Social Determinants of Health by Cluster of Obesogenic Behaviors in Ethnic Minority Adolescents and Korean Adolescents

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Social Determinants of Health by Cluster of Obesogenic Behaviors in Ethnic Minority Adolescents and Korean Adolescents

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"So shall I keep thy law continually for ever and ever." Psalms 119:44 (KJB)

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Mikyung Lee

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

<ABSTRACT>

Social Determinants of Health by Cluster of Obesogenic Behaviors in Ethnic Minorities Adolescents and Korean Adolescents

The obesity rate among domestic adolescents is continuing to increase annually in South Korea. The obesity rate of ethnic minority adolescents has been reported to be higher than that of Korean adolescents. Obesogenic behavior was defined as a complex set of behaviors that can cause obesity and included mainly physical inactivity, long sedentary time, and obesogenic diets. Racial differences were found to be the social determinants of health that had the greatest influence on ethnic minority adolescents' obesogenic behaviors. Therefore, the purpose of this study was to identify different behavioral patterns by analyzing and comparing the obesogenic behavior clusters of ethnic minority adolescents and Korean adolescents and identify the social determinants of health affecting their clusters.

This secondary data analysis study analyzed using the 2020 Korea Youth Risk Behavior Survey (KYRBS) data. The theoretical framework for obesogenic behaviors and related factors (social determinants of health) in this study was constructed based on the social determinant of health framework from World Health Organization (WHO).

The participants of the study included 18,001 excluding the missing values of unresponsive people (e.g., lack of information regarding parents' nationality, height, and weight); the participants consisted of 539 ethnic minority adolescents and 17,462 Korean

adolescents. The obesogenic behaviors consisted of eight variables: two for physical inactivity, two for sedentary time, and four for obesogenic diet.

In this study, the obesity rate was 15.6% in ethnic minority adolescents and 11.2% in Korean adolescents. The cluster analysis of obesogenic behavior led to the identification of three clusters of ethnic minority adolescents and Korean adolescents. Based on the characteristics, each group was named “Inactive & unhealthy eater”, “Moderately active & unhealthy eater”, and “Active & healthy eater”. Two variables (gender and stress) were identified as social determinants of health affecting the obesogenic behavior clusters of ethnic minority adolescents. For Korean adolescents, gender, age, economic status, academic performance, sleep time, depression, stress, width of park, and the number of fast food restaurants were significant.

This study showed the higher level of obesogenic behaviors of ethnic minority adolescents compared to that of Korean adolescents, indicating the need of ethnicity minority adolescents specific interventions for preventing and managing the risk of obesity. It is worthy to note that the current study found three different obesogenic behavior clusters by considering the simultaneous and complex behavioral patterns rather than a single obesogenic factor and also attempted to examine the influence of social determinants of health on obesogenic behavior clusters, encompassing structural factors as well as material circumstances.

Keywords: Obesogenic behavior, Ethnic minority, Adolescent, Social determinant of health, Cluster

Chapter 1. Introduction

1. 1 Significance of the Study

The prevalence of obesity among Korean children and adolescents increases as they progress from elementary to middle school and from middle school to high school, with the prevalence of obesity increasing annually (Ministry of Education, 2019). Despite government policy efforts to reduce the prevalence of obesity, the obesity rate among middle school students in 2020 was 10.9%, the highest rate of year-over-year growth in obesity rates in the past five years (Korea Health Promotion Institute, 2021). Meanwhile, in the ethnic minority adolescent population, the proportion among the total adolescents is increasing yearly, just like the prevalence of obesity. The proportion of ethnic minority adolescents has tripled in 7 years from 0.70% (13,036 persons) in 2012 to 2.52% (32,927 persons) in 2019 (Statistics Korea, 2020). Since the proportion of ethnic minority adolescents among domestic adolescents continues to increase and emerge as an important population, it is necessary to pay attention to research on the health of ethnic minority adolescents.

The obesity rate among ethnic minority adolescents in Korea was reported to be higher than that of Korean adolescents (with Korean -born parents of Korean nationality; Song & Kim, 2019; Song, 2020). In the case of ethnic minority adolescents in foreign countries, it has been consistently reported that the obesity and overweight rate is higher

than that of native adolescents (Labree et al., 2015). In the UK, children from black and Asian backgrounds had a higher rate of overweight and obesity, and obese children were three times more likely to exhibit obesogenic behaviors than white people(Falconer et al., 2014). The evidence of obesity rate among ethnic minority adolescents have shown to be an international phenomenon (Hayba et al., 2020). It is generally agreed that migration to developed countries appears to increase the risk of obesity(Menigoz et al., 2016). The socio-economic status of immigrants is lower than that of the native population, which can affect this risk (Delavari et al., 2014). In addition, this increase in risk can be caused by changes in physical inactivity, more sedentary time, and changes in dietary intake, which are the result of westernized dietary patterns(Méjean et al., 2009). Therefore, it has been continuously reported that ethnic minority groups settled as immigrants are obese due to their low socioeconomic position and have a high obesity rate.

In various studies, obesity has been considered a consequence of multiple lifestyle patterns and health risk behaviors (Liberali et al., 2021). Although scholars have different definitions of *obesogenic behaviors*, in general, the most recognized are physical inactivity, sedentary time, and obesogenic diet (Fleary& Freund, 2018). According to previous studies, obesogenic behaviors include participation in moderate and vigorous intensity physical activities (Donnelly et al., 2009), while sedentary time includes watching television, playing computer games, and using the Internet (Leech et al., 2014), obesogenic diet indicated less fruit and vegetables and more intakes of energy-dense foods (Fleary, 2017).Obesogenic behaviors refer to activities associated with an increased risk of obesity,

including physical inactivity, long sedentary time, and obesogenic diet (Fleary& Freund, 2018), the occurrence of healthy and unhealthy behaviors (Liberali et al., 2021).For example, the behavioral pattern of adolescents who frequently practice vigorous-intensity physical activity(VPA) and have a long sedentary time is one of the common obesogenic behavioral patterns (Matias et al., 2018).Thus, it is crucial to examine the behavioral factors affecting obesity from a complex point of view. In addition, as human behavior can be reflected in health outcomes with combined rather than individual effects, a pattern analysis such as cluster analysis is necessary. This can better explain the complexity of obesogenic behavior patterns rather than simply analyzing risk factors with one or two variables (Fleary, 2017; Schröder et al., 2017).

Obesogenic behaviors are particularly affected by social determinants of health such as gender, race/ethnicity, income, public policy on obesity, and material circumstances (Fleary& Freund, 2018). In addition, sleep time(behaviors and biological factors) and stress(psychosocial factors) are also known as social determinants of health affecting obesogenic behaviors(Liberali et al., 2021). Another study on these social determinants of health demonstrated that the obesogenic behaviors of ethnic minority adolescents owing to racial differences were more pronounced than other factors (Fleary, 2017).In Korea, adolescents' obesogenic behaviors and the social determinants of health related to their socioeconomic position and material circumstances have been conducted using a Hierarchical Linear Model (HLM) analysis (S. Kim et al., 2021). However, the risk of obesity was analyzed including only the school environment among material

circumstances, and Korean adolescents. Recent studies using cluster analysis of Korean adolescents' obesogenic behaviors and the social determinants of health, there have been no material circumstances and no comparison of ethnic minority adolescents (Lee & La, 2021). Therefore, there is a need for a study that reflects material circumstances in social determinants of health that affect obesogenic behaviors in ethnic minority adolescents.

To our knowledge, since differences in obesogenic behaviors by clusters and social determinants of health affecting the clusters of ethnic minority adolescents compared to Korean adolescents have been reported, it is necessary to check the obesogenic behaviors of ethnic minority adolescents in this study. The cluster of obesogenic behaviors is expected to provide cluster-specific interventions for obesity prevention. According to a recent study, the severe consequences of the Coronavirus disease 2019 (COVID-19) pandemic instigated a change in obesogenic behaviors (Ghanemi et al., 2020). Adolescents in Korea have increased their BMI levels while their physical activity levels have decreased due to COVID-19 in 2020 (Kim, Kwon et al., 2021). Given the pandemic-driven disparities in society, the economy, and education being observed worldwide, it is necessary to examine the social determinants of health that affect differences in obesogenic behaviors among ethnic minority adolescents and Korean adolescents.

1.2 Purpose of the Study

This is a secondary data analysis study aimed to explore the clusters of obesogenic behaviors (physical inactivity, sedentary time, obesogenic diet) of ethnic minority

adolescents and Korean adolescents and to examine the correlation between such characteristics and social determinants of health in each cluster. The specific aims are as follows:

First, to describe the differences between obesogenic behaviors and social determinants of health of ethnic minority adolescents and Korean adolescents.

Second, to identify the clusters of obesogenic behavior in ethnic minority adolescents and Korean adolescents.

Third, to explore in characteristics of obesogenic behaviors by cluster among ethnic minority adolescents and Korean adolescents.

Fourth, to identify the social determinants of health that influence clusters of obesogenic behaviors among ethnic minority adolescents and Korean adolescents and to identify the differences between ethnic minority and Korean adolescent clusters.

Lastly, to explore the correlation in obesity classification and each cluster to confirm the validity of the clusters of obesogenic behaviors among ethnic minority adolescents and Korean adolescents.

1.3 Research Hypotheses

The hypothetical model of this study aimed to examine the social determinant characteristics of health within clusters of obesogenic behaviors among Korean adolescents.

Hypothesis 1: There would be differences found in obesogenic behaviors and social

determinants of health between the ethnic minority and Korean adolescent clusters.

Hypothesis 2: The obesogenic behaviors (physical inactivity, sedentary time, obesogenic diet) of the ethnic minority adolescents and Korean adolescents would each be categorized into clusters that demonstrated similar behavioral patterns.

Hypothesis 3: There would be differences found in the characteristics of the obesogenic behaviors of each cluster among the ethnic minority adolescents and Korean adolescents.

Hypothesis 4: There would be differences found in the social determinants of health that influence the clusters of obesogenic behaviors among the ethnic minority adolescents and Korean adolescents.

Hypothesis 5: There would be a statistically significant difference found in obesity classification for each cluster of obesogenic behaviors among the ethnic minority adolescents and Korean adolescents.

1.4 Definitions of Concepts

1.4.1 Ethnic minority adolescents

Theoretical definition: A multi-cultural family is defined by the Ethnic minority Families Support Act as “a family comprised of a married immigrant […] and a person who acquired the nationality of the Republic of Korea by birth” or “a family comprising a person who had obtained permission for naturalization […] and a person who acquired the

nationality of the Republic of Korea by birth." (Ministry of Justice, 2015).

Operational definition: In this study, ethnic minority adolescents are defined as persons whose parents' country of birth is a foreign nation according to Korea Youth Risk Behavior Survey(KYRBS).

1.4.2 Korean adolescents

Theoretical definition: According to the Dictionary by Merriam Webster, "Korean " is defined as "a Korean or inhabitant of Korea " ("Korean ", 2022).

Operational definition: In this study, Korean adolescent refers to a person whose parents are of Korean nationality according to the Korea Youth Risk Behavior Survey(KYRBS).

1.4.3 Obesogenic behaviors

Theoretical definition: Obesogenic behaviors refer to activities associated with an increased risk of obesity, including physical inactivity, long sedentary time, and obesogenic diet (Fleary & Freund, 2018), the occurrence of healthy and unhealthy behaviors (Liberali et al., 2021).

Operational definition: The eight factors related to physical activity, sedentary time, and obesogenic diet included in the Korea Youth Risk Behavior Survey(KYRBS) are defined as obesogenic behaviors. Obesogenic behaviors mean 'physical inactivity or long

sedentary time or unhealthy diet (skipping breakfast, eating less fruit, drinking unhealthy drinks; carbonated or sugary, Descriptions of specific factors are provided below.

1.4.3.1 Physical inactivity

Theoretical definition: The recommendations of American College of Sports Medicine (ACSM) for adolescent physical activity include at least 60 minutes of daily moderate and vigorous intensity physical activities combined. Moderate intensity physical activity is defined as an activity that increases respiration, perspiration, and heart rate, while vigorous intensity physical activity is defined as an activity that significantly increases respiration, perspiration, and heart rate (ACSM, 2015). Physical inactivity in adolescents defined as less than 60 minutes of moderate to vigorous intensity activity daily (WHO, 2012).

Operational definition: There were two variables in the Korea Youth Risk Behavior Survey(KYRBS) of moderate and vigorous intensity physical activity: whether an individual "spent 60 minutes or longer per day engaging in a physical activity that left them out of breath in the past seven days," or "20 minutes or longer per day engaging in a physical activity that left them considerably out of breath or sweaty in the past seven days,". The number of days was classified into the number of days spent engaging in moderate intensity physical activity and the number of days spent engaging in vigorous intensity physical activity.

1.4.3.2 Sedentary time

Theoretical definition: Sedentary lifestyle refers to activities done while sitting or lying down, such as watching television, playing video games, or computer or smartphone use, and is associated with negative health outcomes such as obesity and childhood obesity (de Araújo et al., 2018). Sedentary time refers to time spent engaging in a sedentary lifestyle.

Operational definition: Two variables in the Korea Youth Risk Behavior Survey(KYRBS) dealt with sedentary time, referring to the average time spent sitting during a weekday or weekend for purposes other than learning in the past seven days.

1.4.3.3 Obesogenic diet

Theoretical definition: Diet related to obesity included factors such as "consumption of sugary drinks, consumption of each food cluster (fish, fruits, vegetables, dairy products), eating behavior pattern, meal quality, skipped meals, and the frequency of meals or snacks" (Mohammadi et al., 2019).

Operational definition: Five items in the Korea Youth Risk Behavior Survey(KYRBS) were dedicated to an obesogenic diet, involving the number of days eating breakfast, as well as the number of times eating fruits, carbonated drinks, sugary drinks, and fast food.

1.4.4 Social determinants of health

Theoretical definition: The Commission on Social Determinants of Health (CSDH) defines social determinants of health as "factors that shape health outcomes in the processes in which individuals are born, grow, live, work, and age" (WHO, 2008). The social determinants of health are broadly classified into *structural determinants* of social health inequality (hereinafter referred to as structural determinants) and *intermediary determinants* of health (hereinafter referred to as intermediary determinants, Solar & Irwin, 2010). *Structural determinants* defined that generate stratification and social class divisions in the society and that determine individual socioeconomic position within hierarchies of power, prestige and access to resources. *Intermediary determinants* was defined as specific health-related factors that exist between structural factors and health outcomes with four categories; behaviors and biological factors, psychosocial factors, material circumstances and the health system (Solar & Irwin, 2010).

Operational definition: Social determinants of health were included in the Korea Youth Risk Behavior Survey(KYRBS) and were largely categorized into structural and intermediary determinants for this study's purposes. *Structural determinants (socioeconomic position)* included gender, age, parental nationality, parental educational level, and economic status. *Intermediary determinants* included behaviors and biological factors (sleep time and academic performance), psychosocial factors (stress, depressive symptom, and self-rated health), and material circumstances (poverty rate, city size, width of parks, number of public sports facilities, number of snack bars, number of convenience

stores, number of fast food restaurants, and number of Internet cafe) in the Korea Youth Risk Behavior Survey (KYRBS).

Chapter 2. Literature Review

2.1 Demographic Characteristics and Obesity

According to the 2021 adolescent statistics (Statistics Korea, 2022), the number of Korean adolescents (9-24 years old) was 8,306,000, accounting for 16.0% of the total population. Considering the current trend of population decline, the adolescent population is expected to decrease to half the current number by 2060. Meanwhile, in the ethnic minority adolescent population, the proportion among the total adolescents is increasing yearly, just like the obesity rate. The proportion of ethnic minority adolescents has tripled in 7 years from 0.70% (13,036 persons) in 2012 to 2.52% (32,927 persons) in 2019 (Statistics Korea, 2020). In 2020, the ethnic minority school-age population (elementary, middle, and high school students) increased by 7.4% (147,000) compared to the previous year, with a continuous yearly increase of 5-12% (Statistics Korea, 2022). Since the proportion of ethnic minority adolescents among domestic adolescents continues to increase and emerge as an important population cluster, it is necessary to pay attention to research on the health of ethnic minority adolescents.

According to the 2018 report of the National Ethnic minority Families Survey, of the age distribution of adolescent children aged 9-24, elementary school students aged 9-11 accounted for the largest proportion at 45.8%, followed by middle school students aged 12-14 years old at 24.1%, high school students aged 15-17 years old at 16.4%, and those over 18 years of age at the lowest rate at 13.8%. Currently, the proportion of elementary

school students is the highest, but it is expected that the number of ethnic minority adolescents will increase sharply as they go to secondary school in the future (Ministry of Gender Equality and Family, 2019).

The obesity rate for Korean adolescents has continued to rise every year, reaching 10.9% for middle school students in 2020 (Korea Disease Control and Prevention Agency [KDCA], 2021). Compared to 2019 (9.1%), the obesity rate of middle school students (10.9%) increased sharply by 1.8% in 2020, and that of high school students increased by only 0.4%. The proportion of overweight in both middle and high school students in Korea continued to increase by 0.2-0.3% every year, but in the case of middle school students, it increased sharply by 1.2% in 2020 (10.3%) compared to 2019 (9.1%), whereas high school students showed a decrease by 0.2% in 2020 (10.0%) compared to 2019 (10.2%). This is because the number of middle school students who continued to go to school or attend private academies for the study is less than that of high school students, therefore, it is expected that the obesity rate was relatively high due to the increase in home time caused by COVID-19.

A study by Song (2020) comparing ethnic minority adolescents and Korean adolescents compared the weight status of middle and high school students from 2017 to 2018 by categorizing them into ethnic minority and Korean clusters, as a result, it was shown that ethnic minority students were more likely to be overweight by 1.22 (95% CI: 1.03 to 1.43) times than Korean students. In particular, for female students, the odds ratio for ethnic minority students becoming obese was 1.40 (95% CI: 1.10 to 1.77). Furthermore,

a study compared obesity rates among ethnic minority adolescents and Korean adolescents in Korea using the 2017 and 2018 Youth Risk Behavior Survey and revealed that the prevalence of obesity among ethnic minority adolescents (12.1%) was higher compared to that of Korean adolescents (10.2%) (Song, 2020). In particular, it has been reported that among ethnic minority adolescents, the prevalence of overweight/obesity is higher in county areas (23.2%) than in metropolitan cities (19.7%) (Song & Song, 2019). According to the analysis of obesity classification in low-income and ethnic minorities 6-13 years old in Korea, boys had a higher obesity rate than Korean children. But in terms of body fat percentage, 11.1% of girls were mild obesity, so only the relationship between weight and height was normal, but muscles were reduced and many types of ‘skinny obesity; metabolically obese, normal weight’ were observed.

In summary, ethnic minority adolescents in Korea is rapidly increasing and cannot be overlooked, and their obesity rate is higher than that of Korean adolescents. Ethnic minority adolescents had a difference in obesity rates according to their region and gender, and female students had a lot of normal weight based on BMI, but mild obesity was confirmed during body fat tests, indicating a high obesity rate.

2.2 Obesogenic Behaviors

According to the Nutrition and Physical Activity Program to Prevent Obesity and Other Chronic Diseases (NPAO), a representative obesity prevention program in the United States, the main causes of overweight and obesity can be traced to energy-related

behaviors (physical activity, sedentary behavior, eating behavior, and sleep), and this was due to an energy imbalance between caloric intake and energy expenditure (Centers for Disease Control and Prevention [CDC], 2008). In other previous studies, it was argued that all three, rather than one of physical activity, sedentary time, and obesogenic diet should be managed to prevent obesity. Consequently, a previous study suggested an increase in physical activity, sedentary time reduction, and regulation of diets we eat by eating more low-energy-dense foods such as fruits and vegetables (Harding et al., 2008). As there are differences in the definition of obesogenic behaviors between studies, obesogenic behaviors were classified into two factors: “physical activity” and “obesogenic diet”. Sedentary time, which is the opposite of physical activity, is included in physical activity in some studies. (Cabanas-Sánchez et al., 2018).

Obesogenic behaviors are mainly explained as a concept combining three factors: physical activity, sedentary time, and obesogenic diet (Fleary& Freund, 2018). Factors included in obesogenic behaviors varied among studies, but the diet was the most extensive factor. Not just dietary items (e.g., eating fruits and vegetables, drinking sugary drinks, etc.) or frequency (once a day, once a week, etc.), but also the dietary habit (e.g., disinhibited eating), the frequency of meals with families, physical activity, and sedentary behavior were defined (Rachel & Amy, 2013). Other researchers defined obesogenic behaviors by adding sleep deprivation in addition to sedentary time and dietary variables (Stahlmann et al., 2020). Obesogenic behavior included several factors other than energy-related variables that directly affected obesity.

In summary, obesogenic behavior was mainly composed of three behaviors. Variables that could explain obesogenic behaviors were selected: physical inactivity, sedentary time, and obesogenic diet. Specific variables of three behaviors and other variables of obesogenic behavior were described from 2.2.1.

2.2.1 Physical inactivity

Physical inactivity is a concept corresponding to energy consumption in obesogenic behaviors and has been used as a major variable in obesity prevention and management. In foreign literature, the International Physical Activity Questionnaire (IPAQ, 2004) was referred to as the computer-based-Physical Activity Questionnaire (cPAQ), a measurement tool, that was used to measure physical activity. Physical activity has also been measured with an objective tool like a pedometer or smartwatch (Daly, Foote & Wadsworth, 2017) that either self-reported or automatically records the amount of physical activity through a portable device according to international adolescent survey standards or guidelines. However, in this study, the survey response values already investigated were analyzed.

physical activity as representative obesogenic behavior are moderate-intensity physical activity (MPA), vigorous-intensity physical activity (VPA), moderate to vigorous physical activity (MVPA) (Department of Health and Ageing, 2004; Leech et al., 2014; Tassitano et al., 2020), and active commuting to school (Tassitano et al., 2020), which have been used in the study of adolescent obesogenic behaviors. Besides, the question of

whether MVPA was performed for at least 60 minutes per day according to the guidelines of the CDC (CDC, 2018) or whether MVPA was performed at least 60 days per week for 5 days or more according to the guidelines of the Youth Risk Behavior Surveillance System (YRBSS), PA (physical activity) was used as a major variable (Nagata et al., 2022; Maenhout et al., 2020; Edwards, Mauch& Winkelman, 2011). The variables, “MPA” and “VPA” were set according to CDC and YRBSS criteria, and both were used for cluster analysis (Lee & La, 2021; Fleary, 2017).

As for the difference in PA by race, there was a cumulative report that Caucasians are the most participants in physical activity, while Asians are the least participants in physical activity (Nagata et al., 2022; Fleary, 2017). In the Korean literature, secondary data analysis studies were the most common. For physical activity, MPA was used as the main variable, and VPA or strength training (Kim, Choi & Kim, 2021; Gae, 2019; Hong, 2019; Kim, Kim &Gae, 2018) and Walking (Lee & Cho, 2017) were also included. Most of the research on the physical activity of Korean adolescents was secondary data analysis.

According to the 2020 Korea Youth Risk Behavior Survey (KYRBS) statistics (KDCA, 2021), the level of physical activity was generally higher among middle school students than high school students. For middle school students, 16-17% of the practice rate for “moderate-intensity physical activity for more than 60 minutes a day for 5 days a week” was reported every year, but the practice rate in 2020 was reported to be 12.1%. For middle school students, “high-intensity physical activity for more than 3 days a week” increased slightly from 2009 to 2016 to reach 46.7%, and then decreased continuously to 31.0% in

2020. The highest decrease in physical activity was (7.3%) between 2019 and 2020. The rate of high-intensity physical activity practice in 2020 was 40.8% for male students and 20.5% for female students. Sedentary time (time spent sitting for purposes other than learning on weekdays) was 236.9 minutes in 2020 for middle school students, a sharp increase from 171.6 minutes in 2019. Among them, the sedentary time of male students was 235.0 minutes in 2020, which increased by about 65 minutes compared to 2019, and the sedentary time of female students was 239.0 minutes in 2020, an increase of 65 minutes compared to 2019. The result of the 2017-2018 KYRBS analysis revealed that the probability of practicing physical activity more than 3 days a week was lower in ethnic minority adolescents compared to Korean adolescents (Song, 2020). It has been reported that the physical activity of ethnic minority adolescents decreases and the time of sedentary time increases, resulting in more obesogenic behaviors.

Regarding physical activity, which is an obesity-related factor among ethnic minority adolescents in Korea, 41.3% of them participate in physical activities 1-2 times a week (Sunday) and 27.8% do not participate at all; this is followed by those who participate 3-4 times a week (17.7%), 5-6 times a week (7.3%), and those who participate daily, with the lowest proportion, at 5.8% (Korea Institute of Sport Science, 2017). In another study, ethnic minority adolescents showed a lower rate of physical activity for the past 7 days than Korean adolescents (Song, 2020), and a lower rate of walking for more than 10 minutes a day was reported (Lee & Cho, 2017).

In summary, the overall physical activity rate of ethnic minority adolescents is

lower than that of Korean adolescents. As the main variable of physical activity among obesogenic behaviors, aerobic exercise rather than muscle strengthening exercise was investigated more often, and many studies analyzed moderate and vigorous intensity physical activity.

2.2.2 Sedentary time

Sedentary behavior is one of the variables of obesogenic behaviors, and the seriousness of adolescent sedentary behavior is emerging as a health risk behavior along with the development of media (Calson et al., 2012; Davis et al., 2007). The concept of sedentary behavior has changed over time. Previously, it was understood that sedentary behavior did not meet the criteria for MVPA (Brown, Bauman & Owen, 2009). Since then, the changed concept has been used collectively for sitting or lying down (Bames et al., 2012). Although sedentary and physical activity have been discussed as independent effects on health, the correlation between these behaviors is also being studied (Tassitano et al., 2020; Van Der Horst et al., 2007). Variables measured as sedentary time included TV watching, video games, computer use, and screen time (Mielde et al., 2017). The following question was asked to inquire the time for which one sits out of leisurely time on weekdays and weekends: “During weekdays, how much time do you spend per day sitting talking with friends, laying cards, speaking on phone, reading, studying (do not consider the time on television, videogame, computer, smartphone or tablet)?” (Tassitano et al., 2020). In this study, sedentary time was a major variable of obesogenic behavior,

and time other than the learning purpose of weekends and weekdays was used.

