physical activity, walking, and weight training. Obesity-related health behavior networks were analyzed for density, inclusiveness, degree, and degree/closeness/betweenness centrality using social network analysis.
Results: Participants' obesity rate was 37.6%, with the highest rate observed in the older adult group (39.2%). In all life cycle stages, the non-obese group had a higher density and average degree in the obesity-related health behavior network than the obese group. The young adult group showed higher centrality for vegetable intake, not smoking, alcohol abstinence, and proper sleep. The middle-aged group generally had higher centrality for health behaviors, whereas the older adult group had lower overall centrality for health behaviors, especially proper sleep and physical activity-related behaviors.
Conclusion: There were differences in the levels and network structures of obesity-related health behaviors according to the life cycle stage, indicating a need for differentiated obesity-management strategies according to the life cycle stage.

Keywords: Adult; Health behavior; Life cycle stage; Obesity; Social network analysis

Introduction

The global population of obese individuals has nearly tripled since 1975, making obesity a pandemic that threatens human health [1]. The adult obesity rate in South Korea increased from 34.4% in 2019 to 38.4% in 2020 following the COVID-19 pandemic [2]. Obesity is closely related to health behaviors and lifestyle habits, such as smoking, drinking, physical activity, and diet [2–5]. COVID-19 affected obesity rates through health behavior changes, such as decreased daily activity, reduced exercise, and dietary changes [6].

Living environments and the physical and physiological characteristics of obesity vary significantly with age. Different from adolescents, young adults take responsibility for their lifestyle choices as they pursue activities such as study, employment, and marriage [7]. As physical growth has stopped for young adults, weight gain increases fat cell size, making this a critical period for obesity management [8]. Middle-aged adults, meanwhile, often experience fatigue and physical decline owing to prolonged work or household labor; in particular, middle-aged women face increased obesity risk because of physiological aging, starting with menopause [9]. In older adults, aging is accompanied by a decline in overall physical function, and obesity can coexist with frailty owing to reduced physical activity and various diseases

Received: August 12, 2024; **Revised:** October 7, 2024; **Accepted:** November 2, 2024
Corresponding author: Seung-bin Park
College of Nursing, Pusan National University, 49 Busandaehak-ro, Mulgeum-eup, Yangsan 50612, Korea
Tel: +82-51-510-8356 E-mail: inicole@naver.com

© 2024 Korean Academy of Community Health Nursing
This is an Open Access article distributed under the terms of the Creative Commons Attribution NoDerivs License (https://creativecommons.org/licenses/by-nd/4.0) which allows readers to disseminate and reuse the article, as well as share and reuse the scientific material. It does not permit the creation of derivative works without specific permission.

[10]. Given these differences in obesity-related characteristics across the life cycle, the levels of health behaviors related to obesity, such as drinking, smoking, physical activity, and eating habits, also vary by life cycle stage [11-13]. Therefore, effective obesity management requires a life cycle-specific approach to obesity-related health behaviors.

Health behaviors tend to occur in conjunction with other behaviors [11,14,15]. In such interactions, one behavior can positively or negatively affect another. Health-related behaviors such as drinking, smoking, eating breakfast, and sleeping tend to show correlations and interconnections [15-17]. For effective obesity management, it is necessary to consider the relationships between health-related behaviors, as improving one behavior can positively influence another.

Furthermore, studies have shown that when behaviors that positively affect health are performed simultaneously, obesity rates are lower, and there can be synergistic effects on health outcomes [14,18,19]. Hence, strategies for improving overall health behaviors should be considered. However, exploring improvement strategies for each obesity-related health behavior poses practical challenges because of cost and time constraints. Understanding the relationships among health behaviors can guide the development of strategies focused on specific health behaviors for obesity management. Previous studies have largely examined the relationship between obesity and individual health behaviors [4,20-22], mainly focusing on diet [23,24] and exercise [25-27]. Nevertheless, examining only the relationship between obesity and individual health behaviors offers a limited perspective on the overall pattern of interactions among health behaviors that influence obesity.

Social network analysis (SNA) considers the relationships between entities as a network, which can help us understand the interactions, information flow, and influences among entities. This method allows for the visual identification of the structure and relationships of an entire network formed by all variables [28,29]. Thus, SNA can be used to identify patterns of relationships among obesity-related health behaviors across different life cycle stages, pinpointing the central behaviors. By confirming the connections and centrality of obesity-related health behaviors, strategies can be developed to focus on highly connected health behaviors, leading to improvements in other health behaviors and, thus, effective obesity management.

This study aims to examine the prevalence of obesity across different life cycle stages in adults, analyze the differences in obesity-related health behaviors between non-obese and obese groups, and explore the network of obesity-related health behaviors. Thus, this study provides foundational data for developing life cycle-specific obesity-management programs.

Methods

Study design

This secondary data analysis study aimed to identify the levels and networks of adults' obesity-related health behaviors across different life cycle stages.

Participants

The participants were adults aged 19–79 who participated in the third year of the eighth Korea National Health and Nutrition Examination Survey (KNHANES) (2021), conducted by the Korea Disease Control and Prevention Agency (KDCA). Of the 5,281 participants, 78 were excluded because their body mass index (BMI) was not recorded, resulting in a final sample size of 5,203. Life cycle stages were categorized based on age as follows: young adults (19–44 years), middle-aged adults (45–64 years), and older adults (65–79 years). Obesity status was classified into obese (BMI ≥ 25 kg/m^2) and non-obese (BMI < 25 kg/m^2).

Research variables

1. General characteristics

Data on the participants' general characteristics were collected, including sex, cohabiting family members, employment status, and educational level. Cohabiting family members were categorized into single-person households and households with two or more people [30]. Employment status was divided into employed and unemployed [20]. Educational level was classified as middle school graduate or lower, high school graduate, or university graduate or higher.

2. Obesity-related health behaviors

Obesity-related health behaviors were selected based on previous studies [2-5] to identify behaviors that significantly affect obesity. These behaviors included alcohol abstinence, not smoking, proper sleep, eating breakfast, fruit intake, vegetable intake, not eating out, aerobic physical activity, walking, and weight training. Alcohol and smoking affect lipid metabolism, and lack of sleep alters appetite-regulating hormones, increasing food intake [10]. Skipping breakfast raises the risk of snacking and overeating, while eating out often leads to high-calorie, unbalanced meals, increasing weight gain risk [31]. Vegetables and fruits, rich in vitamins and fiber, provide satiety and reduce overeating [9]. Physical activity boosts muscle mass, metabolism, and reduces body

fat, making it crucial for obesity prevention and management [9]. The classification criteria for obesity-related health behaviors were as follows:

1) Alcohol abstinence
Alcohol abstinence was categorized based on the responses to questions about the frequency of alcohol consumption and the average amount of alcohol consumed per occasion over the past year. Participants who reported drinking less than once a month were classified as not drinking. Based on the KDCA's [32] criteria for high-risk drinking, participants who drank at least twice a week with an average intake of seven or more drinks per occasion (five or more drinks for women) were classified as heavy drinkers. Other responses were categorized as daily drinking.

2) Not smoking
Smoking status was categorized based on responses to questions about lifetime cigarette smoking and current smoking status. Participants who reported never smoking were classified as non-smokers. Those who reported smoking in the past but not currently were classified as past smokers, and those who smoked daily or occasionally were classified as current smokers.

3) Proper sleep
Proper sleep was classified based on total sleep time calculated from the responses regarding typical bedtimes and waking times on weekdays or work days. Following the Alameda 7 [33] definition, sleep duration was classified as appropriate (7–8 hours), normal (6–7 hours or 8–10 hours), and inappropriate (less than 6 hours or more than 10 hours).

4) Eating breakfast
Breakfast consumption was categorized based on the frequency of consumption over the past week, referring to the criteria from Park & Shin [17]: regular (5–7 times a week); irregular (3–4 times a week); rare (less than twice a week).