In previous studies, computer game time, game and screen viewing time, and cell phone use time was utilized for the secondary data variables: seated time per day of the week (Midlke et al., 2017; Kim, Choi & Kim, 2021) or sedentary time including weekdays and weekends (Lee & La, 2021; J. Kim, 2019; Abdullah, Teo & Foo, 2016). Among the recommended guidelines for sedentary time, the CDC limits the daily average to less than 2 hours, and in previous studies, the variable was divided into a binary of 2 hours (Lee & La, 2021; Fleary& Freund, 2018), 3 hours (Fleary, 2017), 5 hours (Leatherdale & Ahmed, 2011) or was used as a continuous variable (Kim, Choi & Kim, 2021; J. Kim, 2019). There was, however, not sufficient evidence to set a precise threshold (or 'cut-off') for the amount of sedentary time from the research on WHO guidelines (Bull et al., 2020). It was reported that the sedentary time of adolescents increased after COVID-19 (Cheval et al., 2021).A recent study analyzes the sedentary life of the teenagers of 3.1- 7.6 hours/day according to several surveysthat reported to have a sedentary time (Prince et al., 2020). In Youth Smoking Survey in Canada, even when using a conservative estimate of average screen time, the youth in the sample exceeded existing guidelines by over 5 hours per day; the daily average time for each screen-based behavior also exceeded recommendations for total screen time (Leatherdale & Ahmed, 2011). So the sedentary time standard was set to 3 hours on weekdaysand 5 hourson weekends reflecting the tendency of adolescents' to increase sedentary time on weekends (Zhao et al., 2019).

In a previous study that comparatively analyzed sedentary time by parental

nationality among ethnic minority adolescents in Korea, the sedentary time of adolescents with East Asian-born parents was shorter than that of adolescents with parents of North Korea and other countries of birth; thus, it can be expected that there are differences in the restraints and guidance on the sedentary time of children by parents' birth nationality (J. Kim, 2019).

In summary, it has been reported that adolescents' sedentary time continues to increase worldwide, and in particular, ethnic minority youth have a longer sedentary time than Korean youth. The official upper limit on sedentary time has not been set, and only the CDC's recommendation to reduce sedentary time as much as possible is known. Previous studies mainly analyzed sedentary time during weekdays.

2.2.3 Obesogenic diet

The obesogenic diet is an energy-related behavior and is a major variable in calorie intake. To measure obesogenic diet, researchers used dietary behavior questionnaires (eating breakfast, snacking, eating out, carbonated or sugary drinks, and nutritional supplements) differently each study, or the food frequency questionnaire (FFQ) were mainly used as a measurement tool (Abdullah, Teo & Foo, 2016). The tool categorizes 124 food items into 15 clusters, with 15 items being “rice and noodle dishes, cereal and wheat-based food, meat and poultry, seafood and shellfish, milk and dairy products, eggs, nuts and legumes, tuber, vegetables, fruits, local desserts, fast food, snack foods, spread and sauce, and drinks.” In addition, adolescents took pictures of the meal menu before meals,

which were then analyzed by the researchers (Daly, Foote, Wadsworth, 2017). The obesogenic diet includes more variables than other obesogenic behaviors, and its range is also being studied in various ways. Numerous research results have been reported on dietary behavior patterns such that it is sufficient to perform cluster analysis with only dietary variables. Brazilian adolescents were analyzed into three clusters: “junk food,” “healthy,” and “traditional” (Pinho et al., 2014). Lebanese adolescents were analyzed into two clusters, “traditional Lebanese” and “Western” (Naja et al., 2015), and Chinese adolescents were analyzed into three clusters: “Chinese wester,” “Westernization,” and “meat diet” (Yang et al., 2016). It can be seen that the diet defined as obesogenic behaviors derives various clusters by inputting various variables.

In the Korean literature, seven studies were analyzed using secondary data variables: the number of days without breakfast, number of eating fruits, carbonated drinks, sugary drinks, and fast food intake. As for other variables, in a study using the National Health and Nutrition Examination Survey, total calories, protein, fat, carbohydrate, and mineral intake were investigated according to the Korean Nutrient Database. As food clusters, rice, grains, ramen, bread, pizza, hamburgers, nuts, vegetables, kimchi, mushrooms, and fruits were investigated (Song et al., 2010). Other investigated ramen, sweets, milk intake, meat and salt intake, meal time (Kim et al., 2012), and intake rate (Lim et al., 2019).

Among studies on the diet of ethnic minority adolescents in Korea, several studies have reported that dietary patterns of ethnic minority adolescents are unhealthy compared

to Korean adolescents (Cho, 2015; Lee et al., 2015; Song, 2020). Ethnic minority adolescents were reported to eat fewer protein foods, fruits, and vegetables, which are healthy foods, than Korean adolescents. And Ethnic minority adolescents were found that they are more likely to eat fast food, carbonated and sugary drinks, instant noodles, and snacks, which are unhealthy diets (Choi, 2015).

In summary, as the main variables of diet among the secondary data studies on obesogenic behaviors, “skipping breakfast or eating breakfast, fruit intake, vegetable intake, sugary drinks, carbonated drinks, and fast food” were extensively used.

2.2.4 Other factors

In previous studies, factors influencing obesity include sleep (Lee & La, 2021), drug use such as marijuana (Fleary, 2017), lazatives/enemas, diuretics, diet pills (Balantekin et al., 2015), smoking (Lee & La, 2021; Naja et al., 2015), drinking (Lee & La, 2021). La, 2021), and experiences of physical violence (Lee & La, 2021; Fleary, 2017) were included in obesogenic behaviors and investigated.

Lack of sleep can increase dietary needs and opportunities by disrupting hormonal homeostasis (ghrelin and leptin) influencing obesity (Fatima et al., 2015; Pereira et al., 2015; Taheri, 2006). Sleep has become a target for obesity prevention as sleep deprivation causes Drug use has been reported to have a high association with obesity because it could activate reward circuits through dopamine hormones, similar to the mechanism of food addiction (Campana et al., 2019). Smoking was associated with low BMI because nicotine

inhibited appetite, but there was no significant correlation between adolescents and young adults (16-24 years old) (Jacobs, 2019).

The positive correlation between drinking and weight gain in adolescents has been reported consistently and it is possible that regular heavy drinking gives to the transition to obesity directly through calories from alcohol consuming, also by possibly increasing food consumption during drinking (Fazzino et al., 2017). And the BMI of adolescents exposed to physical violence, and physical or emotional abuse showed a positive correlation. Victim adolescents have a high risk of negative emotional and internalization disorders, which can contribute to binge eating and other irregular eating behaviors (Gooding et al., 2015).

In summary, health risk behaviors, safety, and damage-related factors have been included in addition to obesogenic behaviors represented by energy-related factors. The simultaneous occurrence of problematic behavior among adolescents is well documented. In addition to obesogenic behavior, overall patterns of risk or damage behavior can be identified.

2.2.5 Relationship among obesogenic behaviors

Obesogenic behaviors need to be analyzed together because not only one factor affects obesity, but interactions between behaviors occur (Leech, Sarah & Anna, 2014).

Foreign studies, especially the study by Hardy et al. (2012) show that obesogenic behaviors were measured with five variables. In other words, “low physical activity practice, long sedentary time, less fruit and vegetable intake, more carbonated drinks, and

frequent snacks intake" were investigated. As a result, it was found that about 51% of male students and 43% of female students of 1,568 Australian adolescents had three or more obesogenic behaviors in common (Hardy et al., 2012).

As a result of a systematic review study on cluster analysis of obesogenic behavior, the most frequent cluster, derived from 17 out of 55 studies, was identified as "Long sedentary time and sugary beverage" (Mello et al., 2021). Next, the high frequency cluster showed a pattern with no obesogenic behaviors as "High physical activity, intake of fruit and vegetables and short sedentary time, sugary beverage". Most of the clusters finally consisted of three clusters: a pattern in which all variables were not obesogenic behaviors, a pattern in which obesogenic behaviors were, and a complex pattern in which obesogenic behaviors and non-obesogenic behaviors were mixed.

As a result of other systematic review, in about 45% (n=25) of studies (Mello et al., 2021), obesogenic behavior variables consisted of three representative variables: physical activity, sedentary time, and obesogenic diet, and other Sleep (Collese et al., 2019) and risk behavior (Lazzeri et al., 2018) were included. As for the relationship between variables, a relationship between physical activity and healthy eating habits was reported a positive relationship. And in the case of a long sedentary time, a positive relationship with high consumption of carbonated drinks was found, confirming a consistent pattern of obesogenic behavior (Mello et al., 2021).

However, complex patterns with more than one negative behavior were found in most clusters. These characteristics suggest that a multi-component plan is needed to

improve at least two behaviors at the same time in the intervention of adolescent obesogenic behaviors. As a result of examining which of the obesogenic behaviors has the greatest effect on the risk of obesity (Kim et al., 2015), a study of 2200 European adolescents showed that TV watching(sedentary time) was an important prediction variable (Rey-Lopez et al., 2012), in contrast, in a study of 2200 Australians adolescents, physical inactivity was reported as the only risk factor for obesity (Chaput et al., 2012).

Meanwhile, as a representative social determinants of health influencing the relationship between obesogenic behaviors, three papers (Fleary, 2016; Kim et al., 2015; Maia et al., 2018;) classified male and female students, analyzed their behavioral patterns, and suggested different intervention directions. It was suggested that male students should sufficiently increase physical activity and decrease sedentary time. It has been reported that, in female students, the risk of obesity may be reduced by increasing physical activity, reducing sedentary time, or either intervention (Kim et al., 2015; Maia et al., 2018).

In summary, as for the correlation between obesogenic behaviors, various results showed that obesogenic behaviors, non-obesogenic behaviors, or both patterns were combined.

2.3 Social Determinants of Health Related to Obesogenic Behaviors

A scoping review was conducted to identify social determinants of health affecting obesogenic behaviors of ethnic minority adolescents. Literature on the analysis of obesogenic behaviors and social determinants of health by cluster including domestic

multicultural and ethnic minority adolescents was investigated (Appendix 1). The search period was limited to between January of 2015 and April of 2022, and four foreign publications were selected by searching international databases including PubMed, Scopus, EMBASE, and CINAHL, as well as Korean domestic databases RISS (Research Information Sharing Service of Korea Education and Research Information Service) and KISS (Korean Studies Information Service System). The specific selection criteria of the literature were (a) peer-reviewed publications either in Korean domestic or international journals, (b) inclusion of ethnic minority adolescents of ages 12 to 18, (c) inclusion of physical activity, sedentary time, and obesogenic diet as dependent variables, and (d) dependent and independent variables related to obesity or social determinants of health. The exclusion criteria were (a) patients suffering from diseases, (b) sexual minorities, (c) studies investigating solely racial and ethnic differences as health determinants, and (d) studies equivalent to theses or dissertations, reports, editorial letters, and abstracts for academic symposiums.

The scoping review of the cluster analyses on obesogenic behaviors of ethnic minority adolescents resulted in a selection of four international publications (Fleary, 2017; Kim et al., 2015; Maia et al., 2017; Tassitano et al., 2020). Of them, two studies were conducted in the United States by using the YRBSS data (Fleary, 2017; Kim et al., 2015), while the other two were conducted in Brazil using the Brazilian national school health survey data (Maia et al., 2020; Tassitano et al., 2020). All were cross-sectional studies that utilized secondary data with sample sizes of over 5,000. The participants were in grades 9 through

12, corresponding to ages 14 to 18.

The literature reviewed in the present study had identified two to five clusters, without separating sex or separately analyzing each sex. When comparing obesity rates between the clusters, the reference group tended to be determined based on the cluster with the least obesogenic behaviors. Results showed higher obesity rates in clusters with higher obesogenic behaviors. The cluster with the largest number of participants (30%) was generally a cluster of patterns, rather than of obesogenic behaviors, with high physical activity and short sedentary time (Fleary, 2017; Kim et al., 2015). Mainly, clusters of high physical activities were reported in male students, while clusters of long sedentary time were identified in female students (Fleary, 2017; Kim et al., 2015; Tassitano et al., 2020). The results of the scoping review revealed that social determinants of health affecting obesogenic behaviors in ethnic minority adolescents were primarily structural factors (gender, race, and mother's educational level) and a couple of mediating factors (sleep time and perceived overweight).

2.3.1 Social determinants of health

After World War II, in 1948, the World Health Organization (WHO) defined health as 'a state of complete physical, mental, and social well-being'. At the same time, social determinants of health were conceptualized to mandate inter-sector measures to improve health by solving social and environmental problems. However, in the 1950s and 1960s, the WHO focused on eradicating diseases through technology-oriented vertical campaigns,

not on improving health itself. It was only after the "Health for All" was advocated in the Declaration of Alma-Ata in 1978 that the social aspects of health were highlighted and discussions on social determinants of health began. In March 2005, WHO established the Committee on Social Determinants of Health (CSDH). It aims to define and manage the social factors that cause health deterioration and health inequality in partner countries around the world (Solar & Irwin, 2010).

The CSDH defined 'social determinants of health' as factors that shape health outcomes in situations in which people are born, grow, live, work, and age (WHO, 2008). From a macroscopic point of view, it includes government, policy, land, housing, public policy, health, education, culture, and social value. As for the secondary factor, characteristics such as economic base, accessibility, political influence, and discrimination hierarchically divide socioeconomic status. In addition, it controls the process in which individual health is formed by social factors according to the distribution of resources such as educational benefits, gender, occupation, and income as the cause, and explains that health inequality and well-being appear as a result (Solar & Irwin, 2010).

The definition of 'social determinants of health' in Healthy People 2020 in the United States is based on the concept of "*place-based*" and consists of five key areas: economic stability, education, social/community context, and personal health and health. Management, neighborhood, and healthy local environment (Office of Disease Prevention and Health Promotion, 2020). In other foreign studies, basic housing, economic inequality, social position, stress, education level, opportunity to participate as a member of society,

stable employment, social support, and sufficient intake of high-quality food were considered as social determinants of health affecting health (Wilkinson & Marmot, 2003).

Theories used for ‘social determinants of health’ about obesogenic behaviors include behavioral models, ecological theories, social theories, and stress coping strategies theories. These were studies that applied theories to obesity management interventions or explored the causes of obesity through social determinants of health (Winkler et al., 2017). Most of the participants were children and adolescents, and intervention studies that sought to create a social environment through family, school, community, and policy changes that belong to the environment surrounding children were insufficient. However, unlike in the past, public awareness of the government's responsibility and the need for supportive public policies to create a social environment is increasing today.

As a social strategy for obesity prevention in the International Obesity Task Force (IOTF), government policy, the role of the health care sector, the role of the food supply sector, the role of the media in providing information and advertising regulation, and obesity prevention strategies are emphasized. It can be seen that most of them are policy and environmental approaches rather than individual approaches.

In summary, for the prevention and management of obesity around the world, support measures are being prepared not at the individual level, but at the community or national level according to SDOH. Regional and environmental factors surrounding adolescents following the flow of the world, affect obesogenic behaviors. And it seemed to appropriately apply the CSDH conceptual framework of Solar & Irwin (2010) for

obesogenic behaviors of adolescents, which broadly embraces the social, economic, and environmental factors that cause.

2.3.2 SDOH related to obesogenic behaviors by CSDH framework

Obesogenic behavior has been studied as a direct target behavior in preventive intervention research as a modifiable factor in obesity intervention (Laxer et al., 2017). Some of the obesity intervention studies among previous studies commonly aimed to improve knowledge, attitudes, and behaviors related to obesity, but the effectiveness of the study depended on whether social determinants of health surrounding the participants were considered. Social determinants of health are the systematic differences in health that are associated with varying levels of social advantage (Braveman&Gruskin, 2003). Structural determinants (socioeconomic position) such as gender, race, and economic status, and intermediary determinants such as stress, are implicated as risk factors for behavior change (Ebbeling et al., 2012; Kumanyika, 2019; Plachta-Danielzik et al., 2007; Webber et al., 2008)

2.3.2.1 Structural determinants (socioeconomic position)

In the result of our scoping review, men (Tassitano et al., 2020) or older adolescents (Fleary, 2017) or ethnic minorities (Kim et al., 2015) had a higher number of obesogenic behaviors. The following have been studied as structural factors affecting obesogenic behaviors in adolescents: gender and race (Cook & Tseng, 2019; Frayon et al., 2019;

Fleary& Freund, 2018), age (Yang et al., 2012; Frayon et al., 2019; Cook & Tseng, 2019), parents' economic status (Park, 2015), parents' occupation, educational background (Mielke et al., 2017; Frayon et al., 2019), household type, etc. Structural factors (socioeconomic position) used in secondary data analysis of Korean literature were gender, age, school level, economic status, and parental educational background.

The differences in obesogenic behaviors according to gender are similar across the Korean and foreign research results. Mainly, male students practiced more physical activity and female students had a longer sedentary time (Fleary, 2017; Kim et al., 2021; Leech et al., 2014). The probability of practicing a healthy diet was higher among female students (Hong, 2019; Leech et al., 2014).

As for the change in obesogenic behaviors pattern according to age, it was a common result that sedentary time increased with increasing age (Park, 2019; Hong, 2019), which can be inferred from the increased amount of watching TV or computer gaming and decreased physical activity. Age is a representative social determinant of health because changes in obesogenic behavior according to age are continuously reported.

Disparities in obesogenic behaviors by race were found worldwide because people of ethnic minority or immigrant clusters and those living in less urbanized areas affect income and socioeconomic status of occupations. Generally, racial differences were found to be more negative in obesogenic behaviors as the ethnic minority or living in rural areas (Ligthart et al., 2017; Frayon et al., 2019; Song, 2020).

Consequently, in the comparative analysis of gender and race, male students

revealed that Caucasians were more likely to be active athletes and have normal weight. In addition, black male students accounted for the largest proportion in the cluster with a lot of sedentary activities. Among the seven clusters, Hispanic male students had the largest proportion in the cluster that ate less and moved less, and for Caucasians and Asians/Aboriginals, the cluster that ate highly nutritious food and engaged in physical activity for weight management took up the largest proportion. Among female students, the proportion of Hispanic adolescents eating moderately and physically active cluster was relatively highest, while Caucasians had the highest proportion of active exercise cluster, and Asians/Aboriginals had the highest proportion of those who ate moderately and were physically active (Boone-Heinonen, Gordon- Larsen, & Adair, 2008).As above, differences in obesogenic behaviors by race were reported among adolescents.

The result of the study on obesogenic behavior differences among adolescents according to parents' economic status and educational background, among American adolescents, males and females in the active exercise cluster were less likely to be obese, and their parents' economic status and educational background were higher than those in other clusters (Boone-Heinonen, Gordon-Larsen, & Adair, 2008). Parental educational attainment is related to health information processing ability and interest in children's health management, and thus is a relevant factor in obese adolescents (Cook & Tseng, 2019). The lower mother's education level, sedentary time were more time for computers or video games(Maia et al, 2018, Tassitano et al., 2020). In a Korean study, parents with low economic status (Lim, Park & Koo, 2009; Hassink, 2009; Janssen et al., 2006) and

those with low educational background (Ji & Kim, 2013) had a higher obesity rate in their children. A low parental level may reduce the purchasing power of relatively high-cost fresh foods, and induce them to consume low-cost, high-calorie foods, which may influence obesogenic behaviors and eventually increase the risk of obesity (Cummins & Macintyre, 2006). In other words, it has been reported that as the socioeconomic status of adolescents increases, the environment or opportunity changes in such a way that obesogenic behaviors decrease, so that participation in physical activity, healthy diet, and unhealthy diet all increase. (Laxy et al., 2015; Maia et al., 2018).

2.3.2.2 Intermediary determinants

According to the result of reviewing studies in this study, the social determinants of health that affect clusters were sleep time(behaviors and biological factor) and perceived overweight(psychosocial factor). The more sleep deprived, the higher the probability of obesogenic behavior and the higher the probability that the cluster was obese (Fleary, 2017; Tassitano et al., 2020). The more people perceived their body type as overweight, the less likely they were to engage in obesogenic behavior (Fleary, 2017). Other intermediary determinants related to obesogenic behavior are as follows.

Behaviors and biological factors

In previous studies, variables such as genetic factors (parental BMI), sleep, and academic performance were included as behaviors and biological factors affecting obesity.

The genetic factors of the biological factors of obesity need to be studied because they are common genetic traits across races. For immigrants from countries with low obesity risk, exposure to the material circumstance may result in a sudden “nutritive shift” effect that accelerates weight gain, but the extent to which genetic factors influence obesity is contentious (Kumanyika et al., 2002). The research results that parental BMI affects children's BMI (Rodríguez-Ramírez; 2011; Naja et al. 2015) are accepted as the consensus theory with many research results.

Since 2000, sleep time has been reconsidered as obesogenic behavior. Sleep is known to play an important hormonal role in various physiological functions, including energy balance, physiological needs, and weight maintenance (Lumeng et al., 2007). In a meta-analysis of 17 studies on the relationship between sleep and obesity, it was found that children who slept less had a 58% risk of becoming obese (Chen et al., 2008). In the Korean literature, a pattern was confirmed where the lower the sleep time, the higher the probability of obesity and the negative pattern of obesogenic behaviors (Lee, Kim & Hong, 2018). In a previous study on diet, the probability of getting enough sleep decreased as one drank more carbonated drinks and sugary drinks, and the probability of getting enough sleep increased as one ate breakfast (Kang et al., 2018). In other words, it has been reported that the more sleep deprived, the more obesogenic behaviors occur.

In three studies of Korean literature, it was found that the lower the academic performance, the more carbonated and sugary drinks consumed (Hong, 2019; Kim, Joeng & Chae, 2019; Kim, Kim & Gae, 2018). Academic performance is expected to induce

stress in middle school students and have a complex effect on obesogenic behaviors. Although academic performance was classified as a behavioral factor in this study, it is expected to be affected by social and psychological factors such as stress and anxiety.

Psychosocial factors

Previous studies on psychosocial factors affecting obesity and obesogenic behaviors revealed that emotional eating is induced by psychological factors (Sutherland, 2021). These include negative emotions such as stress, anxiety, tension, boredom, depression, loneliness, sadness, guilt, and anger. In a Korean secondary data analysis study, the higher the stress and depression, and the worse the subjective health status, the higher the probability of being obese. Other socio-psychological factors that can have a positive effect include family function, conflicts with parents and resolution methods, self-esteem, self-control, and health beliefs (Rillamas-Sun et al., 2019; Yang, Jang & Kim, 2012). In the case of middle school students, the overall stress perception rate was 30.4% in 2020, and female students (36.2%) showed a higher tendency than male students (24.9%) (Korea Disease Control and Prevention Agency, 2021). The stress perception rate of both clusters decreased significantly compared to that in 2019 (male: 29.1%, female: 45.9%). Previous studies (Yoo& Hwang, 2016; Lee & Cho, 2017) revealed that there was no significant difference in stress perception between ethnic minority adolescents and Korean adolescents; however, a comparison between ethnic minority adolescents and Korean adolescents among adolescents who regularly participate in physical activity for more than 60 minutes

a day showed that ethnic minority adolescents had higher stress perception (Lee & Cho, 2017).

The rate of experiencing depressive symptom was 22.9% for all middle school students in 2020, and female students (28.4%) had a higher rate of experiencing depressive symptom than male students (17.8%). The rate of experiencing depressive symptom of both clusters decreased compared to that in 2019 (male: 20.1%, female: 34.1%). It is known that ethnic minority adolescents experience more mental health problems such as depression, anxiety, and social adjustment than native adolescents (Alegria et al., 2019). As a result of comparative analysis, it was reported that there was no significant difference in the depressive feelings experienced by ethnic minority adolescents and Korean adolescents in Korea (Jang, 2020; Kim et al., 2015).

The singularity of ethnic minority adolescents compared to Korean adolescents is because most of the results of studies on acculturation stress in children and adolescents reported that BMI increased when acculturation stress was high (McLeod et al., 2016). In summary, stress, depression, and subjective health status of ethnic minority adolescents affected obesogenic behaviors according to previous domestic studies.

Material circumstances

Since the 2000s, foreign studies on obesity have not been limited to individual factors, but have begun to investigate various material circumstances surrounding individuals (Feng, 2010; Hill, 1998). In other words, it was noted that obesogenic behaviors

including eating habits and physical activity are the result of not only individual choice but also the influence of various material circumstances. Although many scholars have contributed to policy intervention for obesity in each country, it is emphasized that considering obesity as an individual factor cannot explain the rapid pace of the global obesity population over the past two decades (Glanz, 2008, Huang, 2008), and research is actively conducted to confirm the influence of material circumstances.

In particular, there is extensive research on the relationship between material circumstances related to obesogenic behaviors, which is an individual's lifestyle that has the greatest influence on the occurrence of obesity, and the relationship and the occurrence of obesity. In a previous study in the United States that utilized the Child Nutrition Questionnaire as a tool to measure the home environment, it was found that environmental access to obesogenic behaviors varied depending on the region of residence, resulting in differences in weight and obesogenic behaviors (Daly et al., 2017).

The variables to consider other than the physical environment more directly in obesogenic behaviors are socioeconomic environmental factors, such as income inequality, poverty rate, and crime rate. It is known that both healthy and unhealthy diets are highly available as adolescents live in more developed areas, and it has been reported that the relationship between socioeconomic status and regional characteristics affects obesogenic behaviors(Levy et al., 2012). The higher these indices, the higher the obesity rate of local residents (Singh, 2008; Nelson, 2005; Gomez, 2004). Therefore, among material circumstances of adolescents, socioeconomic indicators such as the poverty rate were

included in obesogenic behavior research as a factor to evaluate the local environment.

Also, in previous studies in Korea, there were differences in adolescent obesity according to city size of residential areas. It is noteworthy that the obesity rate among children and adolescents was higher in rural areas, which correspond to county areas, than in urban areas, and that ethnic minority adolescents lived more in county areas (Song, 2020; Song & Song, 2019). In the Korean secondary data analysis study, “city size” was the most used variable, the city size was a major social determinant of health in the anlysis of secondary data related to obesity in Korea.

In addition, the physical activity related environment and regional characteristics such as local population density, land use diversity, public transport convenience, and access to sports facilities are reported to cause differences in obesity rates through physical activity practice by local residents (Feng, 2010). According to results of previous studies that analyzed the relationship between “walkability,” a measure of how the built environment is friendly to the walking people (Wang & Yang, 2019), and the relationship between the material circumstance of the community and obesity related to walking, revealed that the overall obese population is lower where residential area use was high, and it is convenient to move around by walking if the area is walking-friendly (Saelens, 2009; Frank, 2008; Sallis, 2006). As for the relationship between the width of the park, availability of public sports facilities, and obesity, the study showing the tendency that obesity decreases with broader park and more sports facilities was more dominant (Mei et al., 2021). In summary, among the material circumstances related to physical activity, the

width of the park and the number of public sports facilities are social determinants of health that are highly related to obesogenic behaviors and obesity. Adolescents who frequently use snack bars are 21% more likely to be obese (Machado-Rodrigues et al., 2018), confirming the need to measure obesity related material circumstances.

In addition, there have been studies on environmental factors that affect an individual's diet such as food and beverage purchases; the obesity rate in areas where fast food restaurants are concentrated is relatively higher than in other areas (Mylona et al., 2020; Vogli, 2011), and the distribution of fast food restaurants also affects the obesity rate of local residents according to the ratio of other general food and beverage outlets.

It was reported that in terms of the distribution of the number of convenience stores in the region, the higher the number of convenience stores, the higher the obesity rate (Mei et al., 2021). Even after controlling for individual characteristics, it was confirmed that the material circumstance of these areas still affects the individual's obesity (Mehta, 2008). In contrast, research results have reported that obesity rates are low when access to places where healthy ingredients, such as fruits and vegetables can be purchased and consumed, is high (Casey, 2008). The results of these preceding studies are meaningful because they confirmed that in the current culture where the frequency of food delivery and eating out is gradually increasing, the distribution and accessibility of food and beverage outlets in the region determine the food that individuals can choose, which affects obesity, a negative health result.

It has been reported that adolescents frequently use Internet cafes to play games

and eat high-calorie or refined foods there (Kartal&Rakicioglu, 2020), increasing the obesity rate in adolescents (Barbouni et al., 2017). Internet cafes related to the obesogenic behaviors of adolescents these days are also included in the material circumstances.

Chapter 3. Conceptual framework

3.1 Conceptual Framework of the Social Determinants of Health

CSDH has categorized the social determinants of health (WHO, 2008) into two types: Structural determinants social determinants of health inequities (hereinafter referred to as Structural determinants), and intermediary determinants social determinants of health (hereinafter referred to as Intermediary determinants, Solar & Irwin, 2010). According to a 2010 report by Solar and Irwin submitted to the WHO which discusses the social determinants of health, the conceptual framework of CSDH demonstrates how the social, economic, and political systems can establish socioeconomic status.

The population is stratified by factors such as income, educational level, job, gender, race/nationality, and others; moreover, the socioeconomic status, in turn, forms specific determinants of health (Intermediary Determinants) that reflect people's positions within the social hierarchy. Additionally, individuals' experiences related to exposure and vulnerability to health threatening conditions vary by socioeconomic status. The disease affects a specific individual's socioeconomic status as well as their employment opportunities and income decline. Certain infectious diseases also have similar effects, entirely modifying the social, economic, and political institutions. Consequently, these interactions influence health equity and well-being. In recent decades, the social and economic policies aimed at narrowing the gap in social factors that determine health (e.g.,

income, education) have not had a significant effect, and inequality has persisted across populations.

The most important socioeconomic status—the structural class and its proxy indicators—includes income, education, job, social class, gender, race/nationality, etc. Additionally, the socioeconomic and political contexts along with the resulting socioeconomic status of individuals are structural determinants and are, in fact, referred to as social determinants of health inequality. The structural factors included: ① Governance in the broadest sense and its processes (including demand, discrimination patterns, civil society participation, and public administration responsibilities and transparency); ② Macroeconomic policies that combine finance, currency, balance, trade policy, and labor market; ③ Social policies that influence labor, social welfare, distribution of land, and housing; ④ Public policies on education, healthcare, plumbing work, sanitary, and other related fields; and ⑤ Cultural and social values. The fundamental social determinants of health inequality are mediated by the determinants of health before the formation of health outcomes. The causal priorities of the structural determinants over intermediary determinants are emphasized, as shown in Figure 2, with arrangement of the terms “Structural Determinants” and “Intermediary Determinants.”

The social determinants of health are divided into four categories that affect each other: behaviors and biological factors, psychosocial factors, material circumstances, and the health system. Material circumstances include factors such as housing, neighbors’ level of culture, consumption potential, and working environment. Psychosocial situations

include social psychological stressors, stressful living environments and relationships, and social support and coping styles.

Owing to this integrated approach, the CSDH conceptual framework has been generally applied in five fields—natural science, practical science, formal science, social science, and applied science. In particular, among the studies comparing the social determinants that cause an imbalance between obesity and chronic diseases according to the CSDH conceptual framework, a study of adolescents reviewed articles on obesity and nutrition for female adolescents by country (Fatusi& Bello, 2015). The author emphasized that policy intervention is necessary for improving the analysis results because underweight and obesity levels cause gaps depending on the macroeconomic and political contexts and socioeconomic status. Furthermore, in previous studies of the systematic literature on adult obesity in several countries, the results of obesity are characteristics of general health inequality, and the conceptual framework of CSDH is suitable for the theoretical framework applicable to obesity research (Kumanyika, 2019). Therefore, this study attempts to identify the social determinants of health that affect obesogenic behavioral clusters by applying the CSDH conceptual framework.

3.2 Conceptual Framework of the Study

Based on the conceptual framework of CSDH, the factors applied in this study are the same as each factor of the conceptual framework shown in Figure 2. Obesogenic

behavior—a dependent variable—is affected by structural and intermediary determinants of the social determinants of health.

Obesogenic behavior was not identified as a single behavior but as a complex factor; it was investigated using three items on physical inactivity, sedentary time, and obesogenic diet, because these behaviors affect each other. The connection of the arrows in the conceptual framework of this study indicates that structural factors and intermediary factors (behavior and biological factors, psychosocial factors, and material circumstances) affect obesogenic behavior. First, the structural determinants include gender, age, nationality of parents, educational level of parents, and economic status. The patterns of obesogenic behavior vary depending on gender, and the pattern of obesogenic behavior in children varies due to the influence of parents' educational background and economic status. Moreover, intermediary determinants are sub-factors, including behaviors and biological factors, psychosocial factors, and material circumstances that are obesogenic environments.

In summary, the behavioral and biological factors comprised sleep duration and academic performance, and psychosocial factors were stress, depressive symptoms, and self-rated health that affected obesogenic behavior. Material circumstances included the poverty rate, city size, width of parks, number of public sports facilities, number of snack bars, number of fast food restaurants, number of convenience stores, and number of Internet cafes in the relevant city and county to which the adolescents belong.

Eventually, a cluster of obesogenic behaviors affects health outcomes and obesity.

However, as the dependent variable of this study was not obesity but a latent class, obesity is indicated using a dotted line. As a result of the final study, it was schematized that the cluster (latent class) derived after analysis affects obesity as the health result.

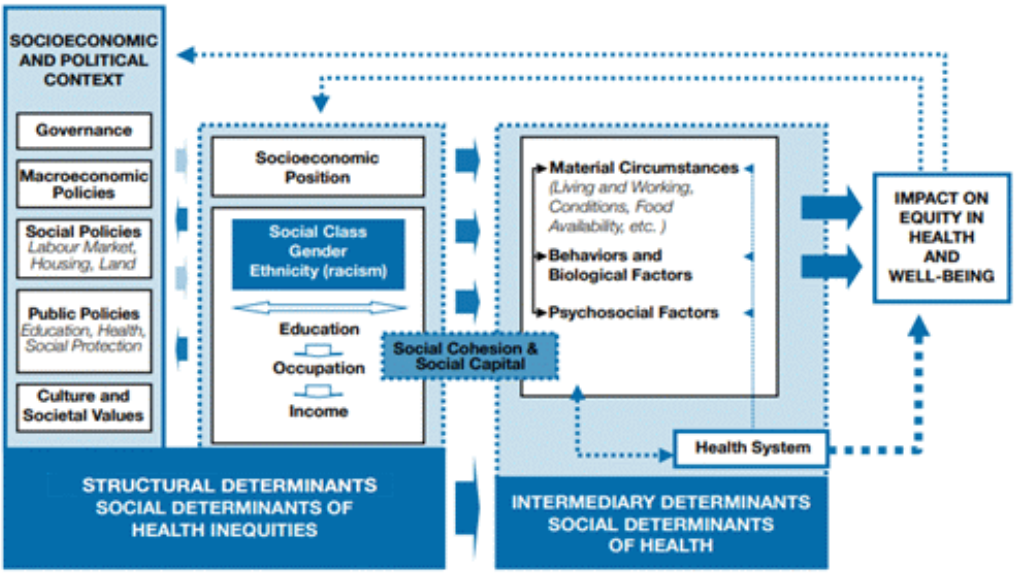


Figure 1. The conceptual framework of the social determinants of Solar & Irwin (2010)

Adapted from: https://apps.who.int/iris/bitstream/handle/10665/44489/?sequence=1

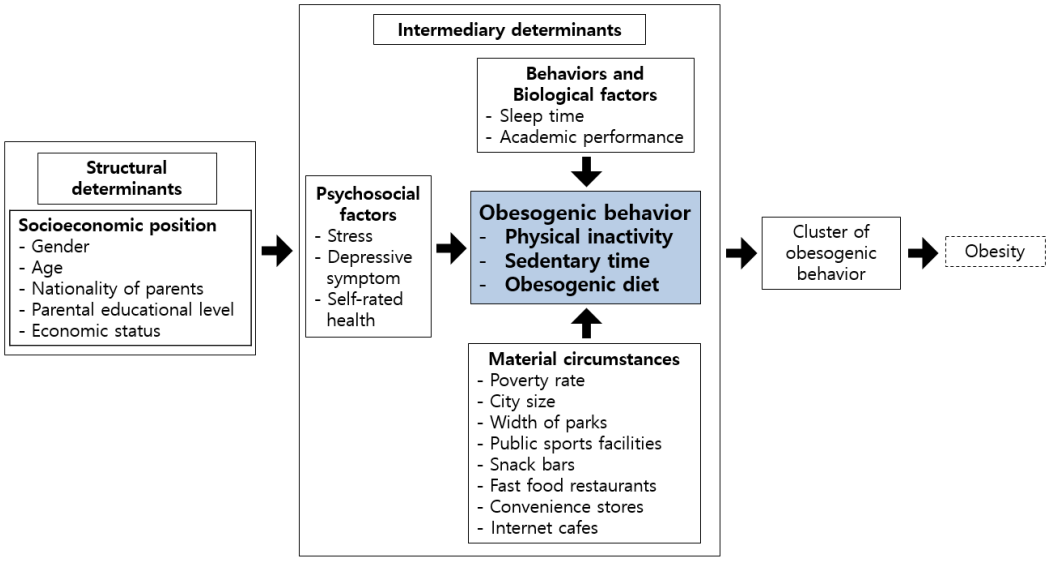


Figure 2. Conceptual framework of this study

Chapter 4. Methods

4.1 Study Design

This study is a secondary data analysis study to understand the social determinants of health based on clusters of obesogenic behaviors in ethnic minority adolescents and Korean adolescents.

4.2Sample and Data

This study used data from the 2020 Korea Youth Risk Behavior Survey (KYRBS), which is public data. KYRBS, a nation approved survey (National Statistical Office #117058), is a self-administrated and anonymous (did not include personal data) questionnaire survey conducted by the Korea Disease Control and Prevention Agency for determining the current state of Korean adolescents' health behaviors.

The selected sample of adolescents participated in the survey by devoting 45~50 minutes of their class time to complete the survey in the computer room of each school, where Internet is available, from August 3 to November 13, 2020. In the 2020 KYRBS, some schools that were difficult to be investigated in the computer room due to COVID-19 were surveyed in the classroom under the supervision of their teachers using mobile devices (tablet PCs and smartphones).

The target population of this study is ethnic minorities and Korean adolescents currently living in Korea. In this study, middle school students were selected in

consideration of the higher proportion of ethnic minority adolescents and the importance of early intervention for obesogenic behaviors. The 2020 (16th) KYRBS selected a total of 800 schools, including 400 middle schools and 400 high schools; however, the number of schools that actually participated was 793, and although a sample size of 57,925 students was planned, the number of participants who participated was 54,948. Of the 28,961 middle school students who participated in this study, 18,001 adolescents were finally included, excluding 10,960 missing data such as parents' nationality, weight, and height, of which 539 were ethnic minorities and 17,462 were Korean adolescents (Figure 3).

The data of the adolescents' health behavior survey were provided through the web download method when the researcher's personal information was entered on the website of Korea Disease Control and Prevention Agency and requested raw data. Regional statistical data of physical factors were downloaded through the websites of the National Tax Service and Statistics Korea.

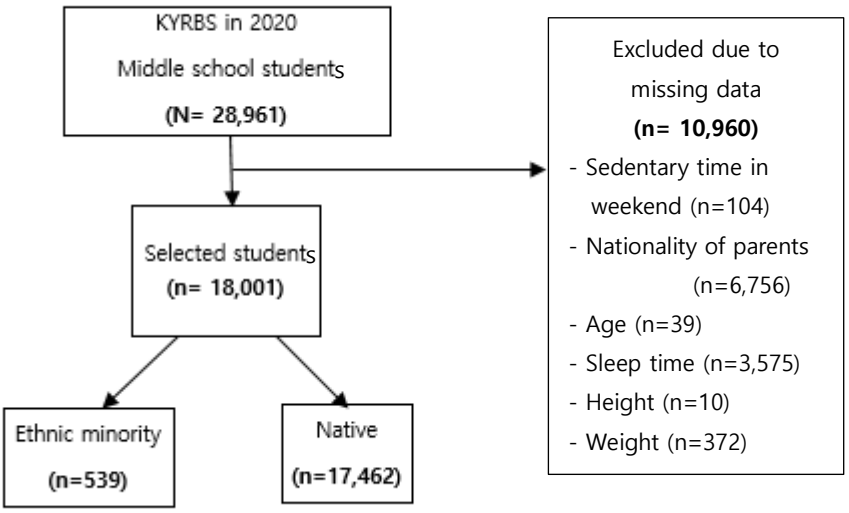


Figure 3. Study sample

4.3 Definition and Characteristics of Variables

Variables analyzed as obesogenic behavior and social determinants of health in this study are as same as shown in Table 1.

4.3.1 Obesogenic behavior

Data on the adolescents' *physical inactivity* (revised from physical activity for interpretation with other obesogenic behaviors), as a subcategory of *obesogenic behaviors*, were collected based on two items, namely moderate intensity physical activity (MPA) and vigorous intensity physical activity(VPA). Data on *sedentary time* was separated into weekday and weekend periods and defined as time spent sitting for purposes other than learning (watching television, gaming, Internet usage, chatting, and sitting on the move).

There were four items in the *obesogenic diet* category, gathered by inquiring about the adolescents' activities during the past seven days, divided into the following subsections: (a) ≥ 2 days of skipping breakfast, (b) < 2 times/day of eating fruits, (c) ≥ 3 times/week of drinking unhealthy drinks; carbonated or sugary drinks, (d) ≥ 3 times/week of eating fast foods.

*Moderate-intensity physical activity(MPA)*was defined as "the number of days out of the past 7 days that yourheart rate was increased or you felt short of breath when engaging in a physical activity for more than 60 minutes. "*Vigorous intensity physical activity(VPA)*was defined as "the number of days out of out of the past 7 days that you exercised until you were short of breath or broke a sweat for more than 20 minutes." Physical activity was based on the official indicators of the CDC's Youth Risk Behavior Surveillance System (2019) and Korea Disease Control and Prevention Agency (KCDA), on the rate of moderate or vigorous physical activity practice in adolescents. MPA was used as a nominal measure of the dichotomy by re-categorizing whether to practice it for 5 or more days a week and VPA for 3 or more days a week. The variable response values and questions were modified so the higher the variable of obesogenic behavior response value, the worse it was considered. For MPA, engaging 5 or more days a week was categorized as a "Low," and less than 5 days a week was categorized as a "High" For VPA, engaging 3 or more days a week was categorized as a "Low" and less than 3 days was categorized as a "High."

The *sedentary time* was defined as the adolescents' average time in the last 7

days spent sitting for purposes other than learning on a weekday' in the last 7 days (Uddin, et al., 2020). The CDC's YRBBS recommends a sedentary time maximum of 2 hours, and WHO's GSHS(Global School-based Student Health Survey)presents a sedentary time index of 3 hours, the previous study reported sedentary time over 5 hours. However, since many participants exceeded the index value, the sedentary time, for purposes other than learning, was classified into less than 3 hours and 3 or more hours on weekdays, or into less than 5 hours and 5 or more hours on weekends, according to reference (Leatherdale & Ahmed, 2011; Prince et al., 2020).

For the *obesogenic diet*, the researchers inquired about the number of days in the last 7 days that the adolescents had eaten breakfast, and their frequency of eating fruits, drinking soft drinks or sugary drinks, and eating fast foods. The variable response values and questions were modified so that the higher the variable of obesogenic behavior response value, the more obesogenic behaviors it was. The variables were defined as the number of days in the last 7 days that the adolescents skipped breakfast, ate fruits, drank unhealthy drinks; carbonated or sugary drinks, and ate fast food. Skipping breakfast was re-categorized into those who ate for more than 2 days as ‘High’, and those who did not, as ‘Low’, based on the index of eating for more than 5 days, which is an index of YRBSS. Eating fruit was categorized as 'less than twice a day’ as ‘High’, ‘twice a day or more’ as ‘Low’ according to the recommended intake for adolescents, at least twice a day (Ministry of Health and Welfare, 2020).

Unhealthy drinks; carbonated or sugary drinks were merged into a similar concept

and converted into one variable. It was categorized as 'less than three times in a week' as 'Low' or 'three times or more in a week' as 'High' according to the index of GSHS and YRBSS. Fast food intake was reclassified to 'less than three times in a week' as 'Low' or 'three times or more in a week' as 'High' according to the index of GSHS and YRBSS.

Table 1. Category of variables in obesogenic behavior

Category	Variables	Response	Reclassification	Reference
Physical inactivity	MPA	1 = 0 day, 2 =1 day, 3 = 2 days, 4 = 3 days, 5=4 days, 6=5 days, 7=6 days, 8=7 days	0^2= ≥ 5 days/week 1^3= < 5 days/week	Indicator of KCDC, YRBSS
	VPA	1== 0 day, 2 =1 day, 3 = 2 days, 4 = 3 days, 5=4 days, 6= ≥ 5 days	0^2= ≥ 3 days/week 1^3= < 3 days/week	Indicator of KCDC, YRBSS
Sedentary time	Weekdays	___hours___minutes	0^2= < 3 hours 1^3= ≥ 3 hours	Index of GSHS
	Weekend	____hours____minutes	0^2= < 5 hours 1^3= ≥ 5 hours	Prince et al., 2020
Obesogenic diet	Skipping breakfast	1= 0 day, 2 =1 day, 3 = 2 days, 4 = 3 days, 5=4 days, 6=5 days, 7= 6 days, 8=7 days	0^2= < 2 days/week 1^3= ≥ 2 days/week	Indicator of KCDC, YRBSS
	Eatingfruit	1= 0 day, 2=1-2 times/week, 3=3-4 times/week,	0^2= ≥ 2 times/day 1^3= < 2 times/day	Ministry of Health and Welfare, 2020
	Drinking unhealthy drinks[1]	4= 5-6 times/week, 5= 1 time/day, 6= 2 times/day,	0^2= < 3 times/week 1^3= ≥3 times/week	Index of GSHS and YRBSS
	Eating fast food	7= ≥ 3 times /day	0^2= < 3 times/week 1^3= ≥3times/week	Index of GSHS and YRBSS

Note. MPA: Moderate intensity physical activity, VPA: Vigorous intensity physical activity
[1]= carbonated or sugary drinks, [2]= Low, [3]= High

4.3.2 Social determinants of health

4.3.2.1 Structural determinants (socioeconomic position)

Specific variables of Structural determinants are gender, age, nationality of parents, education level of parents, and economic status. Genders are two nominal scales: Males, and females. Age was an interval scale. The nationality of the father was categorized according to the frequency of the participants' responses among the 13 nationalities stated in response to the question, 'In which country was the student's father born?' As a result of confirming the order of the mother's birth country, it included China(Korean) and Chinese nationality, like the father's birth country, but Vietnam was added as a response item because there were many mothers born in Vietnam. As for the parents' educational background, four nominal measures of middle school graduation or lower, high school graduation, university graduation or higher (including college graduation), were used the same responses in KYRBS. The economic status was used without re-categorizing the response as a five-point Likert ranking scale of 'high, middle-high, middle, middle-low, low' in response to the question 'What is the economic status of the family?'

4.3.2.2 Intermediary determinants

Behaviors and biological factors

Sleep time and academic performance are included in Behaviors and Biological Factors. For sleep time, this study obtains the mean of sleep hours in a day from the question “bedtime on weekdays, wake-up time on weekdays, bedtime on the weekend,

wake-up time on the weekend in the last 7 days" by calculating the unit of an hour. Sleep time was a continuous variable. For academic performance, the question was "How was your academic grade in the last 12 months?" and in order of Likert ordinal scale: 'Very well, well, moderate, bad, very bad' and used the items without re-categorization.

Psychosocial Factors

Psychosocial factors include three entire variables 'Stress, Depressive Symptoms, and Self-rated Health'. For stress, the question was "How much are you suffering from stress?" in order of Likert ordinal scale: 'Very much suffering, much suffering, a little suffering, not much suffering, never suffering' and used the items in reverse order due to simplicity side of result analysis. For depressive symptoms, the question was "Have you ever felt sorrow that make you quit from your daily life or feel despair for two whole weeks within the last twelve months?" as in two items "Yes or No", and used the items of 2 nominal scales which are changed in reverse order. For self-rated health, the question was "How is your physical condition on ordinary days?" in order of Likert ordinal Scale: 'Very healthy, healthy, moderate, unhealthy, Very unhealthy' and used the items by two categories as Healthy (Very healthy, healthy and moderate), or Not healthy(unhealthy and very unhealthy).

Material Circumstances

The Korea Youth Risk Behavior Survey (KYRBS) categorized 17 cities, provinces,

counties, and provincial districts into three clusters: metropolitan city, small city, and county area. Model sampling schools were selected after categorizing them into 39 local clusters according to geographical accessibility, the number of local schools and population, life environment, smoking rates, drinking rates, etc. Referring to prior research that included associated variables about objectively measurable material circumstances, the researchers included information about the number of public sports facilities, snack bars, fast food restaurants, convenience stores, and Internet cafes per 100,000 people in the 39 regional clusters where the participants lived (Table 2). This study also considered material circumstances including variables such as the poverty rate of the regional clusters, city size, and width of parks.

The point of time of the survey in this study was at August 2020 or December 31st, 2020 as statistics had written, considering of Korea Youth Risk Behavior Survey had gathered data from August to November 2020 (Table 3).

Table 2. Category of variables in social determinants of health

Category	Variables	Response	Reclassification
Structural determinants			
Socioeconomic position	Gender	1=Male, 2=Female	Same
	Age	__years old	Same
	Nationality of father	1=China (Korean), 2=China, 3=North Korea, 4=Vietnam, 5=Philippine, 6= Japan, 7=Taiwan, 8=Mongol, 9=Thai, 10=Cambodia, 11=Uzbekistan, 12=Russia, 13= Etc	1= China (Korean) 2= China 3= Etc
	Nationality of mother		1= China (Korean) 2= China 3= Vietnam 4= Etc
	Education levelof father Education level of mother	1= ≤ Middle school, 2= High school, 3= ≥ University, 4= Unknown	Same
	Economic status	1=High, 2=Middle-high, 3=Middle, 4=Middle-low, 5=Low	Same
Intermediary determinants			
Behaviors and biological factors	Sleep time	Bedtime on weekdays, wake-up time on weekdays, bedtime on weekends, wake-up time on the weekend	Hours(calculated)
	Academic performance	1=Very well, 2=Well, 3=Moderate, 4=Bad, 5=Very bad	Same
Psychosocial factors	Stress	1=Very much felt, 2=Much felt, 3=A little felt, 4=Not much felt, 5= Never felt	1=5, 2=4, 3=3, 4=2, 5=1
	Depressive symptom	1=No in the last 12 months, 2=Yes	0= Yes, 1= No
	Self-rated health	1=Very healthy, 2=Healthy, 3=Moderate, 4=Unhealthy, 5=Very unhealthy	0= 4,5 (Unhealthy), 1= 1-3 (Healthy)
Material circumstances	Poverty rate	(Recipient of national basic livelihood guarantees in relevant city / Population in the relevant city *100	Same
	City size	1= County area, 2=Metropolitan city, 3=Small city	1=Metropolitan city, 2=Small city, 3=County area
	Width of parks	Width of parks/ width of relevant city	Same
	The number of public sports facilities The number of snack bars The number of fast food restaurants The number of convenience stores The number of internet cafe	- Calculating (The number of facilities in the relevant city / Population in the relevant city*100,000	Same
Variable for validity	BMI	Height, Weight	__ kg/m^2
	Obesity classification		1= Underweight: %tile< 5 2= Normal weight: 5≤%tile <85 3= Overweight: 85≤%tile<95 4= Obesity: 95≤ %tile

Table 3. Reference of variables of material circumstances

Variables	The point of time of the survey	Reference
Poverty rate	August 2020	Bokjiro, Social security statistics
City size	August to November2020	KYRBS
Width of parks The number of public sports facilities	December 31, 2020	Ministry of Land, Infrastructure and Transport, Urban planning status
The number of snack bars The number of fast food restaurants The number of convenience stores The number of Internet cafes	End of August 2020	The National Tax Service, Present state of business place (Top 100 Lifestyle Industries)

Note: KYRBS=Korea Youth Risk Behavior Survey

4.3.3 Obesity classification

To confirm the validity of each of the cluster classifications of ethnic minority adolescents and Korean adolescents, the difference in the probability of becoming obese for each cluster, *Body Mass Index(BMI)*had been changed to categorical variables of obesity classification. BMI is calculated based on the data of "Height and Weight" which candidate adolescents self-reported subjectively in the Korea Youth Risk Behavior Survey(KYRBS), this study compared the obesity classification between ethnic minority adolescents and Korean adolescents by considering gender, age, and percentile according to BMI. That is based on the 2017 Korean National Growth Charts for children and adolescents (J. Kim et al., 2018). Then composing categorical variables, 4 nominal scales are divided as Obesity (95≤percentile), Overweight (85≤percentile <95), Normal weight (5≤percentile <85), and Underweight (percentile < 5).

4.4 Data Analysis

First, comparing the frequency and mean of obesogenic behavior and social determinants of health between ethnic minority adolescents and Korean adolescents by chi-square test or t-test.

Second, doing latent class analysis about eight questions related to obesogenic behavior of ethnic minority adolescents and Korean adolescents by cluster to identify the latent class of obesogenic behavior which has a response probability value that is heterogeneity.

Third, identifying differences in obesogenic behavior between the cluster of ethnic minority adolescents and Korean adolescents out.

Fourth, using multinomial logistic regression of cluster for multivariate analysis including social determinants of health after cluster analysis.

Fifth, analyze multinomial logistic regression and predict probability analysis to identify the difference in obesity classification between clusters of ethnic minority adolescents and Korean adolescents' obesogenic behavior.