5) Fruit intake
Fruit intake was categorized based on responses to questions about the frequency of consumption over the past year [34]: regular (at least once a day), irregular (1–6 times a week), and rare (less than three times a month).

6) Vegetable intake
Vegetable intake was categorized based on responses to questions about the frequency of consumption (excluding kimchi, pickled vegetables, mushrooms, and seaweed) over the past year [34]: regular (at least once a day), irregular (1–6 times a week), and rare (less than three times a month).

7) Not eating out
Not eating out was categorized based on responses to questions about the frequency of eating out (including takeout, delivery, institutional meals, and food provided by religious organizations) over the past year, referring to the criteria from Chong & Han [35]: rare (twice a week or less); occasional (3–6 times a week); frequent (at least once a day).

8) Aerobic physical activity
Aerobic physical activity was categorized based on responses to questions regarding the duration of moderate and vigorous physical activity during work and leisure time. Based on the KDCA's [32] criteria for calculating the practice rate of aerobic physical activity, participants who performed moderate-intensity physical activity for at least 2 hours and 30 minutes, vigorous-intensity physical activity for at least 1 hour and 15 minutes, or a combination of both (with 1 minute of vigorous activity equaling 2 minutes of moderate activity) were classified as practicing. Those who performed less than 10 minutes of moderate or vigorous activity were classified as not practicing, and other responses were classified as occasionally practicing.

9) Walking
Walking was categorized based on responses to questions about the number of days participants walked for at least 10 minutes at a time over the past week, including walking for commuting, moving, and exercise. The categories were as follows, based on the criteria from Lee [4]: practicing (at least 5 days a week); occasionally practicing (2–4 days a week); not practicing (1 day or less).

10) Weight training
Weight training was categorized based on responses to questions about the number of days participants performed weight-training exercises (such as push-ups, sit-ups, dumbbells, barbells, and pull-ups) over the past week. The categories were as follows [34]: practicing (at least 4 days a week), occasionally practicing (1–3 days a week), and not practicing (no exercise at all).

Data collection and ethical considerations
The KNHANES used in this study is a nationwide health and nutrition survey conducted annually based on the National

Health Promotion Act. It provides representative and reliable statistics used as foundational data for health policies. The sampling frame is derived from the most recent Population and Housing Census, selecting a representative sample of individuals aged 1 year and older in Korea. A two-stage stratified cluster sampling method was used, with enumeration districts and households as the first and second sampling units. The sampling was stratified by region, housing type (general housing, apartments), and intrinsic factors such as housing area ratio, household head's age, and single-person household ratio. All household members meeting the criteria underwent health, medical, and nutrition assessments through interviews, physical examinations, and questionnaires.

In this study, data were collected by visiting the KNHANES website (https://knhanes.kdca.go.kr/). After agreeing to the "Consent for the Collection and Use of Personal Information for National Health and Nutrition Examination Survey Users" and the "Pledge to Comply with User Obligations for Statistical Data," the researchers entered their personal email addresses to receive the data and the data usage guidelines for the third year of the eighth KNHANES (2021). The researchers obtained an exemption from review from the Institutional Review Board (IRB) of Pusan National University (IRB no. PNU IRB/2023_88_HR). The data from the KNHANES comply with the Personal Information Protection Act and the Statistics Act, ensuring that the data are de-identified and do not contain any information that could be used to identify participants.

Data analysis

KNHANES uses a two-stage stratified cluster sampling method, with survey districts and households serving as the first and second extraction units, respectively. Accordingly, this study used IBM SPSS 27.0 to perform complex-sample statistical analysis considering strata, clusters, and weights. General participant characteristics and levels of obesity-related health behaviors across different life cycle stages were identified and analyzed using frequencies and percentages. Rao–Scott chi-squared tests were used to analyze differences in obesity-related health behaviors.

The networks of obesity-related health behaviors between the obese and non-obese groups across different life cycle stages were analyzed using SNA with UCINET 6 and Gephi 0.10.1. Missing values in survey items related to the selected obesity-related health behaviors were replaced with the median, reflecting the central tendency of each item. The three classifications of each obesity-related health behavior were expressed as 2, 1, and 0, in order from the most positive health behavior to the least, to construct a two-mode matrix. Subsequently, this matrix was transformed into a one-mode matrix representing the relationships between obesity-related health behaviors, with weighted edge values normalized using the "weight rows inversely by row totals" and "sum of cross-products (overlaps)" functions. In the analysis of obesity-related health behavior networks for obese and non-obese groups across different life cycle stages, edges with an average weighted edge value below 16.46 were omitted.

SNA is a method developed based on social network theory, which focuses on relational attributes rather than individual characteristics of entities. This approach models the relationships between entities as a network, emphasizing the exploration of structural patterns by visualizing and quantifying interactions, information flow, and influence among entities [28]. Nodes represent obesity-related health behaviors, and edges denote the relationships between those behaviors. A sociogram was visualized to analyze density, inclusiveness, degree, degree centrality, closeness centrality, and betweenness centrality. In SNA, network members are called nodes, and the connections between nodes are called edges. Density refers to the number of actual connections out of the total possible connections. Inclusiveness refers to the ratio of the number of connected nodes to the total number of nodes in the network. Degree refers to the number of connections a node has within the network. Degree centrality indicates the prominence of a node based on its connections to other nodes, with nodes with many connections occupying a positional advantage in various respects. Closeness centrality measures the closeness of a node to other nodes in the network. Betweenness centrality indicates the extent to which a node controls or mediates relationships between nodes that are not directly connected.

Results

General characteristics of the participants

As shown in Table 1, 37.6% of participants were obese, with 36.2% in the young adult group, 38.4% in the middle-aged group, and 39.2% in the older adult group. There were more males in the young adult (52.6%) and middle-aged groups (50.2%) and more females in the older adult groups (53.6%). Single-person households were the most common among older adults (21.4%), whereas multiperson households were the most common in the middle-aged group (90.2%). Employment was highest among middle-aged adults (69.7%), whereas unemployment was highest among older adults (56.5%). Educational levels varied, with the most common being middle school or below among older

Table 1. General Characteristics of the Participants (N=5,203)

Characteristics	Categories	Total (N = 5,203)	Young adult (n = 1,754)	Middle-aged (n = 2,089)	Older adult (n = 1,360)
		n (%†)			
BMI	< 25kg/m²	3,271 (62.4)	1,145 (63.8)	1,307 (61.6)	819 (60.8)
	≥ 25kg/m²	1,932 (37.6)	609 (36.2)	782 (38.4)	541 (39.2)
Gender	Male	2,312 (50.7)	802 (52.6)	910 (50.2)	600 (46.4)
	Female	2,891 (49.3)	952 (47.4)	1,179 (49.8)	760 (53.6)
Number of cohabiting family members	1	797 (12.6)	227 (12.1)	239 (9.8)	331 (21.4)
	≥ 2	4,406 (87.4)	1,754 (87.9)	1,850 (90.2)	1,029 (78.6)
Occupation‡	Yes	3,095 (65.0)	1,167 (68.4)	1,359 (69.7)	569 (43.5)
	No	1,849 (35.0)	528 (31.6)	620 (30.3)	701 (56.5)
Educational level§	≤ Middle school	1,275 (17.6)	40 (2.3)	379 (16.2)	856 (65.1)
	High school	1,738 (38.0)	636 (37.7)	835 (44.3)	267 (22.5)
	≥ College	1,930 (44.4)	1,019 (60.0)	764 (39.5)	147 (12.4)

†Weighted %.
‡Skipped responses were excluded (n = 4,944).
§Skipped responses were excluded (n = 4,943).
BMI: body mass index.

adults (65.1%), high school graduates among middle-aged adults (44.3%), and university graduates or higher among young adults (60.0%).

Levels of obesity-related health behaviors by life cycle stage

Table 2 shows the analysis of levels of obesity-related health behaviors by the life cycle stage. For alcohol abstinence, not drinking was highest in the older adult group at 42.2%, while daily drinking and heavy drinking were highest in the young adult group at 53.0% and 14.6%, respectively (χ^2 = 69.65, p < .001). For not smoking, nonsmoker was highest in the older adult group at 58.1%, past smoker was highest in the middle-aged group at 27.3%, and current smoker was highest in the young adult group at 21.7% (χ^2 = 67.90, p < .001). For eating breakfast, eating regularly was highest in the older adult group at 91.2%, while eating irregularly and rarely were highest in the young adult group at 11.0% and 44.0%, respectively (χ^2 = 705.99, p < .001). Regarding fruit intake, eating regularly was highest in the older adult group at 41.6%, while eating irregularly and rarely were highest in the young adult group at 67.7% and 13.8%, respectively (χ^2 = 207.58, p < .001). For vegetable intake, eating regularly was highest in the older adult group at 99.3%, while eating irregularly was highest in the young adult group at 3.1% (χ^2 = 45.34, p < .001). For not eating out, rarely eating out was highest in the older adult group at 71.2%, while occasionally and frequently eating out were highest in the young adult group at 51.1% and 21.9%, respectively (χ^2 = 521.81, p < .001). For aerobic physical activity, the young adult group had the highest practicing rate at 52.5%, the middle-aged group had the highest rate of occasionally practicing at 24.1%, and the older adult group had the highest rate of not practicing at 48.4% (χ^2 = 183.47, p < .001). Regarding walking, the highest practicing rate was observed in the older adult group at 48.8%, while occasionally practicing and not practicing were highest in the middle-aged group at 37.3% and 20.9%, respectively (χ^2 = 15.57, p = .029). For weight training, the highest practicing rate was found in the older adult group at 13.8%, occasionally practicing was highest in the young adult group at 19.4%, and not practicing was highest in the older adult group at 78.6% (χ^2 = 74.44, p < .001).

Levels of obesity-related health behaviors among obese and non-obese groups by life cycle stage

Table 3 presents obesity-related health behavior levels among obese and non-obese groups according to life cycle stage. Among young adults, not drinking and daily drinking were higher in the non-obese group at 33.7% and 53.7%, respectively, while heavy drinking was higher in the obese group at 18.1% (χ^2 = 10.05, p = .031). Nonsmoker was higher in the non-obese group at 64.2%, while past smoker and current smoker were higher in the obese group at 26.3% and 27.1%, respectively (χ^2 = 51.74, p < .001). Rarely and occasionally eating out were higher in the non-obese group at 28.4% and 52.2%, respectively, while frequently eating out was higher in the obese group at 26.4% (χ^2 = 11.88, p = .011).

Among middle-aged adults, not drinking and daily drinking

Table 2. Level of Obesity-Related Health Behavior by Life Cycle Stage (*N*=5,203)

Obesity-related health behaviors	Categories	Total (*N* = 5,203)	Young adult (n = 1,754)	Middle-aged (n = 2,089)	Older adult (n = 1,360)	Rao–Scott χ^2	*p*
		n (%†)					
Alcohol abstinence	No drinking	2,018 (36.7)	584 (32.4)	849 (39.2)	585 (42.2)	69.65	< .001
	Daily drinking	2,605 (50.5)	921 (53.0)	977 (47.1)	707 (52.2)		
	Heavy drinking	580 (12.8)	249 (14.6)	263 (13.7)	68 (5.7)		
Not smoking	Nonsmoker	3,105 (56.2)	1,072 (57.8)	1,209 (53.7)	824 (58.1)	67.90	< .001
	Past smoker	1,229 (24.8)	333 (20.5)	508 (27.3)	388 (30.2)		
	Current smoker	869 (19.0)	349 (21.7)	372 (19.0)	148 (11.7)		
Proper sleep	Appropriate	2,643 (51.4)	921 (52.5)	1,055 (51.2)	667 (48.8)	11.13	.053
	Normal	1,788 (34.5)	611 (34.8)	717 (34.5)	460 (33.9)		
	Inappropriate	772 (14.1)	222 (12.7)	317 (14.3)	233 (17.3)		
Eating breakfast	Regular	3,613 (54.0)	813 (45.0)	1,550 (73.3)	1,250 (91.2)	705.99	< .001
	Irregular	359 (9.8)	189 (11.0)	141 (6.9)	29 (1.9)		
	Rare	1,231 (36.2)	752 (44.0)	398 (19.8)	81 (6.9)		
Fruit intake	Regular	1,648 (28.0)	343 (18.5)	724 (32.8)	581 (41.6)	207.58	< .001
	Irregular	2,994 (60.6)	1,176 (67.7)	1,186 (58.0)	632 (47.9)		
	Rare	561 (11.4)	235 (13.8)	179 (9.2)	147 (10.5)		
Vegetable intake	Regular	5,123 (98.2)	1,698 (96.8)	2,074 (99.2)	1,351 (99.3)	45.34	< .001
	Irregular	77 (1.8)	55 (3.1)	15 (0.8)	7 (0.6)		
	Rare	3 (0.0)	1 (0.1)	0	2 (0.1)		
Not eating out	Rarely eat out	2,375 (39.6)	475 (27.0)	899 (40.8)	1,001 (71.2)	521.81	< .001
	Occasionally eat out	2,087 (43.7)	888 (51.1)	879 (42.9)	320 (25.6)		
	Frequently eat out	741 (16.7)	391 (21.9)	311 (16.3)	39 (3.2)		
Aerobic physical activity	Practicing	2,102 (43.8)	891 (52.5)	825 (39.9)	386 (29.8)	183.47	< .001
	Occasionally practicing	1,186 (22.6)	389 (21.5)	511 (24.1)	286 (21.8)		
	Not practicing	1,915 (33.6)	474 (26.0)	753 (36.0)	688 (48.4)		
Walking	Practicing	2,336 (44.8)	805 (46.1)	890 (41.8)	641 (48.8)	15.57	.029
	Occasionally practicing	1,787 (34.8)	596 (33.6)	769 (37.3)	422 (31.6)		
	Not practicing	1,080 (20.4)	353 (20.3)	430 (20.9)	297 (19.6)		
Weight training	Practicing	611 (12.4)	206 (13.2)	228 (11.1)	177 (13.8)	74.44	< .001
	Occasionally practicing	722 (15.4)	331 (19.4)	292 (14.4)	99 (7.6)		
	Not practicing	3,870 (72.2)	1,217 (67.5)	1,569 (74.5)	1,084 (78.6)		

†Weighted %.

were higher in the non-obese group at 40.4% and 47.5%, respectively, while heavy drinking was higher at 16.4% ($\chi^2 = 8.17$, $p = .025$). Nonsmoker was higher in the non-obese group at 58.5%, while past smoker and current smoker were higher in the obese group at 33.9% and 20.2%, respectively ($\chi^2 = 36.25$, $p < .001$). Eating fruit regularly was higher in the non-obese group at 35.1%, while irregular and rare intakes were higher in the obese group at 60.3% and 10.7%, respectively ($\chi^2 = 9.72$, $p = .023$). Practicing weight training and occasionally practicing the same were higher in the non-obese group at 12.5% and 16.0%, respectively, while not practicing was higher in the obese group at 79.3% ($\chi^2 = 15.63$, $p = .002$).

Among older adults, appropriate sleep and normal sleep were higher in the non-obese group at 50.5% and 34.7%, respectively, while inappropriate sleep was higher in the obese group at 21.3% ($\chi^2 = 9.58$, $p = .023$). Eating breakfast regularly was higher in the non-obese group at 92.6% while eating irregularly and eating rarely were higher in the obese group at 3.1% and 7.9%, respectively ($\chi^2 = 8.53$, $p = .025$). Practicing walking and occasionally practicing walking were higher in the non-obese group at 50.5% and 32.8%, respectively, while not practicing was highest in the obese group at 24.3% ($\chi^2 = 11.78$, $p = .008$).