Both ethnic minority adolescents and Korean adolescents are differed by more than 10 times. Because this study distributed sample size by considering clusters of city-province, city size/area cluster from the stage of sampling design, this is the sample which

reflects size differential of both clusters in population. It is at risk of comparing by making values equally when the population ratio is different from other data, which leads to a faulty result that ignores the whole proportion of the population (Smith, 2004). Therefore, it is possible to do a comparative analysis of two clusters by using the chi-square test, and t-test. This study used latent class analysis, one of the cluster analyses.

In KYRBS, weights were calculated according to the ratio of stratified classes such as attempts, school types, and class types planned in the sample survey design stage. Since the participant was selected according to the purpose of this study, the original frame ratio is destroyed in the subsampling stage, and the data is distorted when the weight is applied (Cunningham & Huguet, 2012). When subsampling, it is impossible to calculate everything when there are more than 10 variables because the ratio of the participant's attempt, school type, and class type must be calculated and combined for each variable. Since it is difficult to apply weights during subcluster analysis, it is adopted as a general analysis rather than 'complex sample design'. As a result, although it is a survey representing Korean adolescents, there is a disadvantage in that such data sampling loses its representation (Saylor et al., 2012) because weights reflecting samples across the country are not applied. To apply the weights, it should be used up the entire sample of raw data and not delete missing. However, when analyzing the multiple regression of the entire sample, all missing is deleted and analyzed, so it is impossible to apply the weight if there is missing data.

Latent class analysis is a method of analysis when categorizing different subordinate clusters in a population basis on the replication pattern of categorical variables.

Cluster Analysis, a traditional way of statistics, is known as a method that gathers similar pattern cases into a cluster depending on variables, but there is a limitation that there's no index or test to decide the number of clusters. For that reason, there might be biases caused by the researcher's subjective judgment.

Whereas latent class analysis has the advantage that classifying subordinate latent classes basis on Posterior Class Membership Probability and utilizing an official statistical process. In contrast with confirmatory factor analysis which gathers variables as a common factor, latent class analysis classifies candidates into subordinate latent classes based on replication pattern by index so that the analysis gets attention as an analysis method due to its person-centered accessible attributes (Nylund et al., 2004; Lanza et al., 2010;Visser &Depaoli, 2022).

Generally, the latent class analysis assumes mutuality independent of each of the observed variables, selects the best model by confirming each model's suitability on statistical criteria, starting from a cluster, and increases the number of clusters one by one (Collins & Lanza, 2009). The number of the final model's latent class is determined by utilizing fit indices AIC (Akaike Information Criteria), BIC (Bayesian Information Criteria), SSABIC (Sample-size adjusted BIC), VLMR-LRT (Voung-Lo-Mendell-Rubin Likelihood Ratio Test), Entropy. So as the Goodness of fit index for assuming latent class, AIC, BIC, SSABIC are used, and it is considered that the lower figures, the better goodness. Model fit was assessed using the AIC,BIC and SSABIC, with lower values indicating a better fit. The VLMR-LRT was also calculated. VLMR-LRT tested the parsimony of one

more model against a model with one fewer class (e.g. 2 vs. 1 classes), provided with the probability (p-value) that the one more model is not an appropriate on the model containing one fewer class (Lo et al., 2001; Nylund et al., 2007). VLMR-LRT of latent class analysis is composed by testing statistical significance between the differences in models of "k cluster" and "k-1 cluster," If the p-value is not significant, the model of "k-1 cluster" is better than the model of "k cluster" (Lo et al., 2001). Moreover, the Entropy index means the average classification accuracy on each observation value, it is indicated between 0~1, and it means the observation objective is classified in a specific cluster correctly when it is getting closer to 1 (Jedidi, Ramaswamy, & Desarbo, 1993). But the best model is known that it is desirable to decide considering overall not only the statistical criteria of AIC, BIC, SSABIC, and Entropy, but also the simplicity of the model, analysis possibility of latent class, distribution range (the least ratio over 5% contrast in total subjects) (Jung &Wickrama, 2008). It was performed for research analysis by LatentGOLD 6.0 (Statistical Innovations, Belmont MA, USA) for latent class analysis , SPSS Statistics 26.0 (IBM Corp, Chicago IL, USA) and Stata 16.0(Stata Corp, College Station, TX, USA) for analyzing multinomial logistic regression, and SAS 9.4 version (SAS Institute, Cary, NC, USA) for calculating BMI by sex and age of adolescents in Korean.

4.5 Ethical Considerations

This research is a secondary data analysis utilizing the 16th 2020 Korea Youth Risk Behavior Survey and regional statistics of public data. The researcher could request the

data of the Korea Youth Risk Behavior Survey (KYRBS) via the Internet website of the Korea Disease Control and Prevention Agency by giving the researcher's personal information (name, email address and affiliation) to them.

All data for the study are collected in serial numbers which are unable to identify personal data so that secure the anonymity of candidates and confidentiality. This study had analyzed after obtaining approval of exemption from the Institutional Review Board of Severance Hospital, Yonsei University Health System (IRB No. 4-2022-0083).

Chapter 5. Results

5.1 Differences in Obesogenic Behaviors and Obesity

5.1.1 Differences in obesogenic behavior between ethnic minority adolescents and Korean adolescents

Table 4 showed the obesogenic behavior between ethnic minority adolescents and Korean adolescents. Regarding the physical activity of ethnic minority adolescents, 84.0% of those practiced MPA less than 5 days a week, which is similar to the MPA level of Korean adolescents (83.1%) with no statistically significant difference (x^2=0.31, p=.578). Similarly, the level of VPA less than 3 days a week among ethnic minority adolescents and Korean adolescents was 69.6 vs. 67.9%, respectively and the difference was not statistically significant (x^2=0.69, p=.408).

In the sedentary time of ethnic minority adolescents, 65.9% of those spent three hours or more sedentary time on weekdays, which is different in the sedentary time of Korean adolescents(60.5%) in weekdays with a statistically significant difference(x^2=6.35, p=.012).Similarly, sedentary time in weekends among ethnic minority adolescents and Korean adolescents64.7% vs. 53.9%, respectively and the difference was statistically significant (x^2=24.62, p<.001).

The majority of ethnic minority adolescents(93.3%) had fruit less than twice a day per week while 90.5% of Korean adolescents had fruit less than twice a day per week.

There was a statistically significant difference between two groups (x^2=4.79, p=.029).

About the fast food of ethnic minority adolescents, 17.3% of those who consumed fast food 3 or more times a week, which is different from consuming fast food among Korean adolescents (21.5%) with a statistically significant difference among ethnic minority adolescents and Korean adolescents (x^2=5.56, p=.018).

There was no statistically significant difference in the case of ethnic minority youth skipping breakfast two days a week or more, and 20.4% and 18.5% of Korean youth. There was also no statistically significant difference in the consumption of unhealthy drinks (carbonated or sugary) among ethnic minority adolescents, with 54.9% of those who consumed three or more times a week and 52.2% of Korean adolescents.

Table 4. Comparison of obesogenic behaviors among ethnic minority adolescents and Korean adolescents(N = 18,001)

Variables			Ethnic minority (n=539)		Korean (n= 17,462)		x^2 or F	*p*-value
			n (%)					
Physical inactivity	MPA (< 5 days/week)	Low	86	(16.0)	2945	(16.9)	0.31	.578
		High	453	(84.0)	14517	(83.1)		
	VPA (< 3 days/week)	Low	164	(30.4)	5608	(32.1)	0.69	.408
		High	375	(69.6)	11854	(67.9)		
Sedentary time	Weekdays (≥ 3 hours/day)	Low	184	(34.1)	6901	(39.5)	6.35	.012
		High	355	(65.9)	10561	(60.5)		
	Weekends (≥ 5 hours/day)	Low	190	(35.3)	8043	(46.1)	24.62	<.001
		High	349	(64.7)	9419	(53.9)		
Obesogenic diet	Skipping breakfast (≥ 2 days/week)	Low	429	(79.6)	5794	(81.5)	1.27	.260
		High	110	(20.4)	8439	(18.5)		
	Eating fruit (<2 times/day)	Low	36	(6.7)	1654	(9.5)	4.79	.029
		High	503	(93.3)	15808	(90.5)		
	Unhealthy drinks[1] (≥ 3times/week)	Low	243	(45.1)	8348	(47.8)	1.55	.213
		High	296	(54.9)	9114	(52.2)		
	Eating fast food (≥ 3times/week)	Low	446	(82.7)	13711	(78.5)	5.56	.018
		High	93	(17.3)	3751	(21.5)		

Note. MPA=Moderate intensity physical activity, VPA=Vigorous intensity physical activity,
[1]=carbonated or sugary drinks

5.1.2 Differences in obesity between ethnic minority adolescents and Korean adolescents

Figure 4 shows the results of comparing the obesity classification of ethnic minority adolescents and Korean adolescents by obesity, overweight, normal weight, and underweight, respectively. The percentage for obesity ethnic minority adolescents was 15.6% (n=84), higher than 11.2% (n=1,954) for Korean adolescents. The percentage of overweight ethnic minority adolescents was 10.4% (n=56) and that of overweight Korean adolescents was 10.6% (n=1,843), which were similar. The percentage of ethnic minority adolescents with normal weight was 66.2% (n=357) lower than 71.5% (n=12,488) of Korean adolescents. Among the underweight adolescents, the percentage of an ethnic minority was 7.8% (n=42), and that of Korean adolescents was 6.7% (n=1,177). As a result of the chi-square test, the obesity classification of both groups was statistically significant (x^2=11.83, p-value=.008).

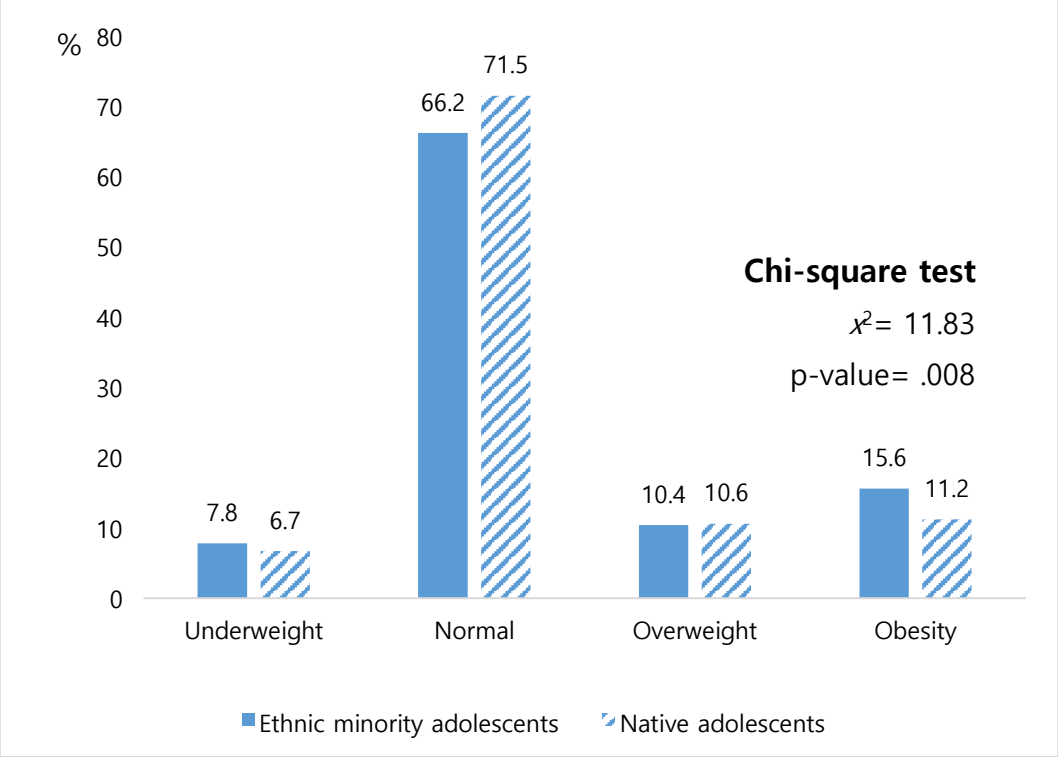


Figure 4. Comparison of obesity in ethnic minority adolescents and Korean adolescents

5.2 Difference in Social Determinants of Health

5.2.1 Structural determinants

Among the structural determinants of ethnic minority adolescents and Korean adolescents, there were statistically significant differences in the variables for age, parents' education level, and economic status (Table 5). The mean age was 13.42 (±0.99) years for ethnic minority adolescents and 13.64 ± (0.93) years for Korean adolescents. The difference in mean age among both groups was statistically significant (F=4.51, p-value=.034). More than 40 % of ethnic minority adolescents reported not knowing their parents' educational level (fathers: 44.5%, mothers: 49.4%), and the majority of students who knew their parents' educational level, reported their parents were high school graduates (fathers: 27.6%, mothers: 22.6%). However, a difference in the educational level was confirmed between parents of ethnic minority adolescents and Korean adolescents(father; x^2=571.75, p<.001, Mother: x^2 = 463.53, p<.001), with more than 50% of the respondents reporting that both parents were college graduates(fathers: 57.5%, mothers: 56.7%).

Among the adolescents who responded that their family's economic status was "high," the percentage of ethnic minority adolescents was 6.7% and that of Korean adolescents was 14.2%. Additionally, among the adolescents whose family's economic status was "middle-high," the proportion of ethnic minority adolescents was 19.1% and that of Korean adolescents was 32.1%, with statistically significant differences (x^2=109.15,

p<.001).

The difference in gender between the two groups was not statistically significant. As a result of determining the country of birth of the parents of ethnic minority adolescents, the most common nationality among fathers was Korean at 80.0%, and that among mothers was Vietnamese at 32.1%.

5.2.2 Intermediary determinants

5.2.2.1 Behaviors and biological factors

There was a statistically significant difference in academic performance, with 8.2% of ethnic minority adolescents and 17.4% of Korean adolescents responding to 'very well' (x^2=106.01, p<.001). The average sleep time was 7.16 (±1.47) hours for ethnic minority adolescents and 6.92 (±1.45) hours for Korean adolescents, which was a longer sleep time for ethnic minority adolescents, although there was no statistically significant difference.

5.2.2.2 Psychosocial factors

In the self-rated health status, 8.9% of ethnic minority adolescents, and 5.1% of Korean adolescents were “unhealthy”. Consequently, ethnic minority adolescents were unhealthier, and there was a statistically significant difference (x^2=14.81, p<.001). In the stress, 8.3% of ethnic minority adolescents, and 5.9% of Korean adolescents were “very much”. In the depressive symptoms, 21.5% of ethnic minority adolescents, and 21.3% of Korean adolescents were “Yes”. There were no statistically significant differences between

the two groups in the variables for stress and depressive symptom.

5.2.2.3 Material circumstance

In terms of city size, 47.7% of ethnic minority adolescents and 50.2% of Korean adolescents lived in small cities, while 14.1% of ethnic minority adolescents lived in the county area, which was statistically significantly higher than 7.1% of Korean adolescents (x^2=37.53, p<.001). In addition, the mean number of public sports facilities was 2.42 (±2.54) for ethnic minority adolescents and 2.06 (±2.11) for Korean adolescents, and there were statistically significant differences in the residential area of the two groups (F=22.88, p<.001). There were no significant differences between the two groups in terms of poverty rate, the width of parks, number of snack bars, number of fast food restaurants, number of convenience stores, and number of Internet cafes.

Table 5. Comparison of the social determinants of health among ethnic minority adolescents and Korean adolescents (N = 18,001)

Variables		Ethnic minority(n=539)		Korean (n= 17,462)		x^2or F	p-value
		n (%)/ Mean ± SD					
Structural determinants							
Socioeconomic position							
Gender	Male	263	(48.8)	8631	(49.4)	0.84	.772
	Female	276	(51.2)	8831	(50.6)		
Age		13.42	±0.99	13.64	±0.93	4.51	.034
Nationality of fathers	Korean	431	(80.0)	17,462	(100.0)	-	-
	Korean Chinese	41	(7.6)	-			
	Chinese	19	(3.5)	-			
	the other	48	(8.9)	-			
Nationality of mothers	Korean	30	(5.6)	17,462	(100.0)		
	Korean Chinese	94	(17.4)	-			
	Chinese	86	(16.0)	-			
	Vietnamese	173	(32.1)	-			
	the other	156	(28.9)	-			
Father's educational level	Middle school	49	(9.2)	154	(0.9)	571.75	<.001
	High school	149	(27.6)	3098	(17.7)		
	University	101	(18.7)	10045	(57.5)		
	Unknown	240	(44.5)	4165	(23.9)		
Mother's educational level	Middle school	33	(6.1)	131	(0.8)	463.53	<.001
	High school	122	(22.6)	3688	(21.1)		
	University	118	(21.9)	9904	(56.7)		
	Unknown	266	(49.4)	3739	(21.4)		

Variables		Ethnic minority (n=539)		Korean (n= 17,462)		x^2 or F	p-value
		n (%)/ Mean ± SD					
Economic status	High	36	(6.7)	2481	(14.2)	109.15	<.001
	Middle-high	103	(19.1)	5614	(32.1)		
	Middle	307	(57.0)	7852	(45.0)		
	Middle-low	82	(15.2)	1314	(7.5)		
	Low	11	(2.0)	201	(1.2)		
Intermediary determinants							
Behaviors and biological factors							
Sleep time (hours)		7.16	±1.47	6.92	±1.45	0.49	.824
Academic performance	Very well	44	(8.2)	3054	(17.4)	106.01	<.001
	Well	100	(18.6)	5219	(29.9)		
	Moderate	184	(34.1)	5070	(29.0)		
	Bad	154	(28.6)	3063	(17.5)		
	Very bad	57	(10.6)	1065	(6.1)		
Psychosocial factors							
Stress	Never	23	(4.3)	709	(4.1)	5.92	.206
	Not much	107	(19.9)	3670	(21.0)		
	A little	237	(44.0)	7988	(45.7)		
	Much	127	(23.6)	4061	(23.3)		
	Very much	45	(8.3)	1034	(5.9)		
Depressive symptoms	No	423	(78.5)	13750	(78.7)	0.22	.883
	Yes	116	(21.5)	3712	(21.3)		
Self-rated health	Unhealthy	48	(8.9)	899	(5.1)	14.81	<.001
	Healthy	491	(91.1)	16563	(94.9)		

Variables		Ethnic minority (n=539)		Korean (n= 17,462)		x^2 or F	p-value
		n (%)/ Mean ± SD					
Material circumstances							
Poverty rate		4.35	±1.23	4.29	±1.41	1.82	.178
City size	Metropolitan city	206	(38.2)	7446	(42.6)	37.53	<.001
	Small city	257	(47.7)	8769	(50.2)		
	County area	76	(14.1)	1247	(7.1)		
Width of parks		0.03	±0.03	0.04	±0.03	0.13	.719
The number of public sports facilities		2.42	±2.54	2.06	±2.11	22.88	<.001
The number of snack bars		105.20	±25.61	106.96	±28.23	0.26	.609
The number of fast food restaurants		84.05	±17.10	83.26	±16.19	2.29	.130
The number of convenience stores		87.14	±22.46	87.81	±23.08	0.17	.676
The number of internet cafes		19.03	±4.45	19.60	±4.58	0.03	.869

Note:SD = Standard deviation,
The number of= The number of facilities in the relevant city / Population in the relevant city*100,000

5.3 Cluster of Obesogenic Behaviors

For cluster analysis, the fitness of each model was analyzed by increasing the number of clusters from one cluster to one on the premise of mutual independence. As a result, ethnic minority adolescents were classified into three clusters (Table 6). To select the appropriate number of latent classes, we estimated 1 to 5 class models. The number of classes were selected by model fit indices, in sequence as Bayesian Information Criteria (BIC), Akaike Information Criteria (AIC), Voung-Lo-Mendell-Rubin Likelihood Ratio Test (VLMR-LRT), the p-value, the entropy value, and class membership probability(cluster size).

Among ethnic minority adolescents, as the model fit index, BIC and AIC were used, the lower the number, the better the model fit. If the number of clusters was three, the BIC value was 4432.21, which tended to be the probability of clustering to three clusters in Table 6. The AIC value decreased as the number of clusters increased; therefore, five clusters were evaluated as the most suitable. In addition, the model comparison verification of the latent class analysis was conducted through the (VLMR-LRT), and the p-value of one - five clusters were judged to be appropriate. Additionally, in the case of ethnic minority adolescents, the entropy value of the cluster 5 was 0.788, which was closest to 1. Lastly, since the class membership probability (cluster size) should normally exceed 0.05 of the total for each cluster in Table 7 (Jung &Wickrama, 2008), one to four clusters were found to be appropriate. Thus, three clusters were finally determined considering every value of the model fit index.

Among Korean adolescents, first of all, BIC and AIC were checked. If the number of clusters was four, the BIC value was 145896.11; if the number of clusters was five, the BIC value was 145564.11, which tended to be the probability of clustering four or five clusters in Table 6. The AIC value decreased as the number of clusters increased, and thus, five clusters were evaluated as the most suitable. In addition, the model comparison verification of the latent class analysis was conducted through VLMR-LRT, and the p-value for all five clusters was <.001. The entropy value in cluster three was 0.714, which was closest to 1. As the cluster size should normally exceed 0.05 of the total for each cluster (Jung &Wickrama, 2008), it could be one to five clusters (Table 7); however, three clusters were finally determined considering other model fix indexes.

Table 6. Fit statistics of the clusters of obesogenic behaviors among ethnic minority adolescents and Korean adolescents

Adolescents	Number of latent classes	Log-Likelihood	Degree of Freedom	BIC	AIC	VLMR-LRT	Entropy
Ethnic minority	1	-2287.38	247	4625.09	4590.77	-	1.000
	2	-2195.32	238	4497.57	4424.64	184.12***	0.742
	3	-2134.34	229	4432.21	4320.68	121.96***	0.728
	4	-2117.35	220	4454.85	4304.71	33.98***	0.759
	5	-2106.97	211	4490.69	4301.94	20.77*	0.788
Korean	1	-77654.74	247	155387.63	155325.49	-	1.000
	2	-75172.29	238	150510.64	150378.58	4964.903***	0.683
	3	-73069.40	229	146392.76	146190.80	4205.784***	0.714
	4	-72777.12	220	145896.11	145624.24	584.5655***	0.647
	5	-72567.17	211	145564.11	145222.33	419.9036***	0.632

Note: *: <.05, **: <.01, ***: <.001

Table 7. Class membership probability among ethnic minority adolescents and Korean adolescents

Adolescents	Cluster size				
	1	2	3	4	5
Ethnic minority	1.000				
	0.666	0.334			
	0.559	0.261	0.180		
	0.522	0.210	0.173	0.095	
	0.515	0.204	0.139	0.099	0.044
Korean	1.000				
	0.756	0.244			
	0.488	0.358	0.153		
	0.428	0.326	0.144	0.102	
	0.371	0.232	0.190	0.110	0.097

5.4 Cluster-specific Characteristics of Obesogenic Behavior

Ethnic minority adolescents and Korean adolescents were classified into three clusters through latent class analysis. The response item of eight obesogenic behaviors was classified according to the criteria of previous studies mentioned in the operational definition. Additionally, the response was modified so that the higher the value of the eight variables, the more obesogenic behaviors. All response values were converted into percentages based on 0-100 to compare the ratio of obesogenic behavioral variables by cluster. Among these, 50% were divided into upper and lower clusters, and the cluster name was determined based on problematic behaviors of more than 50% of the cluster name. In Tables9and 10, the higher the percentage, the worse the obesogenic behavior was.

In Table 8, the first cluster of ethnic minorities was “Inactive & unhealthy eater” (a cluster that was high in PI; MPA was less than 5 days, VPA was less than 3 days, had a long sedentary time, and practices an unhealthy diet; eating less fruit, unhealthy drinks), the second cluster was “Moderately active & unhealthy eater” (a cluster that was low in PI; MPA was 5 days or more, VPA was 3 days or more, has a long sedentary time, and practices an unhealthy diet; eating less fruit, unhealthy drinks)and the third cluster was “Active & healthy eater” (a cluster that was high in PI; MPA was less than 5 days, VPA was less than 3 days and has a short sedentary time and practiced a healthy diet; not skipping breakfast, not drinking unhealthy drinks).

Compared with the cluster classification of ethnic minority adolescents, the cluster

characteristics in Korean adolescents of cluster 1, cluster 2, and cluster 3 were similar, respectively. There were subtle differences in sedentary time and dietary variables between ethnic minority adolescents and Korean adolescents.

Table 8. The final cluster's common name

Cluster number	Cluster 1	Cluster 2	Cluster 3
Character	High PI High ST Unhealthy diet	Low PI High ST Unhealthy diet	High PI Low ST Healthy diet
Common name	**Inactive & unhealthy eater**	**Moderately active& unhealthy eater**	**Active & healthy eater**

Note: PI = Physical inactivity, ST = Sedentary time

5.4.1 Ethnic minority adolescents

Ethnic minority adolescents were classified into three clusters using latent class analysis. The response variables of eight obesogenic behaviors were classified according to the criteria of previous studies mentioned in the operational definition. All response values were converted into percentages based on 0-100 to compare the ratio of obesogenic behavioral variables by cluster. Among these, 50% each were divided into upper and lower clusters, and the cluster name was determined based on problematic behaviors of more than 50% of the cluster name. In Table 9, the higher the percentage, the worse the obesogenic behavior.

The first cluster was "Inactive & unhealthy eater" (a cluster that is high in PI, has a long sedentary time, and practices an unhealthy diet), the second cluster was "Moderately

active& unhealthy eater" (a cluster that is low in PI, has a long sedentary time, and practices an unhealthy diet), and the third cluster was "Active & healthy eater" (a cluster that is high in PI and has a short sedentary time and practices a healthy diet).

Among the ethnic minority adolescent clusters, the cluster with the most subjects was the "Inactive & unhealthy eater", accounting for 61.0% of the total subjects. In the first cluster, "Inactive & unhealthy eater", 97.7% of this cluster were 'they practice moderate-intensity physical activity less than 5 days a week' and 82.1% of this cluster practice vigorous-intensity physical activity less than 3 days a week, which is a result far exceeding the standard 50% line(blue in Figure 5). In addition, 88.3% of respondents who practiced sedentary time for 3 hours or more on weekdays and 90.1% who practiced sedentary time for more than 5 hours on weekends were significantly higher than the standard 50% line (blue in Figure 5).Two variables among dietary variables were also higher than the 50% baseline, the rates of 'eating less fruit and drinking unhealthy drinks' were 96.9% and 57.3%, respectively, showing the unhealthy eating pattern among the three clusters. When the overall obesogenic behavior pattern was evaluated, this cluster showed high physical inactivity, a long sedentary time, and the unhealthiest pattern in dietary variables. Among them, the most names characteristic was "Inactive & unhealthy eater".