Table 3. Level of Obesity-Related Health Behavior According to Obesity Status by Life Cycle Stage (*N*=5,203)

Obesity-related health behaviors	Categories	Young adult (n = 1,754)			Middle-aged (n = 2,089)			Older adult (n = 1,360)		
		Non-obese (n = 1,145)	Obese (n = 609)	$\chi^{2\ddagger}$ (*p*)	Non-obese (n = 1,307)	Obese (n = 782)	$\chi^{2\ddagger}$ (*p*)	Non-obese (n = 819)	Obese (n = 541)	$\chi^{2\ddagger}$ (*p*)
		n (%†)			n (%†)			n (%†)		
Alcohol abstinence	No drinking	405 (33.7)	179 (30.1)	10.05 (.031)	545 (40.4)	304 (37.1)	8.17 (.025)	63 (43.1)	222 (40.7)	7.40 (.052)
	Daily drinking	604 (53.7)	317 (51.8)		625 (47.5)	352 (46.5)		411 (50.0)	296 (55.5)	
	Heavy drinking	136 (12.6)	113 (18.1)		137 (12.1)	126 (16.4)		45 (6.9)	23 (3.9)	
Not smoking	Nonsmoker	777 (64.2)	295 (46.6)	51.74 (< .001)	815 (58.5)	394 (45.9)	36.25 (< .001)	477 (56.3)	347 (61.0)	5.33 (.106)
	Past smoker	185 (17.2)	148 (26.3)		271 (23.3)	237 (33.9)		236 (30.5)	152 (29.7)	
	Current smoker	183 (18.6)	166 (27.1)		221 (18.2)	151 (20.2)		106 (13.2)	42 (9.3)	
Proper sleep	Appropriate	620 (53.7)	301 (50.6)	7.00 (.084)	673 (51.6)	382 (50.7)	0.47 (.841)	412 (50.5)	255 (46.0)	9.58 (.023)
	Normal	404 (35.2)	207 (33.9)		447 (34.6)	270 (34.4)		285 (34.7)	175 (32.7)	
	Inappropriate	121 (11.1)	101 (15.5)		187 (13.8)	130 (14.9)		122 (14.8)	111 (21.3)	
Eating breakfast	Regular	531 (45.3)	282 (44.6)	6.58 (.079)	976 (73.9)	574 (72.5)	2.14 (.475)	762 (92.6)	488 (89.0)	8.53 (.025)
	Irregular	135 (12.3)	54 (10.7)		94 (7.2)	47 (6.3)		12 (1.1)	17 (3.1)	
	Rare	479 (42.4)	273 (59.7)		237 (18.9)	161 (21.3)		45 (6.3)	36 (7.9)	
Fruit intake	Regular	239 (19.8)	104 (16.3)	5.26 (.167)	489 (35.1)	235 (29.0)	9.72 (.023)	362 (42.6)	219 (40.0)	1.00 (.684)
	Irregular	772 (67.5)	404 (68.1)		722 (56.6)	464 (60.3)		366 (46.8)	266 (49.5)	
	Rare	134 (12.7)	101 (15.6)		96 (8.3)	83 (10.7)		91 (10.6)	56 (10.5)	
Vegetable intake	Regular	1,101 (96.3)	597 (97.7)	5.12 (.108)	1,297 (99.1)	777 (99.6)	1.63 (.225)	814 (99.4)	537 (99.0)	2.75 (.264)
	Irregular	44 (3.7)	11 (2.1)		10 (0.9)	5 (0.4)		3 (0.4)	4 (1.0)	
	Rare	0 (0.0)	1 (0.2)		0 (0.0)	0 (0.0)		2 (0.2)	0 (0.0)	
Not eating out	Rarely eat out	321 (28.4)	154 (24.4)	11.88 (.011)	571 (42.4)	328 (38.2)	4.65 (.161)	599 (69.6)	402 (73.9)	5.17 (.126)
	Occasionally eat out	592 (52.2)	296 (49.2)		548 (42.4)	331 (43.8)		191 (26.5)	129 (24.1)	
	Frequently eat out	232 (19.4)	159 (26.4)		188 (15.2)	123 (18.0)		29 (43.9)	10 (2.0)	
Aerobic physical activity	Practicing	577 (51.7)	314 (53.9)	2.90 (.368)	522 (40.1)	303 (39.7)	1.89 (.462)	241 (31.9)	145 (26.7)	4.30 (.215)
	Occasionally practicing	269 (22.8)	120 (19.3)		331 (24.9)	180 (22.7)		175 (21.3)	111 (22.4)	
	Not practicing	299 (25.5)	175 (26.8)		454 (35.0)	299 (37.6)		403 (46.8)	285 (50.9)	
Walking	Practicing	541 (47.4)	264 (43.8)	6.01 (.141)	577 (43.2)	313 (39.7)	2.43 (.415)	406 (50.5)	235 (46.0)	11.78 (.008)
	Occasionally practicing	395 (34.1)	201 (32.8)		476 (36.5)	293 (38.5)		256 (32.8)	166 (29.7)	
	Not practicing	209 (18.5)	144 (23.4)		254 (20.3)	176 (21.8)		157 (16.7)	140 (24.3)	
Weight training	Practicing	132 (13.0)	74 (13.7)	6.67 (.078)	161 (12.5)	67 (8.7)	15.63 (.002)	119 (15.1)	58 (11.8)	3.83 (.268)
	Occasionally practicing	236 (21.0)	95 (16.0)		204 (16.0)	88 (12.0)		60 (8.0)	39 (6.9)	
	Not practicing	777 (66.0)	440 (70.3)		942 (71.5)	627 (79.3)		640 (76.9)	444 (81.3)	

†Weighted %.
‡Rao–Scott chi-square test.

Obesity-related health behavior networks among obese and non-obese groups by life cycle stage

Table 4 and Figure 1 show obesity-related health behavior networks among obese and non-obese groups by life cycle stage. For young adults, the network of obesity-related health behaviors in the non-obese group showed a density of 0.71, inclusiveness of 0.90, and an average degree of 6.40. The degree, closeness, and betweenness centralities for vegetable intake, not smoking, proper sleep, and alcohol abstinence were 0.89, 1.00, and 0.03, respectively, indicating the highest values. This suggests that these behaviors have numerous connections with other health behaviors, are positioned closely within the network, and act as the shortest paths connecting other behaviors. Conversely, the obese group's network had a density of 0.18, inclusiveness of 0.90, and an average degree of 1.60. For this group, the degree, closeness, and betweenness centralities for vegetable intake were the highest at

Table 4. Obesity-Related Health Behavior Networks According to Obesity Status by Life Cycle Stage (*N*=5,203)

Characteristics	Young adult				Middle-aged				Older adult			
	Non-obese		Obese		Non-obese		Obese		Non-obese		Obese	
Density	0.71		0.18		0.80		0.38		0.49		0.16	
Inclusiveness	0.90		0.90		0.90		0.90		0.80		0.50	
Average degree	6.40		1.60		7.20		3.40		4.40		1.40	
Degree centrality (degree)	Vegetables	0.89 (8)	Vegetables	0.89 (8)	Vegetables	0.89 (8)	Vegetables	0.89 (8)	Vegetables	0.78 (7)	Vegetables	0.44 (4)
	Not smoking	0.89 (8)	Proper sleep	0.11 (1)	Breakfast	0.89 (8)	Breakfast	0.67 (6)	Breakfast	0.78 (7)	Breakfast	0.33 (3)
	Proper sleep	0.89 (8)	Not smoking	0.11 (1)	Not smoking	0.89 (8)	Not smoking	0.55 (5)	Not eating out	0.78 (7)	Not eating out	0.33 (3)
	AA	0.89 (8)	Walking	0.11 (1)	Proper sleep	0.89 (8)	Not eating out	0.44 (4)	Not smoking	0.67 (6)	Not smoking	0.33 (3)
	Walking	0.78 (7)	Aerobic PA	0.11 (1)	AA	0.89 (8)	Proper sleep	0.44 (4)	AA	0.55 (5)	AA	0.11 (1)
	Aerobic PA	0.78 (7)	AA	0.11 (1)	Fruit	0.89 (8)	AA	0.33 (3)	Proper sleep	0.55 (5)	Proper sleep	0
	Fruit	0.78 (7)	Fruit	0.11 (1)	Not eating out	0.89 (8)	Fruit	0.22 (2)	Fruit	0.44 (4)	Fruit	0
	Not eating out	0.78 (7)	Not eating out	0.11 (1)	Walking	0.89 (8)	Aerobic PA	0.11 (1)	Walking	0.33 (3)	Walking	0
	Breakfast	0.44 (4)	Breakfast	0.11 (1)	Aerobic PA	0.89 (8)	Walking	0.11 (1)	Aerobic PA	0	Aerobic PA	0
	Weight training	0	Weight training	0	Weight training	0	Weight training	0	Weight training	0	Weight training	0
Closeness centrality	Vegetables	1.00	Vegetables	1.00	Vegetables	1.00	Vegetables	1.00	Vegetables	1.00	Vegetables	1.00
	Not smoking	1.00	Proper sleep	0.53	Breakfast	1.00	Breakfast	0.80	Breakfast	1.00	Breakfast	0.80
	Proper sleep	1.00	Not smoking	0.53	Not smoking	1.00	Not smoking	0.73	Not eating out	1.00	Not eating out	0.80
	AA	1.00	Walking	0.53	Proper sleep	1.00	Not eating out	0.67	Not smoking	0.88	Not smoking	0.80
	Walking	0.89	Aerobic PA	0.53	AA	1.00	Proper sleep	0.67	AA	0.78	AA	0.57
	Aerobic PA	0.89	AA	0.53	Fruit	1.00	AA	0.62	Proper sleep	0.78	Proper sleep	0.00
	Fruit	0.89	Fruit	0.53	Not eating out	1.00	Fruit	0.57	Fruit	0.70	Fruit	0.00
	Not eating out	0.89	Not eating out	0.53	Walking	1.00	Aerobic PA	0.53	Walking	0.64	Walking	0.00
	Breakfast	0.67	Breakfast	0.53	Aerobic PA	1.00	Walking	0.53	Aerobic PA	0.00	Aerobic PA	0.00
	Weight training	0.00	Weight training	0.00	Weight training	0.00	Weight training	0.00	Weight training	0.00	Weight training	0.00
Betweenness centrality	Vegetables	0.03	Vegetables	0.78	Vegetables	0.00	Vegetables	0.44	Vegetables	0.05	Vegetables	0.08
	Not smoking	0.03	Proper sleep	0.00	Breakfast	0.00	Breakfast	0.07	Breakfast	0.05	Breakfast	0.00
	Proper sleep	0.03	Not smoking	0.00	Not smoking	0.00	Not smoking	0.02	Not eating out	0.05	Not eating out	0.00
	AA	0.03	Walking	0.00	Proper sleep	0.00	Not eating out	0.00	Not smoking	0.01	Not smoking	0.00
	Walking	0.00	Aerobic PA	0.00	AA	0.00	Proper sleep	0.00	AA	0.00	AA	0.00
	Aerobic PA	0.00	AA	0.00	Fruit	0.00	AA	0.00	Proper sleep	0.00	Proper sleep	0.00
	Fruit	0.00	Fruit	0.00	Not eating out	0.00	Fruit	0.00	Fruit	0.00	Fruit	0.00
	Not eating out	0.00	Not eating out	0.00	Walking	0.00	Aerobic PA	0.00	Walking	0.00	Walking	0.00
	Breakfast	0.00	Breakfast	0.00	Aerobic PA	0.00	Walking	0.00	Aerobic PA	0.00	Aerobic PA	0.00
	Weight training	0.00	Weight training	0.00	Weight training	0.00	Weight training	0.00	Weight training	0.00	Weight training	0.00

AA = alcohol abstinence; aerobic PA = aerobic physical activity.