The second cluster, "Moderately active& unhealthy eater", has 15.0% of the total subjects. As a specific characteristic of this cluster, 22.6% of the respondents in this cluster practiced moderate-intensity physical activity less than 5 days a week. The proportion of subjects who practiced vigorous-intensity physical activity less than 3 days a week was

5.2%, which was lower than the baseline 50% for all physical inactivity. In addition, 68.0% of respondents who spent sedentary time for more than 3 hours on weekdays and 67.7% who spent sedentary time for more than 5 hours on weekends were higher than the standard 50%. For dietary variables, two variables of responses were higher than the baseline of 50%. The rate of eating less fruit was 85.7%, and the rate of drinking carbonated or sugary drinks three or more times a week was 65.0%, the highest among the three clusters. When the overall obesogenic behavioral pattern was evaluated, this cluster was named "Moderately active& unhealthy eater", the most common characteristic of the three clusters. This is because the behavioral patterns of this cluster included low physical inactivity(more physical activity), more sedentary time, and unhealthy patterns of dietary variables.

The third cluster, "Active & healthy eater", was the cluster to which 24.0% of the total subjects belonged. Regarding the specific characteristics of this cluster, 94.3% of this cluster did not practice moderate-intensity physical activity more than 5 days a week and 84.4% did not practice vigorous-intensity physical activity more than 3 days a week, in addition, 14.7% of the respondents who spent sedentary time for more than 3 hours on weekdays and 6.7% of those practiced sedentary time for more than 5 hours on weekends were lower than the standard 50% line(blue in Figure 5). As for the dietary variables, 1 variable of eating less fruit was 90.5%, higher than the standard 50% line (blue in Figure 5). Moreover, the rate of drinking unhealthy drinks(carbonated or sugary) more than three times a week was 42.9%, which was the lowest among the three clusters. Therefore, this cluster can be regarded to have healthy patterns and low PI(high PA). When the overall

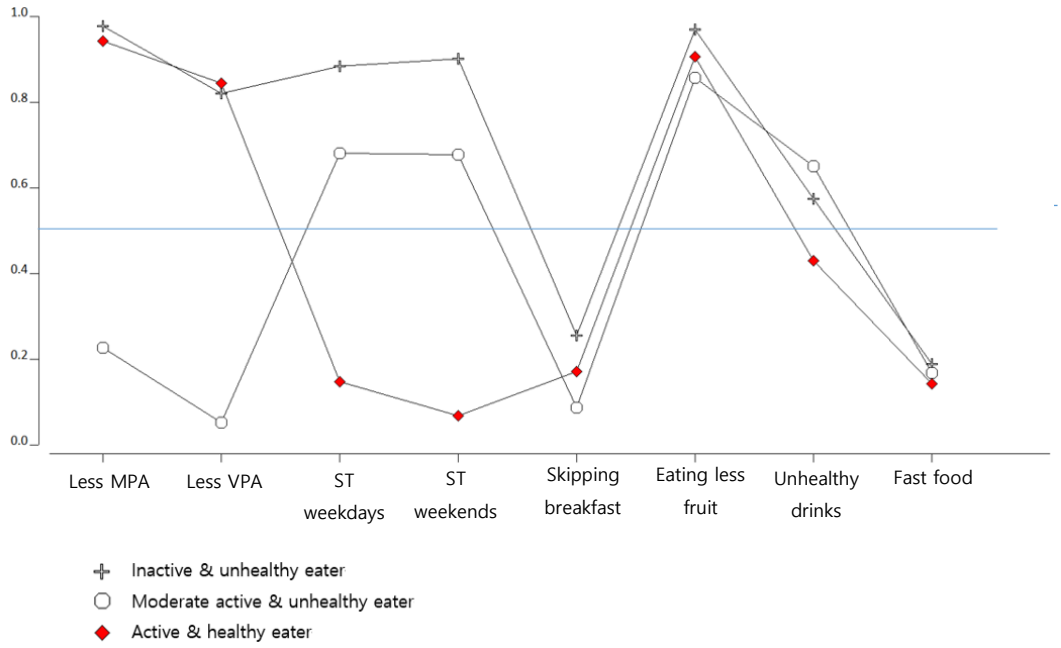
obesogenic behavior pattern was evaluated, the cluster was named “Active & healthy eater” among the three clusters as the behavioral patterns of low physical inactivity and less sedentary time and healthy patterns of the dietary variables were revealed.

Figures 5 shows the graphs of the ethnic minority adolescents’ clusters by converting the percentage of obesogenic behavior variables to 0–1 point. The “Active & healthy eater” cluster used as reference clusters for each cluster are indicated in red. In the graph, the closer to 0, the less the obesogenic behavior, and the closer to 1, the more the obesogenic behavior. As there are many variables located at the bottom of the third cluster “Active & healthy eater” for ethnic minority adolescents, it can be confirmed that obesogenic behavior is a cluster with a good pattern.

Table 9. Item-response probabilities of obesogenic behaviors among ethnic minority adolescents (%)

Variables		**Inactive & unhealthy eater**	**Moderately active& unhealthy eater**	**Active & healthy eater**
	Cluster size	61.0 (n=329)	15.0 (n=81)	24.0 (n=129)
Physical inactivity	MPA (< 5 days/week)	97.7	22.6	94.3
	VPA (<3 days/week)	82.1	5.2	84.4
Sedentary time	Weekdays (≥ 3 hours/day)	88.3	68.0	14.7
	Weekends (≥ 5 hours/day)	90.1	67.7	6.7
Obesogenic diet	Skipping breakfast (≥ 2 days/week)	25.5	8.7	17.0
	Eating fruit (< 2 times/day)	96.9	85.7	90.5
	Unhealthy drinks[1] (≥ 3 times/week)	57.3	65.0	42.9
	Eating fast food (≥ 3 times/week)	18.8	16.7	14.1

Note: MPA = Moderate intensity physical activity, VPA = Vigorous intensity physical activity
[1] = carbonated or sugary drinks



Note: MPA = Moderate intensity physical activity,
VPA = Vigorous intensity physical activity,
ST = Sedentary time

Figure 5. Distribution of obesogenic behavior by the cluster of ethnic minority adolescents

5.4.2 Korean adolescents

Korean adolescents were also classified into three clusters using latent class analysis. The response item of eight obesogenic behaviors was classified according to the criteria of previous studies mentioned in the operational definition. All response values were converted into percentages based on 0-100 to compare the ratio of obesogenic behavioral variables by cluster. Among these, 50% each were divided into upper and lower clusters, and the cluster name was determined based on the problematic behaviors of more than 50% of the cluster name. In Table 10, the higher the percentage, the worse the obesogenic behavior. Compared with the cluster classification of ethnic minority adolescents, the cluster characteristics of cluster 1, 2 and 3 were similar. There were subtle differences in sedentary time and dietary variables between clusters.

The first cluster is “Inactive & unhealthy eater” (a cluster that is high in PI, has a long sedentary time, and practices an unhealthy diet), the second cluster is “Moderately active& unhealthy eater” (a cluster that is low in PI, has a moderate sedentary time, and practices an unhealthy diet) and the third cluster was 'Active & healthy eater' (a cluster that is high in PI and has a short sedentary time and practices a healthy diet).

Among the Korean adolescents’ clusters, that contained the most subjects was the first cluster, accounting for 49.6% of the total subjects. In the first cluster, “Inactive & unhealthy eater”, 97.0% of this cluster practiced moderate-intensity physical activity less than 5 days a week and 81.0% of this cluster practiced vigorous-intensity physical activity less than 3 days a week, which is a result far exceeding the standard 50%. In addition, 90.7%

of the respondents who spent sedentary time for more than 3 hours on weekdays and 85.8% of those who practiced sedentary time for more than 5 hours on weekends were significantly higher than the standard 50%. Among the dietary variables, two variables were higher than the 50% baseline; the rates of eating less fruit, and unhealthy drinks(carbonated or sugary drinks)were 92.4% and 57.1%, respectively, showing the unhealthy eating pattern among the three clusters. When the overall obesogenic behavior pattern was evaluated, this cluster showed high physical inactivity, a long sedentary time, and the unhealthiest pattern in dietary variables. Therefore, based on the most characteristic, the cluster was named “Inactive & unhealthy eater”.

The second cluster, “Moderately active& unhealthy eater”, was the cluster to which 14.7% of the total subjects belonged. As a specific characteristic of this cluster, 8.1% of this cluster practiced moderate-intensity physical activity less than 5 days a week. The proportion of respondents who practiced vigorous-intensity physical activity less than 3 days a week was 0.9%, which was lower than the baseline 50% for all physical inactivity. In addition, 55.6% of the respondents who spent sedentary time for more than 3 hours on weekdays were higher than the standard 50%. Moreover, 48.7% practiced sedentary time for more than 5 hours on weekends. For dietary variables, two variables were higher than the baseline 50%; the rates of “eating less fruit”, and “drinking carbonated or sugary drinks three or more times a week” was 85.5%, and 57.3%, respectively. When the overall obesogenic behavioral pattern was evaluated, this cluster was named “Moderately active& unhealthy eater”. It was revealed that the behavioral patterns of this cluster were low

physical inactivity (high physical activity), moderate sedentary time, eating less fruit, and more unhealthy drinks as the dietary variables.

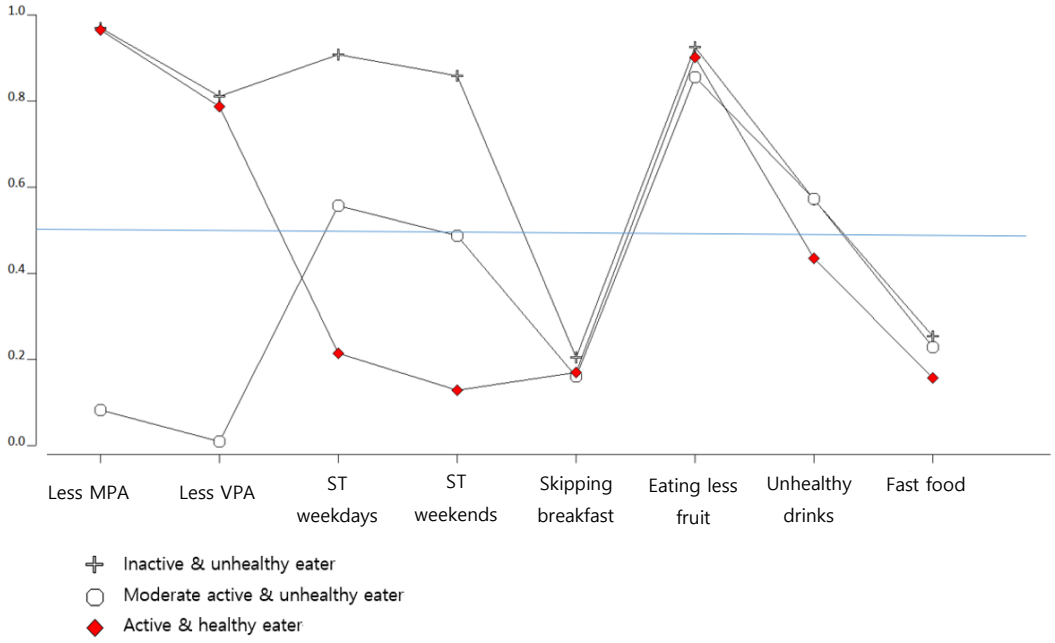
The third cluster, “Active & healthy eater”, was the cluster to which 35.7% of the total subjects belonged. As for the specific characteristics of this cluster, 96.4% of this cluster did not practice moderate-intensity physical activity for more than 5 days a week, and 78.7% of this cluster did not practice vigorous-intensity physical activity more than 3 days a week. Additionally, 21.4% of this cluster who spent sedentary time for more than 3 hours on weekdays and 12.8% who practiced sedentary time for more than 5 hours on weekends were significantly lower than the standard 50%. As for the dietary variables, 1 variable of eating less fruit was 90.1%, which was higher than the 50% baseline. The rate of drinking unhealthy (carbonated or sugary) drinks more than 3 times a week was 43.4%, which was the lowest among the three clusters. When the overall obesogenic behavior pattern was evaluated, the cluster was “Active & healthy diet” among the three clusters as the behavioral pattern of high physical inactivity and more sedentary time and healthy pattern in the dietary variables were revealed.

Figures 6 show the graphs of Korean adolescents’ clusters by converting the percentage of obesogenic behavior variables to 0–1 point. “Active & healthy eater” was used as reference for each group, as indicated in red. In the graph, the closer to 0, the better the obesogenic behavior, and the closer to 1, the worse the obesogenic behavior. As there are many variables located at the bottom of the “Active & healthy eater” cluster for Korean adolescents, it was confirmed that obesogenic behavior is a cluster with a good pattern.

Table 10. Item-response probabilities of obesogenic behaviors among Korean adolescents (%)

Variables		**Inactive & unhealthy eater**	**Moderately active& unhealthy eater**	**Active & healthy eater**
	Cluster size	49.6 (n=8,666)	14.7 (n=2,560)	35.7 (n=6,236)
Physical inactivity	MPA (< 5days/week)	97.0	8.1	96.4
	VPA (<3 days/week)	81.0	0.9	78.7
Sedentary time	Weekdays (≥ 3 hours/day)	90.7	55.6	21.4
	Weekends (≥ 5hours/day)	85.8	48.7	12.8
Obesogenic diet	Skipping breakfast (≥ 2 days/week)	20.5	16.0	16.9
	Eating fruit (< 2times/day)	92.4	85.5	90.1
	Unhealthy drinks[1] (≥ 3 times/week)	57.1	57.3	43.4
	Eating fast food (≥ 3 times/week)	25.4	22.8	15.6

Note: MPA = Moderate intensity physical activity, VPA = Vigorous intensity physical activity
[1] = carbonated or sugary drinks



Note: MPA = Moderate intensity physical activity,
VPA = Vigorous intensity physical activity,
ST = Sedentary time

Figure 6. Distribution of obesogenic behavior variables by the cluster of Korean adolescents

5.5 Difference in Social Determinants of Health between Clusters

5.5.1 Ethnic minority adolescents

Table 11 showed the clusters of obesogenic behaviors in ethnic minority adolescents. There were statistical significantly differences between the clusters among ethnic minority adolescents by gender, sleep time, stress, self-rated health, city size and the number of convenience stores. Those in the "Inactive & unhealthy eater" cluster were more likely to be female, have less sleep, more stress, think of themselves as unhealthy, and live in the county area, compared with other clusters. Those in the "Moderately active& unhealthy eater" cluster were more likely to be male, sleep more, think of themselves as healthy, live in a metropolitan city, and have more convenience stores, compared with other clusters. Those in the "Active & healthy eater" cluster were more likely to be female, less stressed, think of themselves as healthy, and live in a small city, compared with other clusters. There were no significant differences among the clusters in terms of age, nationality of fathers and mothers, father's educational level, mother's educational level, economic status, academic performance, depressive symptom, poverty rate, width of parks, the number of public sports facilities, the number of snack bars, the number of fast food restaurants and the number of Internet cafes.

Table 11. Characteristics across the three clusters of ethnic minority adolescents (N = 539)

Variables		Inactive & unhealthy eater (n=329)		Moderately active& unhealthy eater (n= 81)		Active & healthy eater (n=129)		x^2 or F	*p*-value
		n (%)/ Mean ± SD							
Structural determinants									
Socioeconomic position									
Gender									
Males		151	(45.9)	59	(72.8)	53	(41.1)	22.92	<.001
Females		178	(54.1)	22	(27.2)	76	(58.9)		
Age		13.48	±0.99	13.26	±0.96	13.37	±0.99	1.91	.149
Nationality of fathers	Korean	268	(81.5)	63	(77.8)	100	(77.5)	7.61	.268
	Korean Chinese	28	(8.5)	4	(4.9)	9	(7.0)		
	Chinese	12	(3.6)	3	(3.7)	4	(3.1)		
	Others	21	(6.4)	11	(13.6)	16	(12.4)		
Nationality of mothers	Korean	16	(4.9)	8	(9.9)	6	(4.7)	8.00	.434
	Korean Chinese	60	(18.2)	13	(16.0)	21	(16.3)		
	Chinese	55	(16.7)	16	(19.8)	15	(11.6)		
	Vietnamese	104	(31.6)	21	(25.9)	48	(37.2)		
	Others	94	(28.6)	23	(28.4)	39	(30.2)		
Father's educational level	Middle school	27	(8.2)	7	(8.6)	15	(11.6)	1.68	.947
	High school	93	(28.3)	22	(27.2)	34	(26.4)		
	University	61	(18.5)	17	(21.0)	23	(17.8)		
	Unknown	148	(45.0)	35	(43.2)	57	(44.2)		

Variables		Inactive & unhealthy eater (n=329)		Moderately active & unhealthy eater (n= 81)		Active & healthy eater (n=129)		x^2 or F	*p*-value
		n (%)/ Mean ± SD							
Mother's education level	Middle school	18	(5.5)	3	(3.7)	12	(9.3)	4.94	.552
	High school	73	(22.2)	17	(21.0)	32	(24.8)		
	University	70	(21.3)	21	(25.9)	27	(20.9)		
	Unknown	168	(51.1)	40	(49.4)	58	(45.0)		
Economic status	High	19	(5.8)	6	(7.4)	11	(8.5)	11.81	.160
	Middle-high	65	(19.8)	19	(23.5)	19	(14.7)		
	Middle	177	(53.8)	47	(58.0)	83	(64.3)		
	Middle-low	59	(17.9)	9	(11.1)	14	(10.9)		
	Low	9	(2.7)	0	(0.0)	2	(1.6)		
Intermediary determinants									
Behaviors and biological factors									
Sleep time (hours)		7.01	±1.47	7.62	±1.41	7.26	±1.45	6.01	.003
Academic performance	Very well	23	(7.0)	9	(11.1)	12	(9.3)	5.36	.719
	Well	61	(18.5)	17	(21.0)	22	(17.1)		
	Moderate	112	(34.0)	27	(33.3)	45	(34.9)		
	Bad	93	(28.3)	24	(29.6)	37	(28.7)		
	Very bad	40	(12.2)	4	(4.9)	13	(10.1)		
Psychosocial factors									
Stress	Never felt	8	(2.4)	4	(4.9)	11	(8.5)	17.41	.026
	Not felt much	60	(18.2)	23	(28.4)	24	(18.6)		
	Felt a little	144	(43.8)	30	(37.0)	63	(48.8)		
	Felt much felt	87	(26.4)	18	(22.2)	22	(17.1)		
	Felt very much	30	(9.1)	6	(7.4)	9	(7.0)		

Variables		Inactive & unhealthy eater (n=329)		Moderately active& unhealthy eater (n= 81)		Active & healthy eater (n=129)		x^2 or F	p-value
		n (%)/ Mean ± SD							
Depressive symptom	No	259	(78.7)	68	(84.0)	96	(74.4)	2.71	.258
	Yes	70	(21.3)	13	(16.0)	33	(25.6)		
Self-rated health	Unhealthy	37	(11.2)	3	(3.7)	8	(6.2)	6.09	.048
	Healthy	292	(88.8)	78	(96.3)	121	(93.8)		
Material circumstances									
Poverty rate		4.37	±1.18	4.28	±1.31	4.33	±1.29	0.17	.843
City size	Metropolitan city	117	(35.6)	40	(49.4)	49	(38.0)	9.45	.051
	Small city	156	(47.4)	35	(43.2)	66	(51.2)		
	County area	56	(17.0)	6	(7.4)	14	(10.9)		
Width of parks		0.03	±0.03	0.03	±0.03	0.03	±0.03	0.09	.915
The number of public sports facilities		2.52	±2.68	1.98	±1.77	2.46	±2.55	1.49	.227
The number of snack bars		104.23	±24.08	111.24	±31.48	103.84	±24.97	2.67	.069
The number of fast food restaurants		83.16	±16.47	85.61	±17.59	85.35	±18.31	1.16	.315
The number of convenience stores		85.31	±21.32	91.84	±25.10	88.86	±23.15	3.28	.039
The number of Internet cafes		18.80	±4.45	19.40	±4.05	19.38	±4.69	1.12	.326

Note:SD = Standard deviation

5.5.2 Korean adolescents

Table 12 showed the clusters of obesogenic behaviors in Korean adolescents.

There were differences among the clusters by the socioeconomic position of structural determinants (gender, age, nationality of fathers, nationality of mothers, father's educational level, mother's educational level, economic status), behaviors and biological factors of intermediary determinants (sleep time, academic performance), psychosocial factors (stress, depressive symptom, self-rated health), and material circumstances (poverty rate, city size, width of parks, the number of public sports facilities, the number of fast food restaurants). Those in the "Inactive & unhealthy eater" cluster were more likely to be female (53.9%) and aged older (13.694±0.935), less likely to have parents who graduated university(father: 54.2%, mother: 53.4%), have less sleep (6.781±1.458), have worse academic performance ("well":28.6% and "very well":14.3%, respectively), were the lowest of the three clusters. Those in the "Inactive & unhealthy eater" cluster were also more likely to have more stress(felt much: 24.8%, felt very much: 6.5%), feel more depressive symptoms (22.6%), consider more unhealthy themselves (6.3%), live in a small city or county area (51.1%, and 7.6%, respectively), have more public sports facilities (2.109± 2.109), and more fast food restaurants (83.815±16.535) than other clusters.

Those in the "Moderately active& unhealthy eater" cluster were more likely to be male (71.6%), have better economic status(middle-high: 32.4%, high: 18.4%), have more sleep (7.166±1.375), have worse academic performance; which was well or very well (29.1%, 18.3%, respectively), were second-lowest of the three clusters. Those in the

"Moderately active& unhealthy eater" cluster were also more likely to have less stress (never felt: 6.9%, not felt much: 24.1%), think of themselves as unhealthy (2.6%), and live in higher poverty rate areas (4.348±1.301) compared with other clusters.

Those in the "Active & healthy eater" cluster were more likely to be female (55.0%), have more parents who graduated university (father: 62.1%, mother: 61.3%), have better economic status (middle-high: 33.6%, high: 15.7%), have better academic performance, which was "well" or "very well (32.1%, 3%, 21.4%, respectively), were the highest of the three clusters. Those in the 'Active & healthy eater' cluster were also less likely to feel depressive symptoms (19.2%), more likely to live in lower poverty rate areas (4.229±1.590), live more in the metropolitan city (44.3%), have the highest width of parks (0.038±0.035), have less the number of public sports facilities (1.989±2.159), the fewer number of fast food restaurants (83.386±15.888) than other clusters. The numbers of snack bars, convenience stores, and Internet cafes were not significantly different among the clusters.

Table 12. Characteristics across the three clusters of Korean adolescents (N=17,462)

Variables		Inactive & unhealthy eater (n=8,666)		Moderately active & unhealthy eater (n= 2,560)		Active & healthy eater (n=6,236)		x^2 or F	p-value
		n (%)/ Mean ± SD							
Structural determinants									
Socioeconomic position									
Gender	Males	3992	(46.1)	1834	(71.6)	2805	(45.0)	593.86	<.001
	Females	4674	(53.9)	726	(28.4)	3431	(55.0)		
Age		13.694	±0.935	13.602	±0.930	13.582	±0.929	28.66	<.001
Father's educational level	Middle school	84	(1.0)	20	(0.8)	50	(0.8)	104.99	<.001
	High school	1621	(18.7)	506	(19.8)	971	(15.6)		
	University	4698	(54.2)	1473	(57.5)	3874	(62.1)		
	Unknown	2263	(26.1)	561	(21.9)	1341	(21.5)		
Mother's educational level	Middle school	73	(0.8)	16	(0.6)	42	(0.7)	94.46	<.001
	High school	1943	(22.4)	566	(22.1)	1179	(18.9)		
	University	4630	(53.4)	1453	(56.8)	3821	(61.3)		
	Unknown	2020	(23.3)	525	(20.5)	1194	(19.1)		
Economic status	High	1033	(11.9)	471	(18.4)	977	(15.7)	126.76	<.001
	Middle-high	2686	(31.0)	830	(32.4)	2098	(33.6)		
	Middle	4123	(47.6)	1048	(40.9)	2681	(43.0)		
	Middle-low	714	(8.2)	175	(6.8)	425	(6.8)		
	Low	110	(1.3)	36	(1.4)	55	(0.9)		
Intermediary determinants									
Behaviors and biological factors									
Sleep time (hours)		6.781	±1.458	7.166	±1.375	7.002	±1.458	86.75	<.001

Variables		Inactive & unhealthy eater (n=8,666)		Moderately active& unhealthy eater (n= 2,560)		Active & healthy eater (n=6,236)		x^2 or F	p-value
		n (%)/ Mean ± SD							
Academic performance	Very well	1242	(14.3)	469	(18.3)	1334	(21.4)	248.12	<.001
	Well	2476	(28.6)	744	(29.1)	1999	(32.1)		
	Moderate	2638	(30.4)	680	(26.6)	1752	(28.1)		
	Bad	1694	(19.5)	488	(19.1)	881	(14.1)		
	Very bad	616	(7.1)	179	(7.0)	270	(4.3)		
Psychosocial factors									
Stress	Never felt	248	(2.9)	177	(6.9)	284	(4.6)	149.55	<.001
	Not felt much	1691	(19.5)	617	(24.1)	1362	(21.8)		
	Felt a little	4013	(46.3)	1093	(42.7)	2882	(46.2)		
	Felt much	2147	(24.8)	519	(20.3)	1395	(22.4)		
	Felt very much	567	(6.5)	154	(6.0)	313	(5.0)		
Depressive symptom	No	6708	(77.4)	2002	(78.2)	5040	(80.8)	25.79	<.001
	Yes	1958	(22.6)	558	(21.8)	1196	(19.2)		
Self-rated health	Unhealthy	543	(6.3)	66	(2.6)	290	(4.7)	59.96	<.001
	Healthy	8123	(93.7)	2494	(97.4)	5946	(95.3)		
Material circumstances									
Poverty rate		4.325	±1.294	4.348	±1.301	4.229	±1.590	10.67	<.001
City size	Metropolitan city	3580	(41.3)	1105	(43.2)	2761	(44.3)	16.24	.003
	Small city	4430	(51.1)	1270	(49.6)	3069	(49.2)		
	County area	656	(7.6)	185	(7.2)	406	(6.5)		
Width of parks		0.034	± 0.034	0.033	±0.034	0.038	± 0.035	25.52	<.001
The number of public sports facilities		2.109	± 2.109	2.087	±2.022	1.989	± 2.159	6.11	.002
The number of snack bars		107.240	±27.173	106.701	±27.535	106.667	±29.915	0.87	.419
The number of fast food restaurants		83.815	±16.535	83.526	±15.674	83.386	±15.888	14.53	<.001

Variables	Inactive & unhealthy eater (n=329)	Moderately active& unhealthy eater (n= 81)	Active & healthy eater (n=129)	x^2 or F	p-value
	n (%)/ Mean ± SD				
The number of convenience stores	87.922 ±23.232	88.546 ±23.339	87.358 ±22.762	2.60	.074
The number of Internet cafes	19.658 ±4.485	19.429 ±4.307	19.596 ±4.803	2.48	.084

Note:SD = Standard deviation,
The number of= The number of facilities in relevant city / Population in relevant city*100,000

5.6 Social Determinants of Health Affecting the Clusters

The “Active & healthy eater” cluster, which is the second cluster for each cluster, was set as a reference cluster for the social determinants of health of ethnic minority adolescents and Korean adolescents, and the other two clusters (“Inactive & unhealthy eater”, “Moderately active& unhealthy eater”) were analyzed using multinomial logistic regression to determine the social determinants of health. In this analysis, for the ease of the interpretation of the results, nominal variables with the ordinal scale of parent education, economic status, academic performance, and stress were converted into continuous variables. In ethnic minority adolescents from the 20 variables initially selected, 14 variables were not selected due to rejection in descriptive analysis (Chi-square test and T-test) for cluster analysis.