https://doi.org/10.12799/rcphn.2024.00738

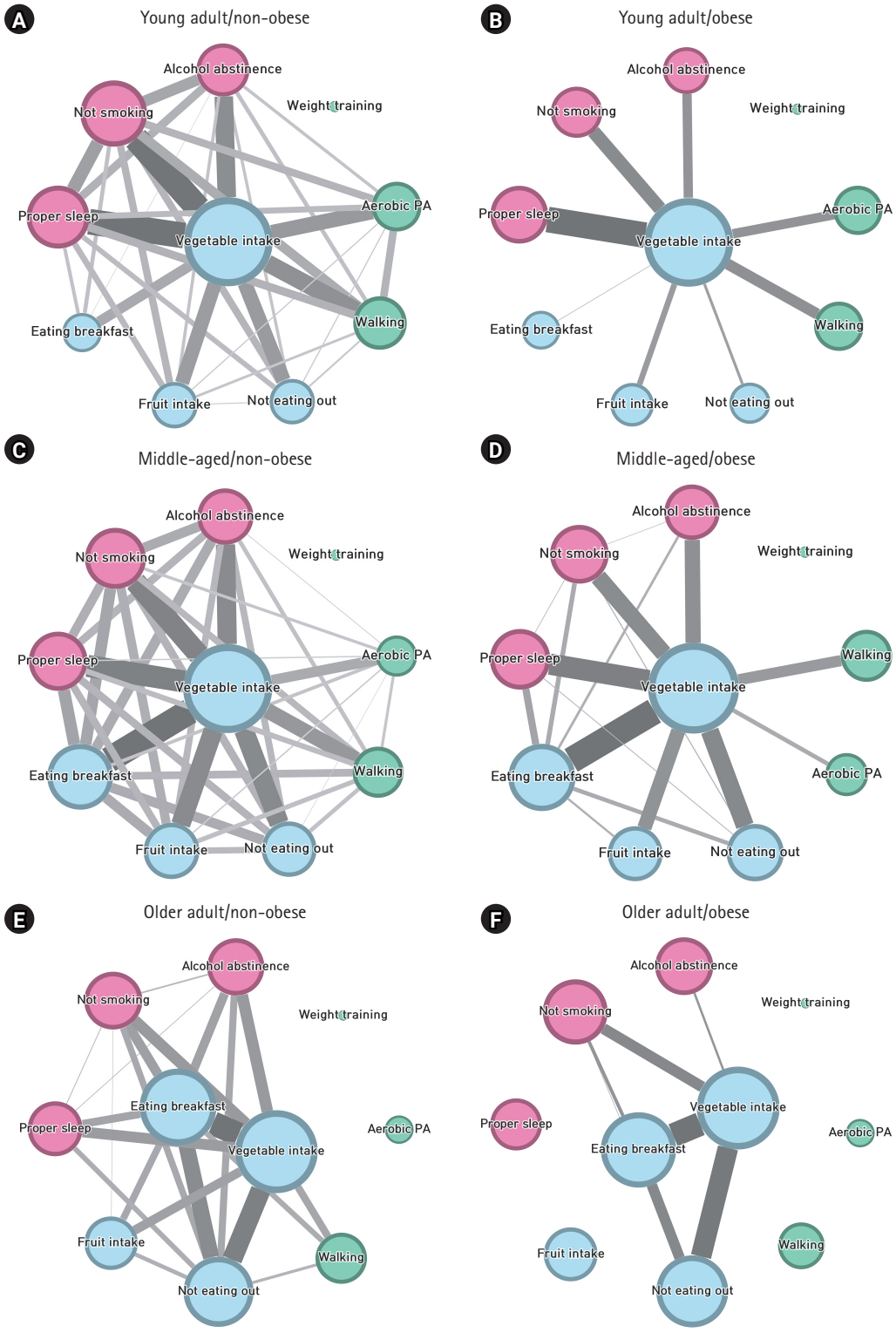

Figure 1. Obesity-related health behavior networks according to obesity status by life cycle stage
The size of the nodes represents its weighted degree in the network, which reflects the sum of the weights of all edges connected to that node. Larger nodes indicate that the node has more and stronger connections. The thickness of the edges represents the weight assigned between two nodes. Thicker edges indicate higher weighted edges in the network, signifying a stronger relationship between the two nodes. Weighted edge values less than 16.46 are omitted. (Blue nodes: eating behaviors; green nodes: physical activities; red nodes: other health behaviors). (A) Young adult/non-obese; (B)Young adult/obese; (C) Middle-aged/non-obese; (D) Middle-aged/obese; (E)Older adult/non-obese; (F) Older adult/obese.

0.89, 1.00, and 0.78, respectively. This was followed by proper sleep, not smoking, walking, aerobic physical activity, alcohol abstinence, fruit intake, not eating out, and eating breakfast, with degree, closeness, and betweenness centralities of 0.11, 0.53, and 0.00, respectively.

In the middle-aged non-obese group, the network had a density of 0.80, inclusiveness of 0.90, and an average degree of 7.20, which were higher than those of the non-obese groups in both young and older adults, indicating the strongest connections between health behaviors. The degree, closeness, and betweenness centralities for vegetable intake, eating breakfast, not smoking, proper sleep, alcohol abstinence, fruit intake, not eating out, walking, and aerobic physical activity were all 0.89, 1.00, and 0.00, respectively, indicating that these behaviors hold the same positional significance within the network. For the obese group, the network had a density of 0.38, inclusiveness of 0.90, and an average degree of 3.40. Vegetable intake had the highest degree, closeness, and betweenness centralities at 0.89, 1.00, and 0.44, respectively, followed by breakfast, with centralities of 0.67, 0.80, and 0.07, respectively.

Among older adults, the network of the non-obese group had a density of 0.49, an inclusiveness of 0.80, and an average degree of 4.40. The highest degree, closeness, and betweenness centralities were for vegetable intake, eating breakfast, and not eating out at 0.78, 1.00, and 0.05, respectively, followed by not smoking at 0.67, 0.88, and 0.01, respectively. In the network of the obese group, the density was 0.16, inclusiveness was 0.50, and the average degree was 1.40, all of which were lower than those of the obese groups in young and middle-aged adults, indicating the fewest connections between health behaviors. Vegetable intake had the highest degree, closeness, and betweenness centralities at 0.44, 1.00, and 0.08, respectively, followed by eating breakfast, not eating out, and not smoking, with degree and closeness centralities of 0.33 and 0.80, respectively.

Discussion

This study used SNA, a big data analysis method, to examine levels of adults' obesity-related health behaviors across different life cycle stages and identify the relationships between these behaviors. The main results are discussed below.

Participants' overall obesity rate was 37.6%, with 36.2%, 38.4%, and 39.2% in the young adult, middle-aged, and older adult groups, respectively—the older adult group had the highest obesity rate. This distribution is similar to the obesity rates for young, middle-aged, and older adults in 2019 and is approximately 3% higher than the overall adult obesity rate of 34.4% [32]. This increase in obesity rates is largely attributable to social distancing policies implemented during COVID-19, which led to increased time spent at home, increased consumption of delivery and high-calorie foods, and decreased physical activity [2,6]. If such changes persist, the risk of chronic diseases such as metabolic syndrome and diabetes, which are associated with obesity, could increase. It is necessary to devise proactive measures to promote healthy eating habits and increase physical activity to reduce obesity rates.

Analysis of the levels and networks of obesity-related health behaviors between the obese and non-obese groups showed that, across all life cycle stages, the non-obese group had a higher density and average degree than the obese group. In particular, in the young adult group, the density and average degree were about four times higher in the non-obese group than in the obese group, indicating the largest difference. This suggests that the obese group formed fewer connections between health behaviors, resulting in a lower level of concurrent healthy behaviors and a tendency to practice only a few health behaviors. Conversely, the non-obese group tended to engage in a broader range of concurrent health behaviors. This is similar to previous findings showing that a higher level of concurrent positive health behaviors is associated with a lower incidence of obesity [14]. It can be inferred that non-obese participants maintained their weight partly because they engaged in higher levels of concurrent health behaviors. It is necessary to develop strategies to improve the overall level of obesity-related health behaviors among people with obesity to make their network structures more similar to those of non-obese groups.

Regarding the obesity-related health behavior levels and networks of young adults, the practice levels and centrality of not eating out and eating breakfast were lower than those of middle-aged and older adult participants. Notably, the obese group among young adults ate out more frequently than the non-obese group. This aligns with previous studies that found that adults who skipped breakfast tended to have higher obesity rates than those who ate breakfast regularly [36] and that higher obesity rates were associated with an increased frequency of consuming delivered food [37]. Previous research [38,39] suggests that young adults tend to spend more time away from home and prefer consuming delivered or processed foods to save time, often skipping breakfast. However, vegetable intake, not smoking, alcohol abstinence, and proper sleep showed high centrality due to their strong connections with other health behaviors. Building obesity management strategies around these behaviors could

positively influence other health behaviors, leading to an overall improvement in health behaviors.

Regarding obesity-related health behavior levels and networks among middle-aged adults, the obese and non-obese groups exhibited a higher density and average degree than the other age groups. This means the overall practice levels of obesity-related health behaviors were higher among middle-aged adults. Middle age is a period of preparing for entry into older adulthood, during which motivation to maintain health may increase [40], contributing to the practice of health behaviors such as regular exercise and healthy eating habits [16]. However, for young and middle-aged adults, the rates and network centrality of not smoking and alcohol abstinence were lower in the obese group than in the non-obese group. This finding is consistent with previous studies showing that among adults aged 20–39, the obese group had higher rates of heavy drinking and smoking than the non-obese group and that the rate of binge drinking at least once a week was the highest among obese women in their 40s and 50s [4,12]. Alcohol consumption and smoking are well-known health-risk behaviors that often occur together [16]. Therefore, it can be inferred that the low rates of both not smoking and alcohol abstinence, along with their lower centralities, are related in the obese groups of both young and middle-aged adults. Additionally, in the middle-aged obese group, the high centrality of vegetable intake and eating breakfast suggests that focusing obesity management interventions on these behaviors could lead to improvements in other health behaviors as well.

In the analysis of obesity-related health behavior levels and networks among older adults, the obese and non-obese groups both exhibited the lowest density and average degree. Thus, obesity-related health behaviors are generally rare among older adults. With age, hormonal changes and decreased bone mass lead to a decline in physical function, resulting in reduced physical activity [9,41]. This makes it more challenging for older adults to practice obesity-related health behaviors compared with younger and middle-aged adults. Therefore, future research should consider the characteristics of older adults by referring to studies showing differences in lifestyle clusters based on the presence of underlying diseases [42]. Additionally, among the obesity-related health behaviors of older adults, centrality was the highest for vegetable intake, eating breakfast, and not eating out. Nevertheless, the levels and centralities of proper sleep, walking, aerobic physical activity, and weight training were lower than those in the other age groups. This finding partially reflects Noh and Park [46], who found that older adults had higher rates of physical inactivity and inadequate sleep among their lifestyle clusters. Furthermore, previous studies have shown a significant negative correlation between sleep duration and BMI, with a higher risk of obesity associated with shorter sleep duration [43,44]. In particular, in the obesity-related health behavior network of older adults with obesity, proper sleep and physical activity–related behaviors were not connected to other behaviors, indicating very limited interrelationships. Therefore, when designing obesity-management programs for older adults, obesity-related health behaviors with low centrality, which exhibit few interrelationships with other behaviors and are independent, necessitate individual strategies to improve each behavior.

This study has some limitations. First, as a secondary data analysis study using raw data from KNHANES, obesity-related health behaviors such as sleep quality [45], average daily food intake [46], snacking, and meal regularity [47] were not included in the survey and, therefore, could not be analyzed. This underscores the need for a comprehensive study design that considers a wide range of obesity-related health behaviors and employs methods such as block modeling or group analysis to deeply examine the characteristics of networks across different life stages. Second, this study categorized participants into non-obese and obese groups based on a BMI of 25kg/m^2, without considering underweight groups. Therefore, further research is needed to analyze obesity-related health behaviors by including diverse obesity indicators, such as body fat percentage and waist circumference, and by dividing participants into underweight, normal-weight, and obese groups.

Despite these limitations, this study has significant implications owing to its use of SNA to identify the networks of obesity-related health behaviors by life cycle stage. First, this study was based on large-scale national data. Using SNA, it structured the data and reaffirmed the findings of previous obesity-related studies, thereby objectifying the data. This approach helped verify and reinforce existing research results, yielding reliable, representative findings. Second, the study visually confirmed the overall relationship patterns of obesity-related health behaviors through SNA, thereby providing crucial insights for obesity prevention and management. In particular, by comparing the connectivity and centrality of health behaviors across life cycle stages, this study provides foundational data for suggesting effective obesity-management strategies tailored to different life cycle stages.

Conclusions

This study used data from the third year of the eighth KNHANES (2021) to examine differences in obesity-related health

behavior levels by life cycle stage and identify networks of obesity-related health behaviors. It aimed to provide foundational data for the development of life cycle–specific obesity-management programs. The results indicated that, owing to the COVID-19 pandemic, changes in dietary habits and decreases in physical activity significantly increased obesity rates among adults. Additionally, the networks of obesity-related health behaviors for young, middle-aged, and older adults showed that the non-obese group had higher levels of concurrent health behaviors than the obese group. It is necessary, then, to improve the overall level of obesity-related health behaviors among individuals with obesity at each life cycle stage. In the network of obesity-related health behaviors among young adults, the centralities of vegetable intake, not smoking, alcohol abstinence, and proper sleep were higher. Therefore, focusing obesity management interventions on these behaviors could positively impact other health behaviors, contributing to an overall improvement in healthy practices. The network of obesity-related health behaviors among middle-aged adults showed that both the obese and non-obese groups had higher overall levels of health behavior practices than the other age groups. In addition, among the middle-aged obese group, the centralities of vegetable intake and eating breakfast were high. Therefore, focusing obesity management interventions on these behaviors could potentially improve other health behaviors as well. Conversely, the network of obesity-related health behaviors among older adults showed that both the obese and non-obese groups had lower overall levels of health behavior practices. In particular, in the network structure of older adults with obesity, proper sleep and physical activity–related behaviors had few interrelationships with other behaviors, indicating the need for individual strategies to improve each behavior.

Thus, there are differences in the levels and network structures of obesity-related health behaviors according to life cycle stage, and differentiated obesity-management strategies are required for each stage. It is suggested that strengthening high-centrality obesity-related health behaviors in young and middle-aged adults can lead to positive ripple effects on other health behaviors. In older adults, however, individualized strategies for improving independent health behaviors should be considered for comprehensive obesity management.

ORCID

Seung-bin Park, https://orcid.org/0009-0000-3057-2905
Insoon Kang, https://orcid.org/0000-0002-3637-2549

Conflict of interest

The authors declared no conflict of interest.

Funding

None.

Authors' contributions

Seung-bin Park contributed to conceptualization, data curation, formal analysis, methodology, visualization, writing - original draft, review & editing, resources, supervision, and validation. Insoon Kang contributed to conceptualization, methodology, and writing - review & editing.

Data availability

Please contact the corresponding author for data availability.

Acknowledgments

This article is a revision of the first author's master's thesis from Pusan National University.

References

1. World Health Organization. Obesity and overweight [Internet]. Geneva: World Health Organization. 2021 [cited 2023 Mar 14]. Available from: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight
2. Korea Disease Control and Prevention Agency. Korea health statistics plus: In-depth report on adult obesity based on the Korea national health and nutrition examination survey. Research report. Cheongju: Korea Disease Control and Prevention Agency; 2022 December. Report no.: 11-1352159-001174-12.
3. Baek SH, Lee MS, Shin JE. Comparison of characteristics by obesity types classified based on body mass index and waist circumference of Korean adults. Journal of Converging Sport and Exercise Sciences. 2022;20(2):69–82. https://doi.org/10.22997/jcses.2022.20.2.69
4. Lee KW. The associated factors of obesity and severe obesity in young adults with a focus on health habits, mental health and chronic diseases: Data from community health survey, 2019. Journal of the Korea Convergence Society. 2021;12(9):

351–360. https://doi.org/10.15207/JKCS.2021.12.9.351
5. Baik IK. Forecasting obesity prevalence in Korean adults for the years 2020 and 2030 by the analysis of contributing factors. Nutrition Research and Practice. 2018;12(3):251–257. https://doi.org/10.4162/nrp.2018.12.3.251
6. Chew HSJ, Lopez V. Global impact of COVID-19 on weight and weight-related behaviors in the adult population: A scoping review. International Journal of Environmental Research and Public Health. 2021;18(4):1876. https://doi.org/10.3390/ijerph18041876
7. Small M, Bailey-Davis L, Morgan N, Maggs J. Changes in eating and physical activity behaviors across seven semesters of college: Living on or off campus matters. Health Education and Behavior : The Official Publication of the Society for Public Health Education. 2013;40(4):435–441. https://doi.org/10.1177/1090198112467801
8. Lanoye A, Brown KL, LaRose JG. The transition into young adulthood: A critical period for weight control. Current Diabetes Reports. 2017;17(11):114. https://doi.org/10.1007/s11892-017-0938-4
9. Korean Society for the Study of Obesity. Clinical practice guidelines for obesity 2022. 8th ed. Seoul: Korean Society for the Study of Obesity; 2022. 268 p.
10. The Study of Obesity and Metabolic Syndrome. Useful knowledge of obesity treatment to know. Seoul: Korean Medical Publishing; 2021. 400 p.
11. Lee YJ, Kang JW, Kim JY, Nah EH, Kim YR, Ko KS, et al. Clustering of health risk behaviors for chronic diseases in Korean adults. Korean Journal of Health Education and Promotion. 2017;34(3):21–31. https://doi.org/10.14367/kjhep.2017.34.3.21
12. Jeon HO. The influence of drinking, stress, and sleep on depression of Korean obese women by different age groups. Journal of Korean Public Health Nursing. 2017;31(3):451–463. http://doi.org/10.5932/JKPHN.2017.31.3.451
13. Choi JY, Park YM, Choi DJ, Ha YO. Factors influencing the quality of sleep in Korean adults by age groups. Journal of East-West Nursing Research. 2019;25(1):17–25. https://doi.org/10.14370/JEWNR.2019.25.1.17
14. Heo JH. Associations between multiple health-promoting behaviors and obesity among Korean adults. Journal of Wellness. 2020;15(4):889–904. http://doi.org/10.21097/ksw.2020.11.15.4.889
15. Park SH. An Association Rule Mining-Based Framework for Understanding Lifestyle Risk Behaviors [dissertation]. Seoul: Seoul National University; 2014. 149 p.
16. Gu HM, Ryu SY, Park J, Choi SW, Han MA, Shin JH. Clustering of healthy behaviors and related factors among 19-64 aged Korean adults. Journal of Health Informatics and Statistics. 2021;46(3):267–275. https://doi.org/10.21032/jhis.2021.46.3.267
17. Park SY, Shin JE. A study on the characteristics of health risk behavior in older adults with chronic joint pain using association analysis. Journal of Korean Gerontological Nursing. 2021;23(2):107–116. https://doi.org/10.17079/jkgn.2021.23.2.107
18. Livingstone KM, McNaughton SA. A health behavior score is associated with hypertension and obesity among Australian adults. Obesity. 2017;25(9):1610–1617. https://doi.org/10.1002/oby.21911
19. Loprinzi PD, Mahoney S. Concurrent occurrence of multiple positive lifestyle behaviors and depression among adults in the United States. Journal of Affective Disorders. 2014;165:126–130. https://doi.org/10.1016/j.jad.2014.04.073
20. Kwak JW, Jeon CH, Kwak MH, Kim JH, Park YS. Relationship between obesity and lifestyle factors in young Korean women: The seventh Korea national health and nutrition examination survey 2016. Korean Journal of Health Promotion. 2019;19(1):9–15. https://doi.org/10.15384/kjhp.2019.19.1.9
21. Bae NH, Kim OS. A prediction model for health promoting behavior in obese middle-aged women. Journal of Korean Academy of Fundamentals of Nursing. 2022;29(1):84–93. https://doi.org/10.7739/jkafn.2022.29.1.84
22. Serrano-Fuentes N, Rogers A, Portillo MC. The influence of social relationships and activities on the health of adults with obesity: A qualitative study. Health Expectations. 2022;25(4):1892–1903. https://doi.org/10.1111/hex.13540
23. Byrne NM, Sainsbury A, King NA, Hills AP, Wood RE. Intermittent energy restriction improves weight loss efficiency in obese men: The MATADOR study. International Journal of Obesity. 2018;42(2):129–138. https://doi.org/10.1038/ijo.2017.206
24. Witjaksono F, Prafiantini E, Rahmawati A. Effect of intermittent fasting 5:2 on body composition and nutritional intake among employees with obesity in Jakarta: A randomized clinical trial. BMC Research Notes. 2022;15(1):323. https://doi.org/10.1186/s13104-022-06209-7
25. Lee CB, Baek SS. Effects of aquabike exercise on gait ability, cardiovascular and fall-related fitness in older women with obesity. Exercise Science. 2023;32(1):33–40. https://doi.org/10.15857/ksep.2023.32.1.33
26. Bliss ES, Wong RHX, Howe PRC, Mills DE. The effects of Aerobic exercise training on cerebrovascular and cognitive