As a result, only statistically significant variables among the social determinants of health by cluster were extracted and included in Tables 13(Ethnic minority adolescents) and 14 (Korean adolescents). It means that the variables (i.e. Male, Depressive symptom) shown in the table or the risk of belonging to the cluster increases depending on the direction of the variable arrow. Referring to Tables 13 and 14, in the case of gender, it was found that male adolescents had an increased risk of belonging to the group than the reference group, compared with female adolescents.

In the case of “Inactive & unhealthy eater”, the first cluster of ethnic minority adolescents, the higher the stress level compared to the reference cluster “Active & healthy

eater", the higher the risk of belonging to "Inactive & unhealthy eater". Additionally, as a result of extracting and analyzing only those variables that were significant in the univariate logistic regression analysis, the higher the level of stress, the higher the risk of belonging to "Inactive & unhealthy eater".

For the "Moderately active& unhealthy eater" cluster, the second cluster of the ethnic minority adolescents, being male increased the risk of belonging to this cluster.

Compared to the reference cluster "Active & healthy eater", the cluster "Inactive & unhealthy eater" of Korean adolescents, being older, male, having lower economic status, lower sleep time, and worse the academic performance, higher the stress level, and the higher the number of fast food restaurants in the region, and increased the risk of belonging to the "Inactive & unhealthy eater" cluster. In addition, as a result of extracting and analyzing the only variables that were significant in the univariate logistic regression analysis, the same variables were statistically significant.

Compared to the reference cluster "Active & healthy eater", the cluster "Moderately active& unhealthy eater" of Korean adolescents, as male, lower the father's educational level, higher economic status, worse academic performance, depressive symptoms, higher self-rated health status, higher the poverty rate, the more convenience stores, and fewer Internet cafe, which increased the risk of belonging to the "Moderately active& unhealthy eater" cluster. Furthermore, as a result of extracting and analyzing only the variables that were significant in the univariate logistic regression analysis, only the width of parks was significant in the material circumstances variables. The lower the width

of parks, the higher the risk of belonging to this cluster, while the other statistically significant variables remained the same.

Specific relative risk ratios (RRR) and 95% confidence intervals (CI) for each cluster were prepared in Tables 13 ~ 16.

Table 13. Key points of the variables among ethnic minority adolescents (n=539)

Social determinants of health	**Inactive & unhealthy eater**		**Moderately active& unhealthy eater**	
	All	Partial*	All	Partial*
Structural determinants				
Socioeconomic position	-	-	Male	Male
Intermediary determinants				
Psychosocial factors	Stress ↑	Stress ↑	-	-

Note:*: Only variables were analyzed as covariate which were statistically significant by univariate logistic regression. That was 'Gender, Nationality of fathers, Economic status, Stress, The number of snack bars'

Table 14. Key points of the results among Korean adolescents (N=17,462)

Social determinants of health	Inactive & unhealthy eater		Moderately active& unhealthy eater	
	All	**Partial***	**All**	**Partial***
Structural determinants				
Socioeconomic position	Male, Age ↑, Economic status ↓	Male, Age ↑, Economic status ↓	Male, Father's education ↓, Economic status ↑	Male, Father's education ↓, Economic status ↑
Intermediary determinants				
Behaviors and biological factors	Sleep time ↓, Academic performance↓	Sleep time↓, Academic performance↓	Academic performance↓	Academic performance↓
Psychosocial factors	Stress ↑	Stress ↑	Depressive symptom, Self-rated health ↑	Depressive symptom, Self-rated health ↑
Material circumstances	Fast food restaurants↑	Fast food restaurants↑	Poverty rate ↑, Convenience stores↑, Internet cafes↓	Width of parks↓

Note: *: Only those variables were analyzed as covariates which were statistically significant by univariate logistic regression. That was 'Gender, Age, Father's education, Economic status, Sleep time, Academic performance, Stress, Depressive symptom, Self-rated health, Poverty rate, City size, Width of parks, The number of public sports facilities, The number of fast food restaurants, The number of convenience stores, The number of Internet cafes'

5.6.1 Ethnic minority adolescents

The risk factors of belonging to the “Inactive & unhealthy eater” and “Moderately active& unhealthy eater” clusters for each social determinant of health were analyzed by setting the “Active & healthy eater” cluster as a reference cluster for ethnic minority adolescents. As a result of analyzing the social determinants of health affecting the obesogenic behaviors of ethnic minority adolescents by cluster, the statistically significant variables were stress among psychosocial factors. Compared to the reference, the risk of belonging to “Inactive & unhealthy eater” was increased with more stress felt by 1.41 times (95% CI: 1.10-1.82) compared to not feeling stress (Table 15).

As a result of analyzing the risk of being “Moderately active& unhealthy eater” in the second cluster compared to the reference of “Active & healthy eater”, the statistically significant variable was gender among the structural factors. In male, the risk increased by 3.72 times (95% CI: 1.94-7.12) compared with female.

Table 15. Social determinants of health affecting clusters among ethnic minority adolescents (N=539)

Variables		Inactive & unhealthy eater		Moderately active & unhealthy eater	
		RRR	95% CI	RRR	95% CI
Structural determinants					
Socioeconomic position					
Gender	Males (ref.= females)	1.35	0.86-2.13	3.72***	1.94-7.12
Age		1.13	0.91-1.40	0.91	0.66-1.25
Nationality of fathers		0.79	0.62-1.00	0.93	0.68-1.28
Nationality of mothers		0.83	0.69-1.01	0.77	0.59-1.00
Father's education (higher)		1.05	0.82-1.34	0.86	0.61-1.21
Mother's education (higher)		1.14	0.89-1.47	1.31	0.92-1.87
Economic status (worse)		1.08	0.83-1.41	0.89	0.61-1.29
Intermediary determinants					
Behaviors and biological factors					
Sleep time (hours)		0.92	0.79-1.07	1.12	0.89-1.40
Academic performance (worse)		1.08	0.88-1.33	0.97	0.73-1.29
Psychosocial factor					
Stress (worse)		1.41**	1.10-1.82	1.27	0.90-1.78
Depressive symptom	Yes (ref. No)	0.59	0.34-1.01	0.61	0.28-1.36
Self-rated health	Unhealthy (ref. healthy)	1.47	0.63-3.45	0.54	0.13-2.24
Material circumstances					
Poverty rate		0.99	0.75-1.30	0.85	0.59-1.22
City size (Smaller)		1.46	0.89-2.38	0.69	0.34-1.39
Width of parks		1.85	0.00-96222.47	0.12	0.00-234815.33
The number of public sports facilities		0.97	0.86-1.09	0.95	0.79-1.14
The number of snack bars		1.01	1.00-1.02	1.01	1.00-1.03
The number of fast food restaurants		1.00	0.98-1.02	1.01	0.99-1.04
The number of convenience stores		0.99	0.98-1.01	1.00	0.98-1.02
The number of internet cafe		0.99	0.93-1.04	0.97	0.90-1.05

Note: Reference cluster= Active & healthy eater, RRR=Relative risk ratio, CI= Confidence interval, ref= reference, **: <.01 ***: <.001

In Table 16, from the 20 variables selected initially, 14 were not selected due to rejection in descriptive analysis (Chi-square test and T-test) for cluster analysis (i.e., Age, Nationality of fathers and mothers, Father's and mother's education level, Economic status, Academic performance, Depressive symptoms, etc). After performing a univariate logistic regression analysis with social determinants of health and cluster, respectively, the significant variables were Gender, Sleep time, Stress, Self-rated health, City size, and The number of snack bars. Compared to the reference, the risk of belonging to the "Inactive & unhealthy eater" cluster was increased due to feeling more stress by 1.33 times (95% CI: 1.06-1.68), as compared to not feeling stress (Table 16).

As a result of analyzing the risk of being "Moderately active& unhealthy eater" in the second cluster compared to the reference of "Active & healthy eater", the statistically significant variable was gender among the structural factors. In male adolescents, compared to females, the risk increased by 3.93 times (95% CI: 2.10-7.35).

Table 16. Selected factors in social determinants of health affecting the cluster among ethnic minority adolescents (N=539)

Variables		Inactive & unhealthy eater		Moderately active& unhealthy eater	
		RRR	95% CI	RRR	95% CI
Structural determinants					
Socioeconomic position					
Gender	Males (ref.= females)	1.38	0.90-2.14	3.93***	2.10-7.35
Intermediary determinants					
Behaviors and biological factors					
Sleep time (hours)		0.90	0.77-1.04	1.10	0.89-1.37
Psychosocial factors					
Stress (worse)		1.33*	1.06-1.68	1.18	0.86-1.61
Self-rated health	Unhealthy (ref. healthy)	1.51	0.67-3.44	0.48	0.12-1.94
Material circumstances					
City size		1.23	0.90-1.68	0.66	0.42-1.04
The number of convenience stores		0.99	0.98-1.00	1.01	0.99-1.02

Note: Reference cluster= Active & healthy eater, RRR=Relative risk ratio, CI= Confidence interval, ref= reference,
*: <.05 ***: <.001

5.6.2 Korean adolescents

The risk factors of belonging to the “Inactive & unhealthy eater” and “Moderately active& unhealthy eater” clusters for each social determinant of health were analyzed by setting the third cluster “Active & healthy eater” as a reference cluster for Korean adolescents.

The risk of belonging to the “Inactive & unhealthy eater” cluster compared to the “Active & healthy eater” cluster was analyzed. The statistically significant variables were

gender, age, father's educational level, economic status (among structural factors), sleep time, academic performance (among behaviors and biological factors), stress (among psychosocial factors), and the number of fast food restaurants (among material circumstances of intermediary factors).

Compared to the reference, the risk of belonging to "Inactive & unhealthy eater" was increased in males by 1.159 times (95% CI: 1.081-1.241) compared with females (Table 17). As the age increased, the risk of being "Inactive & unhealthy eater" increased by 1.082 times (95% CI: 1.043-1.122) and as the economic status worsened, the risk of 'Inactive & unhealthy eater' increased by 1.073 times (95% CI: 1.031-1.117). Among the behaviors and biological factors, the risk of belonging to this cluster decreased by 0.915 times (95% CI: 0.893-0.937) as sleep time increased, and the risk of belonging to this cluster increased by 1.211 times (95% CI: 1.175-1.249) as the academic performance worsened. Regarding psychosocial factors, the higher the stress level, the more the risk of being in this cluster increased 1.069 times (95% CI: 1.027-1.113). Among the material circumstances, as the number of fast food restaurants increased, the risk of belonging to this cluster increased by 1.004 times (95% CI: 1.001-1.007).

The risk of belonging to the "Moderately active& unhealthy eater" cluster was analyzed compared with the "Active & healthy eater" cluster. As a result, the statistically significant variables were gender, father's educational level, economic status (among structural factors), academic performance (among behaviors and biological factors), depressive symptom, self-rated health (among psychosocial factors), poverty rate, number

of convenience stores, and number of Internet cafe (among material circumstances of intermediary factors) (Table 17).

Compared to the reference, the risk of belonging to 'Moderately active& unhealthy eater' increased in males by 3.227 times (95% CI: 2.909-3.581) compared with females. The higher the father's educational level, the lower the risk of "Moderately active& unhealthy eater" by 0.909 times (95% CI: 0.831-0.994). As the economic status worsened, the risk of being "Moderately active& unhealthy eater" decreased by 0.922 times (95% CI: 0.871-0.976). Among the behaviors and biological factors, as academic performance worsened, the risk of belonging to this cluster increased by 1.193 times (95% CI: 1.142-1.246). As for the psychosocial factors, the risk of belonging to this cluster for depressed adolescents increased by 1.424 times (95% CI: 1.257-1.613). Furthermore, the risk of belonging to this cluster was reduced by 0.542 times (95% CI: 0.411-0.715) among adolescents who were unhealthy in their self-rated health. Among the material circumstances, as the poverty rate increased, the risk of belonging to this cluster decreased by 1.076 times (95% CI: 1.021-1.133). As the number of convenience stores increased, the risk of belonging to this cluster decreased by 1.003 times (95% CI: 1.001-1.006); moreover, as the number of Internet cafes increased, the probability of belonging to this cluster decreased by 0.982 times (95% CI: 0.969-0.995).

Table 17. Social determinants of health affecting the cluster among Korean adolescents (N=17,462)

Variables		Inactive & unhealthy eater		Moderately active& unhealthy eater	
		RRR	95% CI	RRR	95% CI
Structural determinants					
Socioeconomic position					
Gender	Males (ref.= females)	1.159***	1.081-1.241	3.227***	2.909-3.581
Age		1.082***	1.043-1.122	0.999	0.9495-1.052
Father's education (higher)		1.022	0.959-1.089	0.909*	0.831-0.994
Mother's education (higher)		0.993	0.932-1.058	0.942	0.861-1.030
Economic status (worse)		1.073***	1.031-1.117	0.922**	0.871-0.976
Intermediary determinants					
Behaviors and biological factors					
Sleep time (hours)		0.915***	0.893-0.937	0.999	0.965-1.036
Academic performance (worse)		1.211***	1.175-1.249	1.193***	1.142-1.246
Psychosocial factors					
Stress (worse)		1.069***	1.027-1.113	0.966	0.913-1.022
Depressive symptom	Yes (ref. No)	1.056	0.967-1.153	1.424***	1.257-1.613
Self-rated health	Unhealthy (ref. healthy)	1.152	0.991-1.339	0.542***	0.411-0.715
Material circumstances					
Poverty rate		1.029	0.991-1.068	1.076**	1.021-1.133
City size (Smaller)		1.076	0.998-1.161	1.008	0.905-1.123
Width of parks		0.355	0.084-1.505	0.143	0.018-1.124
The number of public sports facilities		0.993	0.971-1.016	0.988	0.957-1.020
The number of snack bars		1.000	0.999-1.002	0.998	0.996-1.000
The number of fast food restaurants		1.004**	1.001-1.007	1.003	0.999-1.007
The number of convenience stores		1.000	0.998-1.002	1.003*	1.001-1.006
The number of Internet cafe		0.994	0.985-1.004	0.982**	0.969-0.995

Note: Reference cluster= Active & healthy eater, RRR=Relative risk ratio, CI= Confidence interval, ref= reference, *: <.05 **: <.01 ***: <.001

In Table 18, from the 18 variables selected initially, 3 variables were discarded due to rejection in descriptive analysis (Chi-square test and T-test) for cluster analysis (i.e., The number of snack bars, The number of convenience stores, The number of Internet cafes).

Compared to the reference, the risk of belonging to “Inactive & unhealthy eater” increased by 1.159 times (95% CI: 1.082-1.242) in males compared with females. As the age increased, the risk of being “Inactive & unhealthy eater” increased by 1.082 times (95% CI: 1.043-1.122). Moreover, as the economic status worsened, the risk of being “Inactive & unhealthy eater” increased by 1.073 times (95% CI: 1.031-1.117). Among the behaviors and biological factors, as sleep time increased, the risk of belonging to this cluster decreased by 0.915 times (95% CI: 0.893-0.937), and as the academic performance worsened, the risk of belonging to this cluster increased by 1.211 times (95% CI: 1.174-1.249). Furthermore, as stress increased in psychosocial factors, the risk of belonging to this cluster increased by 1.069 times (95% CI: 1.027-1.112). Among the material circumstances, as the number of fast food restaurants increased, the risk of belonging to this cluster increased by 1.004 times (95% CI: 1.001-1.006).

Compared to the reference, the risk of belonging to the “Moderately active& unhealthy eater” cluster increased in males by 3.217 times (95% CI: 2.900-3.569), as compared to females. The higher the father’s educational level, the lower the risk of being “Moderately active& unhealthy eater” by 0.874 times (95% CI: 0.815-0.938). As the economic status worsened, the risk of being “Moderately active& unhealthy eater”

decreased by 0.923 times (95% CI: 0.873-0.977). Among the behaviors and biological factors, as academic performance worsened, the risk of belonging to this cluster increased by 1.191 times (95% CI: 1.140-1.244). As the adolescents felt depressive symptoms in psychosocial factors, the risk of belonging to this cluster increased by 1.428 times (95% CI: 1.261-1.618). Additionally, the risk of belonging to this cluster was reduced by 0.542 times (95% CI: 0.411-0.715) among adolescents who were unhealthy in their self-rated health. Among the material circumstances, as the width of parks increased, the risk of belonging to this cluster decreased by 0.037 times (95% CI: 0.006-0.238).

Table 18. Selected variables in social determinants of health affecting cluster among Korean adolescents

(N=17,462)

Variables		Inactive & unhealthy eater		Moderately active& unhealthy eater	
		RRR	95% CI	RRR	95% CI
Structural determinants					
Socioeconomic position					
Gender	Males (ref.= females)	1.159***	1.082-1.242	3.217***	2.900-3.569
Age		1.082***	1.043-1.122	1.001	0.950-1.054
Father's education (higher)		1.017	0.968-1.070	0.874***	0.815-0.938
Economic status (worse)		1.073***	1.031-1.117	0.923**	0.873-0.977
Intermediary determinants					
Behaviors and biological factors					
Sleep time (hours)		0.915***	0.893-0.937	1.000	0.965-1.037
Academic performance (worse)		1.211***	1.174-1.249	1.191***	1.140-1.244
Psychosocial factors					
Stress (worse)		1.069***	1.027-1.112	0.966	0.913-1.022
Depressive symptom	Yes (ref. No)	1.057	0.968-1.154	1.428***	1.261-1.618
Self-rated health	Unhealthy(ref.healthy)	1.152	0.991-1.339	0.542***	0.411-0.715
Material circumstances					
Poverty rate		1.024	0.993-1.055	1.020	0.980-1.062
City size (Smaller)		1.068	0.991-1.151	0.992	0.891-1.104
Width of parks		0.288	0.076-1.089	0.037***	0.006-0.238
The number of public sports facilities		0.996	0.975-1.018	1.004	0.974-1.034
The number of fast food restaurants		1.004**	1.001-1.006	1.001	0.997-1.005
The number of convenience stores		1.000	0.998-1.001	1.001	0.999-1.004

Note: Reference cluster: Active & healthy eater, RRR=Relative risk ratio, CI= Confidence interval, ref= reference, **: <.01 ***: <.001

5.7 Validation of Differences in Obesity Classification by Clusters

To confirm the validity of all three cluster classifications of ethnic minority adolescents and Korean adolescents, the difference in the probability of becoming obese for each cluster was analyzed using multinomial logistic regression. In addition, the graphs and the frequency of subjects were analyzed and compared to confirm the predictive probability of obesity according to clusters (Appendix 2).

5.7.1 Ethnic minority adolescents

In the obesogenic behavior cluster of ethnic minority adolescents, the probability of obesity classification compared to normal weight was statistically significant at underweight. The risk of being “underweight” decreased in the “Moderately active& unhealthy eater” by 0.19 times (95% CI: 0.04-0.86), as compared to the reference (Table 19). In other words, the probability of becoming underweight increased compared to the “Moderately active& unhealthy eater” cluster. This can be explained by the higher number of males in the obesity group, compared with the female in the “Moderately actively & unhealthy eater” cluster; therefore, subjects in this cluster tended to be obese or overweight rather than underweight. However, it was not statistically significant for obesity or overweight.

Table 19. The obesity classification related to cluster among ethnic minority adolescents (N=539)

Variables	Clusters	RRR	95% CI
Obesity	Inactive & unhealthy eater	0.76	0.43-1.32
	Moderately active& unhealthy eater	0.68	0.31-1.51
	Active & healthy eater	ref	
Overweight	Inactive & unhealthy eater	0.80	0.40-1.62
	Moderately active& unhealthy eater	1.42	0.61-3.29
	Active & healthy eater	ref	
Underweight	Inactive & unhealthy eater	0.58	0.29-1.16
	Moderately active& unhealthy eater	0.19*	0.04-0.86
	Active & healthy eater	ref	

Note: Reference= Normal weight, RRR=Relative risk ratio, CI= Confidence interval, ref= reference
*: <.05

5.7.2 Korean adolescents

In the obesogenic behavior cluster of Korean adolescents, the probability of obesity was statistically significant for obesity, overweight, and underweight. The risk of having "obesity" was increased in the "Inactive & unhealthy eater" and "Moderately active& unhealthy eater" clusters by 1.22 times (95% CI: 1.10-1.36) and 1.38 times (95% CI: 1.20-1.59), respectively, compared to the "Active & healthy eater" cluster (Table 20).

This can be explained by the worse pattern cluster of obesogenic behavior having a positive correlation with obesity, compared to the relatively good pattern cluster. The risk of being "overweight" was increased in the "Moderately active& unhealthy eater" cluster by 1.28 times (95% CI: 1.10-1.48), as compared to the "Active & healthy eater" cluster. Finally, the risk of being "underweight" decreased in the "Moderately active& unhealthy eater" by 0.49 times (95% CI: 0.39-0.63), as compared with the "Active & healthy eater" cluster. This can be explained by the higher number of males in the obesity group, compared with the females in the "Moderately actively & unhealthy eater" cluster;

Table 20. The obesity classification related to cluster among Korean adolescents (N=17,462)

Variables	Clusters	RRR	95% CI
Obesity	Inactive & unhealthy eater	1.22***	1.10-1.36
	Moderately active & unhealthy eater	1.38***	1.20-1.59
	Active & healthy eater	Ref	
Overweight	Inactive & unhealthy eater	1.10	0.99-1.23
	Moderately active & unhealthy eater	1.28***	1.10-1.48
	Active & healthy eater	ref	
Underweight	Inactive & unhealthy eater	1.13	0.99-1.28
	Moderately active & unhealthy eater	0.49***	0.39-0.63
	Active & healthy eater	ref	

Note: Reference= Normal weight, RRR=Relative risk ratio, CI= Confidence interval, ref= reference
***: <.001

Chapter 6. Discussion

This study aimed to identify the cluster of obesogenic behavior, confirm the social determinants of health, and compare the determinants of the cluster of obesogenic behavior among ethnic minority adolescents and Korean adolescents. This chapter explains the results and discusses the meaning of findings in the area of obesogenic behaviors, the difference in characteristics of the cluster, social determinants of health associated with the cluster of obesogenic behaviors, and the validity of the clusters of obesogenic behaviors of ethnic minority adolescents and Korean adolescents. Finally, the chapter concluded with a discussion on the study's limitations, suggestions, and the implication and significance of the study in nursing theory, research and practice.

6.1 Obesogenic Behaviors among Ethnic minority adolescents and Korean adolescents

Obesogenic behavior is several complex behaviors that affect obesity and refers to behavioral factors that are correlated with obesity(Liberali et al., 2021).In this study, it was also found that the behavioral factors (Physical inactivity, sedentary time, obesogenic diet) affecting obesity of ethnic minority adolescents and Korean adolescents were accompanied with high correlation. Overall, ethnic minority adolescents in this study are sedentary for a longer time on weekdays and weekends and eat less fruit than Korean adolescents. The findings are consistent to another study by Kim (2019) that showed that ethnic minority

adolescents are also more sedentary than Korean adolescents on weekdays and weekends. In the United States, research comparing sedentary time among different ethnic groups showed that black and Hispanic adolescents spend more sedentary time than Caucasian adolescents, confirming the length of sedentary time gap among the various ethnic groups of adolescents(Yang et al., 2019). In a comparative study among ethnic minority adolescents in Korea, those from North Korea and other countries spent longer sedentary time than those from the parents of East Asian nationalities(Kim, 2019). Therefore, showing a sedentary time may be accepted at different levels among various ethnicities.

The difference in sedentary time by ethnic group is likely to occur due to differences in parenting styles of various cultural backgrounds. South Asian women dislike structured exercise and have a cultural feature that prefers a sedentary lifestyle because of virtues such as humility and social events based on religious beliefs(Lucas et al., 2013). Therefore, intervention considering the difference like preference of sedentary lifestyle by culture is recommended to reduce ethnic minority adolescents' sedentary time. The recommendation also applies to the ethnic minority parents with adolescent children in Korea, as many studies show that providing knowledge on health regarding sedentary time to the parents effectively reduces the sedentary time of their teenage children(Altenburg, Kist-van Holthe, &Chinapaw, 2016). Although this study had no comparative analysis of the sedentary time by nationality of the parents of ethnic minority adolescents, we suggest investigating its relationship with children's sedentary time by parents' cultural background in a future study.

Fruit intake is considered a component of a balanced diet as it is a major vitamin source in adolescents and provides a feeling of satiety, potentially preventing obesity (Aprilia et al., 2018; Sharma et al., 2016; Tetens&Alinia, 2009). In previous studies, insufficient fruit intake of adolescents is found to be a primary factor in obesogenic behavior(Pengpid, &Peltzer, 2019; Liberali et al., 2021), and diseases (Krishnaswamy & Gayathri, 2018). However, it has been known that both adolescents in Korea(KDCA, 2021) and abroad(Li et al., 2021) gradually consume less fruit yearly. It is also confirmed that ethnic minority adolescents consume less fruit than Korean adolescents in Korea (Lee et al., 2015; Choi, 2015; Song, 2020), and longitudinal research abroad also shows corresponding results to this study that ethnic minority adolescents consistently consumed less fruit(Huang et al., 2019).

In the United States, adolescents from various ethnic groups showed disparities in fruit intake and preferred types of fruit(Herrick et al., 2015). For instance, Asian consumed more citrus and dried fruits than other ethnic groups, and Caucasians consumed berries the most. Such disparity originates from acculturation, accessibility to fruit intake, and the social experience of each ethnic group(Herrick et al., 2015). Moreover, there is a difference in the cultural belief on fruit that 'healthy food is not tasty.' The study showed that Asians tend to choose healthy food even though it is not tasty(Briers et al., 2020). Also, it is reported that various ethnic groups have different amounts of family mealtime, affecting nutritional education and a balanced diet, leading to disparity in fruit intake (Surjadi et al., 2017). Accordingly, intervention based on fruit preference in culture, the cause of insufficient fruit

intake such as cultural belief, and family mealtime by ethnicity will effectively boost the fruit intake of ethnic minority adolescents. Follow-up research on why ethnic minority adolescents in Korea consume less fruit is also required.