function in sedentary, obese, older adults. Frontiers in Aging Neuroscience. 2022;14:892343. https://doi.org/10.3389/fnagi.2022.892343
27. Winters-Stone KM, Medysky ME, Stoyles S, Bumgarner L, Witzke K. A brief whole-body vibration intervention to avoid weight gain in college students: A randomized controlled pilot trial. Journal of American College Health. 2022;70(4):1010–1018. https://doi.org/10.1080/07448481.2020.1784179
28. Kwak KY. Social network analysis. Seoul: Cheongram Publishing; 2017. 690 p.
29. Kim YH, Kim YJ. Social network analysis. Seoul: Parkyoungsa; 2016. 330 p.
30. Kim A. Effect of health behaviors, dietary habits, and psychological health on metabolic syndrome in one-person households among korean young adults. Journal of Digital Convergence. 2018;16(7):493–509. https://doi.org/10.14400/JDC.2018.16.7.493
31. Longo-Silva G, Bezerra de Oliveira PM, Pedrosa AKP, Ribeiro da Silva J, Bernardes RS, Egito de Menezes RC, et al. Breakfast skipping and timing of lunch and dinner: Relationship with BMI and obesity. Obesity Research and Clinical Practice. 2022;16(6):507–513. https://doi.org/10.1016/j.orcp.2022.10.012
32. Korea Disease Control and Prevention Agency. Korea health statistics 2021: Korea national health and nutrition examination survey (KNHANES VIII-3). Research report. Cheongju: Korea Disease Control and Prevention Agency; 2021 December. Report No.: 11-1790387-000796-10.
33. Berkman LF, Breslow L. Health and ways of living : The Alameda county study. New York, NY: Oxford University Press; 1983. 236 p.
34. Park SB, Lee MJ, Kang IS. Social network analysis of obesity-related health behavior among young adult men and women: Insights from the 2021 Korea national health and nutrition examination survey. Global Health & Nursing. 2024;14(2):134–145. https://doi.org/10.35144/ghn.2024.14.2.134
35. Han IH, Chong MY. The study on the difference of blood level of HDL-cholesterol by obesity and health behavior from the weventh (2016) Korea national health and nutrition examination survey. Journal of the Korean Society of Food Science and Nutrition. 2020;49(12):1377–1388. https://doi.org/10.3746/jkfn.2020.49.12.1377
36. Park MS, Ahn BI. Effects of Meal Regularity on Adult Obesity. Journal of Rural Development. 2016;39(3):79–122. https://doi.org/10.22004/ag.econ.330698
37. Ko MJ, Ha KH. Association of delivered food consumption with dietary behaviors and obesity among young adults in Jeju. Journal of Nutrition and Health. 2024;57(3):336–348. https://doi.org/10.4163/jnh.2024.57.3.336
38. An NY, Le MT, Park CH, Kang HS. A Comparative Study of Eating Behavior and Self-body Image, Weight Control Between Korean and Vietnamese Students. The Korea Journal of Sport. 2019;17(4):815–824.
39. Hilger J, Loerbroks A, Diehl K. Eating behaviour of university students in Germany: Dietary intake, barriers to healthy eating and changes in eating behaviour since the time of matriculation. Appetite. 2017;109:100–107. https://doi.org/10.1016/j.appet.2016.11.016
40. Cheon KI, Shin YH. Health promotion behavior, self-efficacy, marital intimacy, and successful aging in middle-aged. Journal of Korean Academy of Fundamentals of Nursing. 2020;27(3):259–267. https://doi.org/10.7739/jkafn.2020.27.3.259
41. Yoo HN, Chung E, Lee BH. The Effects of augmented reality-based Otago exercise on balance, gait, and falls efficacy of elderly women. Journal of Physical Therapy Science. 2013;25(7):797–801. https://doi.org/10.1589/jpts.25.797
42. Roh EH, Park SC. Association between clustering of lifestyle and chronic disease using healthcare big data. Journal of Health Informatics and Statistics. 2020;45(2):113–123. https://doi.org/10.21032/jhis.2020.45.2.113
43. Kim GH. Effect of quality of life, sleep time, and subjective health status on pbesity. The Journal of Humanities and Social Science. 2022;13(5):71–86. https://doi.org/10.22143/HSS21.13.5.6
44. Lee SH, Lee MJ, Seo BJ. The effect of sleep duration on obesity in Korean adults. Journal of Convergence for Information Technology. 2022;12(4):219–230. https://doi.org/10.22156/CS4SMB.2022.12.04.219
45. Fatima Y, Doi SAR, Mamun AA. Sleep quality and obesity in young subjects: A meta-analysis. Obesity Review : An Official Journal of the International Association for the Study of Obesity. 2016;17(11):1154–1166. https://doi.org/10.1111/obr.12444
46. Berg C, Forslund HB. The influence of portion size and timing of meals on weight balance and obesity. Curren Obesity Reports. 2015;4(1):11–18. https://doi.org/10.1007/s13679-015-0138-y
47. Cachelin FM, Thomas C, Vela A, Gil-Rivas V. Associations between meal patterns, binge eating, and weight for Latinas. The International Journal of Eating Disorders. 2017;50(1):32–39. https://doi.org/10.1002/eat.22580