This study found that ethnic minority adolescents consume fast food less frequently than Korean adolescents. In the same context, a study comparing the fast food consumption frequency of ethnic minority adolescents and Korean adolescents in 2018-2019 proved that adolescents from ethnic minority groups had fast food less frequently (Song, 2020). Meanwhile, research showed that ethnic minority adolescents took fast food more regularly in other countries when compared fast food consumption by each ethnic group, contrasting the result of the domestic research (Noonan, 2018). The reason can be found in the accessibility to fast food restaurants. In this research, the number of ethnic minority adolescents was more than twice that of Korean adolescents in rural areas. A preceding study (Dunn, Sharkey, & Horel, 2012) shows the limited accessibility to fast food restaurants in rural areas, causing contrasting results of ethnic minority adolescents eating less fast food. In this research, the two groups did not show the disparity in material circumstance related to fast food consumption (number of fast food restaurants, convenience stores, and snack bars). It is recommended to execute a study on the relationship between the material circumstance related to fast food consumption and ethnic minority adolescents having fast food to prove the significance of the material circumstance in the future.

Fast food is an affordable food option for adolescents (Janssen et al., 2018), and fast

food consumption is reported to be an important representation of a social and cultural affiliation with peers (Bugge, 2011). According to this study, only 17.3% of ethnic minority adolescents ate fast food, but intervention is necessary to continuously reduce fast food consumption in the future based on an understanding of not only the material circumstance but also the psychosocial factors (a sense of belonging with peers) that affect fast food consumption.

This study found that 67-84% of both ethnic minorities and Korean adolescent groups did not meet the WHO's recommended guidelines for MPA and VPA. In the case of physical activity of domestic adolescents, middle school students engaged in a relatively similar MPA rate over five years and the rate of physical activity engagement decreased only recently in 2020 (KDCA, 2021). VPA values have continuously decreased over the past five years with the largest decline (7.3%) occurring between 2019 and 2020 (KDCA, 2021). As physical activity has declined for both groups, regional or national measures are urgently needed to promote physical activity for domestic adolescents.

Foreign studies also show that the rate of adolescents engaging in physical activity has continuously declined over 10 years. In particular, a comparison of the rates of physical activity engagement by race found that Caucasian adolescents engaged in a consistent level of physical activity while African-American and Latino adolescents showed a decrease in rates of physical activity engagement over 10 years (Chen et al., 2021). In Korea, cross-sectional research reports that ethnic minority middle school students practiced in lower levels of physical activity compared to Korean middle school students (Song, 2020; Lee

&Cho, 2017); however, there was a lack of studies tracking yearly changes in physical activity. Because a longitudinal design study can identify the various causes that affect fluctuations in physical activity levels with considerations for time and can predict obesity probability health outcomes based on changing levels of physical activity at two or more points in time, a longitudinal design study is proposed to investigate the physical activity of ethnic minority adolescents.

The data source for this study was investigated in 2020, after the outbreak of the COVID-19 pandemic. In studies of obesity-inducing behaviors among adolescents abroad and in Korea, there were changes such as decreased physical activity, increased sedentary time (Pietrobelli et al., 2020), increased number of meals, and increased consumption of fried and sweet foods(Ruiz-Roso et al., 2020). The obesity rate among adolescents in the United States increased rapidly for one year among all adolescents (Dutta, 2020), and as a difference in the risk of obesity between races was confirmed (Eneli& Pratt, 2022), changes in the obesity rate and obesogenic behaviors among ethnic minority adolescents in Korea are also expected, so further research is needed.

6.2 Difference in Characteristics of Clusters among Ethnic Minority Adolescents and Korean Adolescents

The purpose of this study was to identify the cluster of obesogenic behaviors affecting obesity by understanding obesogenic behavior as a combination of complex behavioral

factors. Complex obesogenic behavior varies from person to person and is a combination of multiple behaviors, making it a difficult health problem in which to intervene (Montesi et al., 2016). There are recent cluster analysis studies on domestic adolescents (Lee & La, 2021), but there is no research on obesogenic behavior in ethnic minority adolescents. This study is significant in that it is the first attempt to identify obesogenic behavior in ethnic minority adolescents through cluster analysis.

Latent class analysis results from this study show that obesogenic behavior in ethnic minority adolescents and Korean adolescents was identified in three clusters, in this study. Most subjects belonged to the “Inactive & unhealthy eater” cluster(ethnic minority: 61.0%, Korean: 49.6%), which was the cluster that had the highest incidence of obesogenic behavior. However, in previous studies, the cluster that most subjects (30%) fell under, overall, was healthy behavior patterns ‘high physical activity and short sedentary time’ (Fleary, 2017; Kim et al., 2015). Therefore, it was found difference the ratio of the cluster that they belonged to in each study. For the validity of the ratio of the cluster after the cluster analysis, it is suggested that a study should be conducted reflecting the real life of adolescents in the future as an intervention study or a qualitative study.

Among the variables comprising the clusters in this study, the difference in sedentary time was the most prominent and confirmed a successive difference between the three clusters. The “Inactive & unhealthy eater” cluster had the longest sedentary time and showed the highest number of obesogenic behaviors, while the cluster with the second longest sedentary time. And the cluster with the shortest sedentary time followed a positive

direction in the degree of obesogenic behaviors. Therefore, the most critical variable in obesogenic behavior is sedentary time. Previous research also shows that a sedentary lifestyle has the greatest influence on obesity, making it the most notable behavior among obesogenic behaviors (Liberali et al., 2021; Tabacchi et al., 2018). The results of this study and previous studies emphasize the need for sedentary time intervention to solve the adolescent obesity problem.

As a result of confirming the difference in characteristics between the clusters of the two groups(ethnic minority adolescents and Korean adolescents), the three clusters in this study showed similar results if they belonged to a cluster with the same name, whether ethnic minority adolescents or Korean adolescents. Three pairs of clusters with the same number and similar characteristics were suitable for comparison between the two groups. However, in the "Moderately active &unhealthy eater" cluster, the item-response probability of physical inactivity and sedentary time among obesogenic behavior of ethnic minority adolescents was higher than that of Korean adolescents. Among the clusters, the "Moderately active &unhealthy eater" had a mixed pattern of a higher level of physical activity and long sedentary time. This pattern of cluster behavior was frequently reported in previous studies (Ferrar et al., 2013; Tassitano et al., 2020). Cluster is known as the occurrence of healthy and unhealthy behaviors at the same time (Liberali et al., 2021), so it is difficult to regard them as bad behaviors. The time units of questions about physical activity(the number of days during the week) and sedentary time (hours during the

weekdays or weekends) are different, and it is difficult to reflect meal time, sleep time, and standing time other than two actions, so it is not a concept that can be counted relatively.

To date, the mixed behavioral patterns of clusters are known to be a problem that should not be considered “the two sides of the same coin,” due to the complex interaction between behaviors (Miranda et al., 2021). Thus, a future intervention study should be performed to prove the relationship between physical activity and a sedentary lifestyle.

One of the obesogenic behavior variables, sedentary time, in which three step-by-step differences were confirmed, produced outcomes that were identical across clusters provided they shared the same name, whether they belonged to ethnic minority adolescents or Korean adolescents. The results of the study in Czech, which analyzed adolescents aged 12~16, showed that the amount of recreational sedentary time on weekends increased more than on weekdays (Sigmundova & Sigmund, 2021), and was similar to that of the entire adolescents in this study.

However, it was found that the main difference between ethnic minority adolescents and Korean adolescents was the amount of sedentary time on the weekends. In both clusters (Inactive & Unhealthy Eater, Moderately Active & Unhealthy Eater) of this study, ethnic minority adolescents' weekend sedentary time was longer than that of Korean adolescents. Similarly, a European study reported that sedentary time on the weekends of ethnic minority adolescents was higher than that of native adolescents (Iguacel et al., 2018). That was explained that adolescents' sedentary time decreased because they were free to spend time with their families or do outdoor activities on weekends. However, in the case of

vulnerable groups such as immigrant families or parents of unemployed families, adolescents' sedentary time was reported to be longer, and fewer adolescents joined sports clubs (Iguacel et al., 2018). It has been reported that for adolescent children whose parents are working, the child's sedentary time rises if they are not subject to penalties or supervision (Hatakeyama, 2020). Also, adolescents with non-working mothers are more involved in sports programs because working mothers do not have time to take their children to activities such as sports programs (Hofferth & Sandberg, 2001). Not only that, working moms preferred to sit together and relax after work rather than engage in physical activities with their children, and there was a pattern that allowed their children watch TV while the mother's doing chores (Beyens & Eggment, 2017). As such, it can be interpreted that ethnic minority adolescents in Korea are unable to engage in outdoor and physical activities due to having a working mom and a lack of cultural or activity space to enjoy, and instead spend time sitting watching TV, playing on Internet games, etc. Another study reported that the obesity rate was higher among adolescents who were often sedentary during the weekends, and the intervention using weekend time was paid attention as an essential factor in preventing adolescent obesity (Li et al., 2019). Therefore, it is considered necessary for a health program to induce ethnic minority adolescents to do outdoor activity or be physically active so that their weekend leisure time is not biased toward sedentary time compared to Korean adolescents.

Physical activity variables among the obesogenic behavior variables were classified into two clusters with high physical inactivity levels and one cluster with low physical

inactivity levels. In this study, both ethnic minority adolescents and Korean adolescents reported that more than 60% of the total subjects had a high level of physical inactivity. In particular, fewer ethnic minority adolescents practiced MPA for more than five days a week. The future study is suggested why ethnic minority adolescents practiced less MPA than Korean adolescents.

The self-reported responses to the frequency of five food intakes in this study made up the obesogenic diet factors, which were included in the obesogenic behavioral variables. However, the results of the obesogenic diet between ethnic minority adolescents and Korean adolescents were very similar, so the difference between clusters was not confirmed. Future research on the obesogenic diets of Ethnic minority adolescents and Korean adolescents is recommended to take a range of dietary factors (particular food preference, meal cost, family meal time, regularity; Kim et al., 2012) into account to distinguish between the characteristics of each cluster.

Regarding the number of clustering and variables, in previous studies that conducted cluster analysis on adolescent obesogenic behavior, the number of clusters varied in each study (Liberali et al., 2021). In previous studies, the number of clusters was mainly narrowed down to two to seven clusters, with two to four clusters being the most common (Liberali et al., 2021). The number of variables consisting of clusters was used down to five to seventeen (Liberali et al., 2021). because affiliation probabilities may vary depending on the number of variables and responses included in the cluster analysis (Dean & Raftery,

2010), for this study, response values were recategorized using a binary scale in consideration of a large number of variables with eight variables for obesogenic behavior.

In this study, the three clusters were named ‘Inactive & unhealthy eater’, ‘Moderately active & unhealthy eater’, and ‘Active & healthy eater’. While clusters were directly referred to and intuitively named High PA, High ST, etc. in previous research (Park & Kim, 2020), this study considered names that were easy to understand, conveyed meaning and revealed all variable characteristics of obesogenic behavior.

6.3 Social Determinants of Health Associated with Cluster of Obesogenic Behaviors

Social determinants of health, including gender, ethnicity, stress and material circumstances, influence obesogenic behavior (Fleary & Freund, 2018). Mainly, ethnicity crucially affects the obesogenic behavior of ethnic minority adolescents (Fleary, 2017), thus it is worthy to identify ethnic minority specific social determinants of health and their implication for research and practice compared to those in Korean adolescents.

6.3.1 Ethnic minority adolescents

Among the social determinants of health of ethnic minority adolescents, gender among socioeconomic position of structural determinants and stress among psychosocial factors of intermediary determinants were found to have significant correlations with the

‘Moderately active & unhealthy eater’ and ‘Inactive & unhealthy eater’ cluster, respectively. The other variables were found to have no significant correlations with any clusters.

First of all, gender of socioeconomic position in structural determinants affected ‘Moderately active & unhealthy eater’ cluster. Compared to the ‘Active & healthy eater’ reference group, male adolescents were more likely to be in the ‘Moderately active & unhealthy eater’ cluster than female adolescents. In the other study with cluster analysis, ‘Techno-active gamers,’ the similar cluster with ‘Moderately active & unhealthy eater’ in this study, showed a pattern of having low physical inactivity and spending longer sedentary time (Tassitano et al., 2020), being appeared a pattern similar to the results of this study. Compared to the reference group (average in all variables), male adolescents were 10.37 times (95% CI: 7.35–14.62) more likely to be in the ‘Techno-active gamers’ cluster, supporting the result that male adolescents have a higher chance of being in ‘Moderately active & unhealthy eater’ cluster from this research. Among them, in a cluster analysis study classifying gender, it was reported that 40% of male students and 60% of female students practiced high physical inactivity(Kim et al., 2016). Although gender was not categorized and examined in this study, a future study is suggested since it is expected that the level of physical inactivity of the cluster produced from cluster analysis will differ when defining gender. Moreover, this cluster with the occurrence of healthy or unhealthy behavior in obesogenic behavior is prevalent among male adolescents (Huh et al., 2011) and female adolescents (Lee & La, 2021), confirming inconsistent results. Additional studies on obesity behavior clusters according to gender are needed, and gender-specific

interventions are needed according to the characteristics of different clusters according to gender.

Nextly, the stress of psychosocial factors in intermediary determinants, affected 'Inactive & unhealthy eater' cluster. According to the analysis of social determinants of health in ethnic minority adolescents by cluster, the adolescents were more likely to be in the 'Inactive & unhealthy eater' cluster when they get more stressed, compared to the 'Active & healthy eater,' the reference group. Obesogenic behaviors of the 'Inactive & unhealthy eater' cluster include high physical inactivity, long sedentary time, and obesogenic dietary habits like small eating fruit and having many carbonated drinks.

Preceding foreign study also shows that higher stress level is linked to high physical inactivity (Ajibewa et al., 2021). It supports the result from this research that more stressed adolescents are more likely to be in the 'Inactive & unhealthy eater' cluster with high physical inactivity. Among the studies on the correlation between physical inactivity and stress, the results of the study that physical inactivity affects stress are predominant, also indicate that the two factors are strongly related to each other. Physical activity can have immediately a positive effect on emotions (Liao et al., 2017) and also distract from negative thoughts as well as stress (Mikkelsen et al., 2017).

Also, among the studies on the correlation between ST and stress, more research results have been reported that ST has an effect on stress than the effect of stress on ST. Within the 'Inactive & unhealthy eater,' the result is consistent with the preceding study that sedentary time is in proportion to stress (Fang et al., 2014). Sedentary behaviors have

been reported to cause stressbecause they displace time spent on other important activities such as cleaning the house, work-related job (Teychenne et al., 2016).Therefore, the higher the stress, the longer the sedentary time, so stress management is required to reduce the sedentary time of adolescents.

Among the studies on the correlation between obesogenic diet and stress, more research results have been reported that obesogenic diet has an effect on stress than on the effect of stress on obesogenic diet. Another point that stress level is more likely to increase in a cluster with little eating fruit and heavy drinking of carbonated and sweetened drinks is concurrent with this research's finding (Lee & La, 2021).Instead of eating fruits or vegetables, teenagers eat foods rich in sugar and fat, called comfort foods, to cope with stress and raise temporary positive moods through compensation feelings (Michels, 2019). Most are followed by negative emotions such as shame and guilt, so this emotional eating is reported to cause a vicious cycle (Michels, 2019).That is, stress management is crucial to reducing obesogenic behavior of the 'Inactive & unhealthy eater' cluster among ethnic minority adolescents.

Meanwhile, the importance of stress management is highlighted as a directly influencing mechanism of stress to obesity is emphasized, not that obesogenic behavior has a successively mediating effect between stress and obesity (Foss & Dyrstad, 2011). It is explained as a pathophysiological mechanism including the stress reaction system of the body and cortisol release. The studies tell that stress directly triggers cell transformation or alters gene structure beyond simply affecting obesogenic behavior (Kansra et al., 2021;

Kappes et al., 2021). Notably, it is clarified that chronic stress induces enlargement of a fat cell and expedites transformation from a pre-fat cell to a mature fat cell (Kappes et al., 2021). It indicates that stress intervention is required not only for obesogenic behavior but also for obesity.

As ethnic minority adolescents get stressed from cultural adaptation and have limited ways to release stress (Eun et al., 2019), the quantity and quality of their stress are expected to show a gap from those of Korean adolescents. Therefore, evaluating and managing ethnic minority adolescents' stress will improve their mental health as well as ultimately deter obesogenic behaviors, and solve the obesity problem.

6.3.2 Korean adolescents

Among the social determinants of health of Korean adolescents, structural determinants (gender, age, father's educational level, economic status) and intermediary determinants (behaviors and biological factors: sleep time, academic performance; psychosocial factors: stress, depressive symptom and self-rated health; material circumstances: width of parks, fast food restaurants) were found to have significant correlations with the clusters. The other factors were found to have no significant correlations with any clusters.

First of all, gender affected 'Inactive & unhealthy eater' and 'Moderately active & unhealthy eater' clusters among Korean adolescents. Participants were more likely to be in the cluster than the reference group of 'Active & healthy eater' when they are male. A

previous study also demonstrated that adolescents tend to have more obesogenic behaviors when they are male adolescents from low-income families (Fan & Zhang, 2021). As a result of the scoping review of this study, the high PA cluster was mainly reported in male students, and the long sedentary time cluster was identified primarily in female students, demonstrating similar cluster characteristics to those in these clusters (Fleary, 2017; Kim et al., 2015; Tassitano et al., 2020). In conclusion, these results indicated that there was a definite difference in behavioral patterns between male and female adolescents.

In this study, the probability of belonging to the 'Inactive & unhealthy eater' cluster increased with increasing age. Similar to the results of this study, previous studies have reported that obesogenic behavior increases with age (Sigmundova& Sigmund, 2021). It was considered that obesogenic behavior increased with age as autonomy increased and the influence of parents' supervision decreased. Further research is needed for alternatives to manage obesogenic behaviors in older adolescents.

About the father's educational level in this study, the lower the parent's educational level, the higher the PA cluster 'Moderately active & unhealthy eater'. In previous studies(Muñoz-Galiano, et al., 2020), it was confirmed that the higher the parent's educational background, the higher the PA, which contradicted the results of this study.

About the economic status of clusters, the difference was confirmed, which was identified that the economic status of the physically active cluster was higher. A previous study also demonstrated that adolescents tend to have more physical activity when they are from high-income families (Fan & Zhang, 2021). Higher SES of households was associated

with longer sitting times for adolescent children, which was identical to the results found by the current study (Atkin et al., 2013). The phenomenon has been explained as the sedentary lifestyles of parents with high SES, who have relatively longer sitting times, affecting their children; in the current study, the parents' behavior patterns could not be confirmed. Future studies should also analyze additional variables—parents' thoughts and attitudes toward the sedentary lifestyle of their adolescent children, and the length of sitting time for the parents—to identify the influence of parents.

Among behaviors and biological factors, adolescents with a longer sleep time are less likely to be in the 'Inactive & unhealthy eater' cluster. As sleep time is involved in regulating appetite-controlling hormones, lacking sleeping time is a primary behavior and biological factor causing aggravated obesogenic behavior (Miller et al., 2015). They suggested starting to sleep earlier and longer because obesity behavior is altered with sleep duration as a mediating factor to help the recovery of hormonal balance and control of obesogenic dietary habits. So the intervention regarding sleep time will be needed to manage obesogenic behaviors.

Among behaviors and biological factors in the intermediary determinants, there was a higher risk of being in the 'Inactive & unhealthy eater', 'Moderately active & unhealthy eater' cluster among those with lower academic achievements. There were more studies on the effect of PA on academic performance than on the effects of academic performance on PA, and the interpretation of the correlation was as follows. Previous research indicated that academic achievement scores increased with the addition of 1 minute of daily physical

activity (PA), which did not agree with the results of the current study (Lima et al., 2019). However, it has been explained that PA can be associated with academic achievement via various paths. PA is known to be related to brain activations—such as executive functions, neurobiological measures of the brain, psychosocial measures, and mental health outcomes—in increasing academic achievement. As a result, the association between PA and academic achievement can be said to be controversial.

Like ethnic minority adolescents, Korean adolescents with higher stress among psychological factors also had a higher chance of being categorized in the 'Inactive & unhealthy eater' cluster. A study explained that stress leads to obesity with psychological, behavioral, and physiological influences, and obesity induces stigma of the obesity itself, creating a cycle leading back to stress (Tomiyama, 2019). Accordingly, supervising stress is crucial for obesity management.

Among the psychosocial factors, there was a higher risk of being in 'Moderately active & unhealthy eater' cluster for those who had higher levels of depression and better assessments of perceived health. Well-known research articles indicate that adolescents with high PA are less likely to indicate symptoms of depression, which did not agree with the results of the current study (McDowell et al., 2017; Schuch et al., 2018).

Regarding self-rated health, there were more studies on the effect of PA on self-rated health than on the effects of self-rated health on PA. Among the factors related to the self-rated health of adolescents, PA was reported to have the greatest influence, and it was found that the subjective health level of adolescents who practiced PA every day was high

(Lachytova et al., 2017). Since the correlation between the two variables is reported to be high, if the self-rated health is high, other health behaviors can be evaluated as positive.

Among material circumstances, there was a higher risk of being in 'Moderately active & unhealthy eater' cluster for smaller widths of parks. As a result of previous systematic review studies on the material circumstances, it was reported that there was no relationship between widths of parks and PA(Zhang et al., 2019). In this study, 'Moderately active & unhealthy eater' as a cluster that does PA a lot, but it is possible that they do not practice PA in the park. As there have been few studies on the size of parks among adolescents in Korea, further research is needed on the obesogenic behavioral patterns of adolescents related to width of park and park use.

Lastly, among material circumstances, Korean adolescents residing in the area with many fast food restaurants are more likely to be in the 'Inactive & unhealthy eater' cluster. The number of fast food restaurants is an obesogenic environment (ECHO, 2016), and it is reported that simpler access to fast food restaurants leads to a higher obesity rate (An et al., 2019). Based on previous research that adolescents living in the area with highly accessible fast food restaurants are more likely to have fast food (Wu et al., 2021), if there are more fast-food restaurants in the 'Inactive & unhealthy eater' cluster's residential area, eating fast food more often is likely to lead to obesity.

Some countries impose legal restrictions on starting fast food restaurants near schools to promote healthy eating behaviors in adolescents (Bhawra et al., 2018). In South Korea, a law was enforced since 2010 to designate and manage areas within 200m distance from

schools as Green Food Zone (Bae et al., 2012). The Special Act on Safety Management of Children's Dietary Lifestyle bans the sale and advertising of high-calorie, low-nutrient and high-caffeine foods inside Green Food Zone. By 2016, it was reported that Green Food Zones were implemented in over 7,333 schools (Ministry of Food and Drug Safety, 2021). In Canada, policies for adolescent obesity banned advertising fast foods, imposed taxations and had calorie, high sugar, and high salt labeled on all menus of fast food restaurants to restrict fast food intake. Menu labeling was reported to have the largest effect on BMI (Bhawra et al., 2018). Therefore, the results of this study suggest that to restrict fast food consumption in adolescents, policy interventions such as restricting material circumstance such as fast food restaurants, banning advertisements, and food labeling are necessary.

6.4 The Validity of the Clusters of Obesogenic Behaviors

This study aimed to secure the validity of the three clusters of obesogenic behaviors derived by checking the probability of obesity according to the clusters. In this regard, multinomial logistic regression analysis was used to confirm differences in obesity by cluster. In addition, obesity classification differences of predict probability by cluster were explained using the percentage distribution (Appendix 2).

Based on the 'Active & healthy eater' cluster that had the lowest obesogenic behaviors among ethnic minority adolescents' clusters, the probability of being obese and overweight compared to normal weight was not significant in the other clusters. In the case of

‘Moderately active & unhealthy eater’ cluster, the probability of being underweight decreased compared to normal weight. (However, based on the ‘Active & healthy eater’ cluster that showed less obesogenic behaviors among Korean adolescent clusters, the probability of being obese and overweight compared to normal weight increased in the other clusters. Compared to ‘Active & healthy eater’ cluster, the probability of being obese increased in the ‘Inactive & unhealthy eater’ cluster. In the ‘Moderately active & unhealthy eater’ cluster, the probability of being obese and overweight increased, and the probability of being underweight decreased.)

Reflection on statistically insignificant factors—in the relationship between clusters of multicultural youth and obesity—can be organized into four reasons, as follows.

The reason for statistically non-significant results regarding the association between ethnic minority adolescents’ clusters and obesity is that obesity and being overweight may not appear at the same time as obesogenic behaviors, and it may take a long period to reach obesity. Time differences were observed in adolescents for obesogenic behaviors to reach obesity, and it was reported that as age increased, physical activity and sedentary lifestyle increased, leading to increased BMI (Datar et al., 2013; Iannotti& Wang, 2013).

In addition, the physical activity variable analyzed in this study did not measure the amount of physical activity by objective method, but the number of days of physical activity depending on the subject's recollection. This may not sufficiently reflect the energy consumption that affects obesity, and thus the correlation with obesity may not have been confirmed because there was no difference in the characteristics of each cluster. So, an

objective data collection method that uses a wearable activity tracker to estimate energy consumption in real life is recommended (Brickwood et al., 2019). Wearable devices are known to be useful for research on physical activity because they can collect data related to 24-hours steps and energy consumption or provide real-time feedback to medical professionals(Cadmus-Bertram et al., 2015).

Third, as BMI was measured using a self-report survey in this study, there is a possibility that subjective answers were not accurately reported real weight or height. In the United Kingdom, as a result of comparing self-report values and directly measured values of height and weight of students aged 15-16, self-report bias was observed, where weights were underestimated by an average of 0.52kg (Elgar et al., 2005). In particular, those who were obese or overweight underestimated their weight more compared to those who were normal or underweight, confirming that the obesity rate of the measured values was higher than the self-report values (Elgar et al., 2005; Leatherdale & Laxer, 2013).

Lastly, while another study reported ‘not intake of vegetables, intake of bread or snacks, not intake of fish, and high-fat diet’ as major obesogenic eating behaviors (Leandro et al., 2019; Liberali et al., 2020), this study did not include ‘frequencies of vegetable intake, high-fat diet, and carbohydrates intake’ in obesogenic behavior. As a result, due to this, it is possible that the difference in obesity or overweight by obesogenic behavior clusters, was not statistically significant, because it was insufficient to support the theoretical basis of obesogenic behavior. Therefore, it is suggested future studies with ‘vegetables, high-fat

diet, etc.' included in obesity-related diet should be conducted to classify obesogenic behavior clusters.

In this study, ethnic minority adolescents showed a higher probability of being underweight. Previous studies also reported a higher probability of being underweight in ethnic minority adolescents compared to Korean adolescents (Park, 2017; Song, 2020). The problem of being underweight was confirmed by the insufficient nutritional intake of ethnic minority adolescents (Song & Song, 2020). Associated factors with ethnic minority adolescents being underweight were reported to be cultural adaptation stress, body image dissatisfaction (McCullough et al., 2020), depression symptoms (Lim & Park, 2014), or dietary problems of international marriage migrant women who are their mothers (Yang, 2016). Therefore, appropriate nutrition education should be provided in consideration of psychosocial factors for underweight ethnic minority adolescents. In addition, because the socioeconomic environment of ethnic minority adolescents is the primary factor determining household food security, level of nutritional knowledge in parents, health behaviors, selection of foods in adolescents, and quality of diet (Noonan, 2018), it can lead to being underweight. Therefore, among them, guidelines for selecting healthy foods and food culture education are needed to enhance food literacy among a group of immigrants as a possible intervention factor (Blanchet et al., 2018).

In addition to the regression method used in this study (Magee et al., 2013; Kim, Barreira, & Kang, 2016; Tassitano et al., 2020), other studies conducted validity analyses using likelihood ratio tests or hypothesis tests such as ANOVA (Liberali et al., 2020),

percentages of ‘obese, overweight, normal, underweight’ (Liberali et al., 2020; Iannotti& Wang, 2013), or distribution (Huh et al., 2011). As alternative statistical methods, Propensity Score Matching (PSM) analysis (Dhdda& Greene, 2018) or regression analysis with moderators (Riley et al., 2021) are suggested. In other words, after securing homogeneity by selecting subjects with similar socioeconomic levels for the two groups (ethnic minority adolescents and Korean adolescents) using PSM, we can then compare differences between obesogenic behavior clusters for each group. In addition, we propose a study to identify the mediating factors affecting obesity that can be intervened in nursing practice using moderation analysis of regression analysis.

In summary, differences in obesity between the three obesogenic behavior clusters of ethnic minority adolescents and Korean adolescents were identified. For ethnic minority adolescents, it was confirmed that interventions for being underweight rather than overweight are necessary. In the case of Korean adolescents, the probability of being obese was highest in ‘Moderately active & unhealthy eater’ cluster, thus suggesting development of obesity education program according to the obesogenic behavioral characteristics of that cluster.

6.5. Nursing Implications

6.5.1 Nursing theoretical aspect

This study is meaningful in that it analyzed ethnic minority adolescents’ obesogenic behavior clusters based on social determinants of health to identify characteristics of the

clusters and associated social determinants of health (structural determinants, intermediary determinants; behaviors and biological factors, psychosocial factors, material circumstances), which provide evidence-based body of knowledge for preventing obesity in ethnic minority adolescents. Gender among the structural factors and stress among the social-psychological factors were identified as social determinants of health that affected the clusters, thus providing evidence for consideration of gender differences during obesogenic behavior interventions, and provision of stress management programs to increase intervention effects.

6.5.2 Nursing research aspect

This study was one of the first attempts to project the latent subtypes by analyzing the ethnic minority adolescents' obesogenic behaviors. The three clusters which were derived through the cluster analysis showed the biggest difference in sedentary lifestyle, with the ethnic minority adolescents being more sedentary than Korean adolescents during the weekends. The obesogenic behavior cluster with the highest frequency was 'the cluster with less physical activities, longer sedentary hours and unhealthy dietary intake (fewer fruits and more carbonated drinks).' We presented the basis for the design of an integrated obesity intervention program which will overcome the limitations of the existing obesity intervention programs focusing on the increase of physical activities and the decrease of fast-food intake, by identifying the traits of each obesogenic behavior cluster. Additionally, we presented the fact that there are differences in the food preference among the ethnic

minority adolescents by their ethnic and cultural background as well as the necessity of a new approach which is informed by the psychosocial factors such as the sense of belonging with their peer group and the stress of cultural adaptation.

6.5.3 Nursing practice aspect

This study stresses the necessity to manage the psychosocial factors such as stress when institutions for the ethnic minority adolescents' health consider the obesity prevention and intervention, based on the fact that the 'inactive & unhealthy eater' was the most common factor with stress being an affiliated one for the obesogenic behavior clusters of the ethnic minority adolescents who are more vulnerable than Korean adolescents. Difference in the sedentary hours during the weekends was identified between Korean adolescents and the ethnic minority adolescents which will be the basis to support the necessity of the health improvement intervention to help them better utilize their leisure time on the weekends.

6.6Limitations of the study

Though this study has some important implications, it has some limitations.

First, the sample may be representative of adolescents residing in South Korea. However, it is difficult to generalize the findings of this study because the samples of this study were selected for the study. Moreover, the results by LCA have a limitation because of being highly data-driven. Therefore, the results of the current study will need to be

supported by other independent samples of ethnic minority adolescents.

Second, the data relied on adolescents' self-report for obesogenic behaviors, height, weight, economic status, and academic performance, which may have led to information bias. Adolescents seem to overestimate health behavior, which can be an indicator of social desirability bias. The weight and height information was analyzed after confirming the measurements beyond the acceptable limit and the outlier. We also used standardized protocols and indicators of obesogenic behaviors to minimize measurement errors. We also considered that this problem does not impair the relevance of the study because the analyzed cluster of obesogenic behavior was recognized to be associated with obesity.

Third, in this study, there is a limitation in that the sedentary time of real life is not reflected because the sedentary time means time for purposes other than learning of weekdays and weekends, not including time for purposes the learning or eating of weekdays and weekends. Therefore, the interpretation was not clear why adolescents did a high frequency of physical inactivity and short sedentary time or adolescents did a low frequency of physical inactivity and long sedentary lifetime.

Forth, cluster classification may not have been elaborated because obesogenic dietary variables were not included fully according to the purpose of this study as secondary data. In particular, the vegetable intake questionnaire surveyed until 2019 in KYRBS was excluded in 2020 in KYRBS. To understand the validity and characteristics of cluster classification, it is suggested that an investigation into not only vegetables, but also high-fat and high-calorie diets are needed.

Chapter 7. Conclusion and suggestions

This secondary data analysis study showed evidence of the social determinants of health in the ethnic minority adolescents' and Korean adolescents' obesogenic behavior clusters, based on the conceptual framework of the social determinants of health (Solar & Irwin, 2010). This study is meaningful in that it aimed to identify the obesogenic behavior clusters by considering the simultaneous and complex behavioral patterns rather than regarding individual behaviors as a single factor, and was also considered the material circumstance for the ethnic minority adolescents' obesogenic behaviors.

In this study, the level of obesogenic behaviors of ethnic minority adolescents were greater than that of Korean adolescents, and three clusters of obesogenic behaviors were derived. The obesogenic behaviors were classified into three areas such as physical inactivity, sedentary time and the obesogenic diet, while social determinants of health were classified into the structural factor and intermediary factors which include the behaviors and biological factors, psychosocial factors and material circumstances. The cluster analysis revealed the clusters such as 'Inactive & unhealthy eater', 'Moderately active & unhealthy eater', and 'Active & healthy eater' for both the ethnical minority adolescents and Korean adolescents. For ethnic minority adolescents, the social determinant for health that affects 'Inactive & unhealthy eater' cluster was stress and the social determinant of health that affects the 'Moderately active & unhealthy eater' cluster was the male gender. By identifying the social determinants of health affecting the identified clusters, this study

provided an evidence on the group in need of obesity prevention and management, suggesting cluster-specific intervention. Only the difference in the underweight was identified for the ethnic minority adolescents while the difference in both the obesity and underweight were identified for Korean adolescents, which provided the validity of the clusters.

This study utilized representative and publicly open secondary data about the ethnical minority adolescents and Korean adolescents residing in South Korea, which was extracted through a stratified sampling method by region. However, due to the decrease of the sample size caused by the data cleaning process against the no-responses and not applying the value of the weight, discretion is required in the generalized interpretation. It is suggested the follow-up studies use larger samples of the ethnic minority adolescents in regional communities, perform the cluster analysis, and compare each cluster's traits.

There was a difference between adolescents' genders in the obesogenic behaviors and therefore a gender-specific cluster analysis is suggested as a follow-up study as long as the size of the sample becomes large enough.

Obesogenic behaviors among adolescents are being accelerated due to the increased screen-based lifestyles and this study revealed that the sedentary lifestyle was the biggest differentiator between clusters. Therefore, it is crucial for nurses and researchers in the adolescents' health care field to provide interventions for reducing the sedentary time and seeking ways to improve the physical activities as an alternative.

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Appendix 1. Previous studies regarding the cluster of obesogenic behaviors in ethnic minority adolescents (N=4)

No	First author (Year)	Location, Questionnaire, data collection	Study design, Analysis	Subjects, male:female, (age)	Cluster name	Related factors	Ethnicity	Variables, used as the latent class indicators and their key covariates	Conclusion class= (% or RRR)
1	Fleary (2017)	America, YRBSS, self-reported by students	Cross-sectional study, Latent class analysis	14,815 , 7345:7470 (9th-12th grade)	Male • class 1 (17%) Healthy • class 2 (31%) Physically active • class 3 (24%) **Sedentary activity** • class 4 (28%) HRB/PA Female • class 1 (14%) Healthy • class 2 (19%) Physically active • class 3 (40%) **Sedentary activity** • class 4 (6%) HRB/F&V • class 5 (21%) HRB	• Age • Race • Gender • Cigarette smoking • Alcohol use • Binge drinking • Marijuana use • Physical fight	• White • Black • Hispanic • Hispanic -Multiple • Asian • Other	• PA 5+days • PA 7 days • SA daily • Diet(fruit, vegetables, breakfast) • Insufficient Sleep < 8 hours • Substance use • Tried to lose weight • Perceived overweight • Unhealthy weight control	OWOB • (Male) White, Other (Physically Active: 0.69,0.33) • (Female) White, Black (Physically Active: 0.61, 0.52)

Note: OW/OB=Overweight/Obesity, YRBSS=Youth risk behaviors surveillance system, HRB=Health Risk Behaviors, F&V=Fruit & Vegetable, PA=Physical activity, SA=Sedentary activity, RRR=Relative risk ratio, Bold denote reference cluster

No	First author (Year)	Location, Questionnaire, data collection	Study design, Analysis	Subjects, male: female (age)	Cluster name	Related factors	Ethnicity	Variables, used as the latent class indicators and their key covariates	Conclusion class= (%, RRR)
2	Kim et al., (2015)	America, YRBSS, Self-reported by students	Cross-sectional study, Latent class analysis	12,081, 6109:5972 (9th-12th grade)	Male, Female • class 1 (20.3%, 17.6%) High PA/High SB • class 2 (38.6%, 23.1%) Low PA/High SB • class 3 (7.7%, 26.4%) Low PA/Low SB • class 4 (33.5%, 33.0%) **High PA/Low SB**	• Gender • grade(9th–12th), • race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, or others)	• Non-Hispanic, white • Non-Hispanic, Black • Hispanic • Others	• Physical activity (MVPA(moderate and vigorous physical activity), STP (sports team participation), MSEx (muscle-strengthening exercise) • Sedentary behavior (TV hours, Computer hours) • Diet (Breakfast consumption, Fruit and vegetable consumption, Soda consumption) • Obese	OW/OB • (Male) Low PA /High SB: 4.7 High PA /High SB: 2.7 • (Female) Low PA/ High SB: 23.5 High PA /High SB: 10.8
3	Maia et al., (2018)	Brazil, National School Health Survey, Self-reported by students	Cross-sectional study, K-means cluster anaylsis	109,104, 52,015:57,089 (9th grade)	• cluster 1 (57.13%) **(low frequency of both risk and protective factors for obesity)** • cluster 2 (42.87%) (high frequency of both risk and protective factors for obesity	• Age • Gender • School management • Ethnicity/skin color • Mother's educational level • Geographical region	• White • Black or brown • Asian or American • Indian	• Physical activity (active commuting, PA at school, PA at leisure times) • Sedentary behavior (TV watching, Time sitting) • Diet (Healthy foods, Unhealthy foods, Eating behavior)	X

Note: OW/OB=Overweight/Obesity, YRBSS=Youth risk behaviors surveillance system, PA=Physical activity, SB=Sedentary behavior, RRR=Relative risk ratio, Bold denote reference cluster

No	First author (Year)	Location, Questionnaire, data collection	Study design, Analysis	Subjects, male: female (age)	Cluster name	Related factors	Ethnicity	Variables, used as the latent class indicators and their key covariates	Conclusion class= (%, RRR)
4	Tassitano et al., (2020)	Brazil, National School Health Survey, Self-reported by students	Cross-sectional study, Latent profile analyses	5520, 2462:3058 (16.3 ± 1.0 year)	• cluster 1 (13.6%) Computer users • cluster 2 (11.3%) Short sleepers • cluster 3 (35.7%) **Typical behaviors class** • cluster 4 (6.4%) Techno-active-gamers • cluster 5 (33.1%) Lower screen engagement	• Sex • Age • Skin color • Home location • Mother education • School attendance	• White, • Non-white	• Moderate-to-vigorous physical activity • Active commuting to school • Sitting time • Video game • Computer time • Television • Sleep	OW/OB • Overweight cluster 1 (25.5%) cluster 2 (22.0%) cluster 3 (19.3%) cluster 4 (20.3%) cluster 5 (17.3%) • Obesity cluster 1 (9.0%) cluster 2 (7.7%) cluster 3 (7.4%) cluster 4 (6.3%) cluster 5 (6.0%) Cluster 1 (vs 3): 1.52 (95% CI= 1.25-1.86)

Note: RRR=Relative risk ratio, OW/OB=Overweight/Obesity, Bold denote reference cluster

Appendix 2. The shape of Differences in Obesity Classification by Clusters (predict probability)

1. Ethnic minority Adolescents

As a result of predictive probability analysis, analyzing the difference in the shape of obesity classification in each cluster on the graph (Figure 7), there was a difference in the frequency of each cluster (Table 21). 'Inactive & unhealthy eater' cluster had a high ratio of obesity and normal weight, and 'Moderately active& unhealthy eater' cluster had a high ratio of overweight, so it was confirmed that obesity preventive intervention is needed. Unexpectedly, 'Active & healthy eater' as a high-risk cluster about obesity represented a high ratio of obesity and underweight, a low ratio of normal weight. It was confirmed that required both obesity and underweight intervention.

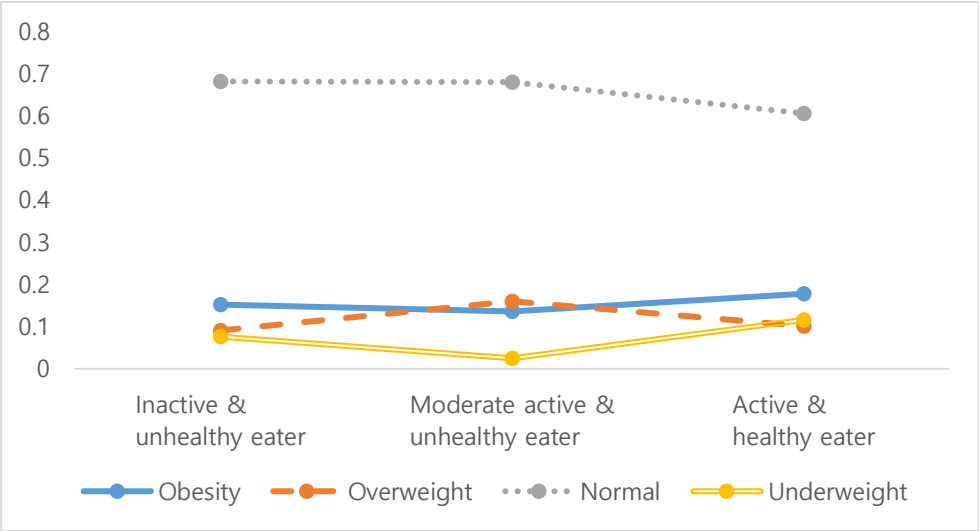


Figure 7. Differences in predicted probability of obesity classification by clusters in ethnic minority adolescents

Table 21. Predicted probability of obesity classification by clusters in ethnic minority adolescents

Obesity Classification	Inactive & unhealthy eater	Moderately active & unhealthy eater	Active & healthy eater
Obesity	0.152	0.136	0.178
Overweight	0.091	0.160	0.101
Normal	0.681	0.679	0.605
Underweight	0.076	0.025	0.116

2. Korean adolescents

As a result of predictive probability analysis, analyzing the difference in the shape of obesity classification in each cluster on the graph (Figure 8), there was a difference in the frequency of each cluster (Table 22). ‘Inactive & unhealthy eater’ cluster had a high ratio of obesity and underweight, and ‘Moderately active& unhealthy eater’ cluster had a high ratio of obesity and overweight, a low ratio, so it was confirmed that obesity preventive intervention is needed. Expectedly, ‘Active & healthy eater’ represented a high ratio of normal weight and underweight, a low ratio of obesity and overweight. It was confirmed as a high-risk cluster of obesity that required both obesity and underweight intervention. Among the clusters, ‘Active & healthy eater’ was considered relatively the healthier patterns of obesogenic behaviors, which was confirmed that has a positive relation with normal weight.

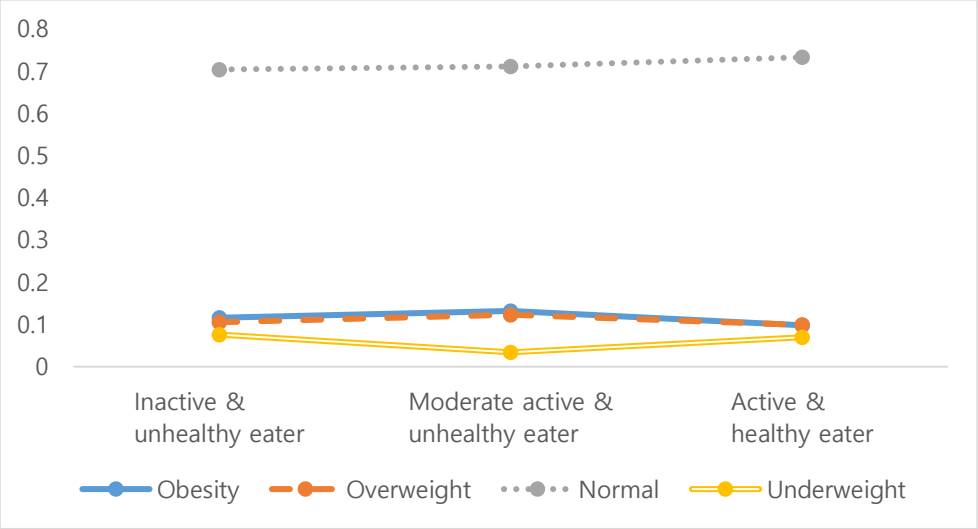


Figure 8. Differences in predicted probability of obesity classification by clusters in Korean adolescents

Table 22. Predicted probability of obesity classification by clusters in Korean adolescents

Obesity Classification	Inactive & unhealthy eater	Moderately active & unhealthy eater	Active & healthy eater
Obesity	0.116	0.132	0.098
Overweight	0.105	0.123	0.099
Normal	0.704	0.711	0.733
Underweight	0.076	0.034	0.070

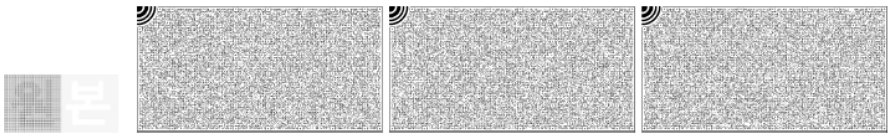
Appendix 3. Result of IRB approval

연세의료원 세브란스병원 연구심의위원회
Yonsei University Health System, Severance Hospital, Institutional Review Board
서울특별시 서대문구 연세로 50-1 (우) 03722
Tel.02 2228 0430~4, 0450~4 Fax.02 2227 7888~9 Email. irb@yuhs.ac

심 의 일 자	2022년 3 월 18 일
접 수 번 호	2021-4496-001
과제승인번호	4-2022-0083

세브란스병원 연구심의위원회의 심의 결과를 다음과 같이 알려 드립니다.

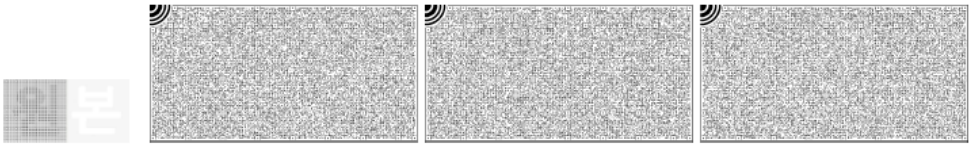
Protocol No.	
연 구 제 목	다문화 청소년과 선주민 청소년 비만 유발 행동의 군집별 사회적 건강결정요인
연 구 책 임 자	이현경 / 세브란스병원 간호학과
의 뢰 자	세브란스병원
연구예정기간	2022.03.18 ~ 2022.09.17
지속심의 빈도	면제
과 제 승 인 일	2022.03.18
위 험 수 준	Level I 최소위험
심 의 방 법	신속
심 의 유 형	신규과제
심 의 내 용	- 연구계획서 (국문) - 증례기록서 - 연구책임자 이력 및 경력에 관한 사항
심 의 위 원 회	제1위원회
참 석 위 원	제1위원회 신속심의자
심 의 결 과	승인, 대상자 동의 면제
심 의 의 견	-



※ 본 통보서에 기재된 사항은 세브란스병원 연구심의위원회의 기록된 내용과 일치함을 증명합니다.
※ 세브란스병원 연구심의위원회는 국제 임상시험 통일안(ICH-GCP), 임상시험 관리기준(KGCP), 생명윤리 및 안전에 관한 법률을 준수합니다.
※ 연구책임자 및 연구담당자가 IRB위원인 경우, 해당 위원은 위 연구의 심의과정에 참여하지 않았습니다.

연세의료원 세브란스병원

연구심의위원회 위원장



국문초록

다문화청소년과 선주민청소년 비만유발행동의 군집별 사회적 건강결정요인

이 미경

연세대학교 일반대학원 간호학과

국내 청소년의 비만율은 매년 지속적인 증가추세를 나타내고 있다. 국내 다문화청소년은 선주민청소년에 비해 비만율이 더 높은 것으로 보고되었고 국외 소수인종 청소년 역시 선주민청소년에 비해 비만율이 높았다. 그 이유는 다문화청소년이나 소수인종 청소년의 사회경제적 지위가 선주민보다 낮기 때문이 것으로 보고되었다. 선행연구에서는 비만유발행동을 비만을 일으키는 복합적인 여러 개의 행동집합으로써 정의하며 구체적으로 주로 낮은 신체활동, 긴 좌식생활 시간, 비만관련 식이 섭취를 의미하였다. 선행 연구에서 소수민족 청소년의 비만유발행동에 가장 큰 영향을 미치는 사회적 건강결정요인은 인종 차이로 나타났다. 코로나19로 인해 소수인종 인구집단의 사회경제적 격차가 벌어지고 교육 및 건강 역시 격차가 발생함이 보고되어 국내의 취약계층인 다문화청소년의 비만유발행동의 변화를 확인할 필요가 있다. 따라서 본 연구는 다문화청소년과 선주민청소년의 비만유발행동 군집을 분석하여 행동패턴을 확인하고자 하였고 다문화청소년과 선주민청소년 군집에 영향을 미치는 사회적 건강결정요인을 비교분석하였다.

본 연구는 2020년 청소년건강행태조사와 청소년건강행태조사의 39개 지역군을 기준으로 국세청 또는 지역통계자료를 이용해 지역적 특성을 병합하여 분석한 이차자료분석연구이다. 본 연구는 세계보건기구(WHO)의 사회적 건강결정요인 모델을 통해 비만유발행동과 관련요인(사회적 건강결정요인)의 개념적 기틀을 구성하였다. 연구대상자는 부모 국적, 키, 몸무게 등 미응답자의 결측치를 제외하고

총 18,001명으로 12-15세의 다문화청소년 539명, 선주민청소년 14,293명으로 구성되었다. 해당 변수는 비만유발행동은 '중강도신체활동, 고강도신체활동, 평일 좌식생활시간, 주말 좌식생활시간, 아침결식, 과일섭취, 탄산음료 및 가당음료 섭취, 패스트 푸드 섭취'의 8개의 변수로 구성되었다. 사회적 건강결정요인은 구조적 요인으로 '성별, 연령, 부모교육수준 등'이 포함되었고, 매개요인으로 '학업성적, 수면, 스트레스, 우울, 빈곤율, 패스트푸드점 수 등'이 포함되었다. 통계프로그램은 LatentGOLD 6.0 (Statistical Innovations, Belmont MA, USA), SPSS Statistics 26.0 (IBM Corp, Chicago IL, USA)를 활용하였다.

연구 결과, 다문화청소년의 비만율이 15.6%(선주민 11.2%)로 더 높았으며 부모학력, 경제적 수준, 성적, 주관적 건강, 도시규모에서 전체적으로 사회경제적 지위가 낮은 결과가 나타났다. 비만유발행동 8개의 변수를 군집분석한 결과 다문화청소년과 선주민청소년 각각 3개의 군집이 확인되었다. 각 군집은 특성에 따라 '비활동적 & 비건강 식이실천군', '중간활동적 & 비건강 식이실천군', '활동적 & 건강 실천군'로 명명하였다. 다문화청소년의 군집에 영향을 미치는 사회적 건강결정요인은 성별, 스트레스로 2개의 요인이 확인되었다. 선주민청소년의 군집에 영향을 미치는 사회적 건강결정요인은 성별, 경제적 상태, 수면시간, 스트레스, 패스트푸드점 수 등이 유의하였다. 다문화청소년과 선주민청소년의 군집별 특성 중 좌식생활시간 변수에서 가장 큰 차이가 나타났다. 마지막으로 군집의 타당성을 확보하기 위해 군집별 비만도의 상관성을 분석한 결과 선주민청소년에서 비만유발행동을 많이 하는 군집의 비만일 확률이 더 높게 나타났고 다문화청소년의 군집은 저체중일 확률이 유의하였다.

본 연구는 청소년들의 비만유발행동을 군집분석을 통해 복합적인 요인을 파악하고자 한 점과 다문화청소년의 비만유발행동에 초점을 둔 연구인 점, 비만유발행동 관련요인으로써 물리적 환경을 고려한 점에서 의의가 크다고 할 수 있다. 향후 본 연구결과를 토대로 다문화청소년의 비만의 예방 및 중재 프로그램이 효과적으로 적용될 것을 기대한다.

주요어: 비만유발행동, 다문화, 청소년, 사회적 건강결정요인, 군집