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Identifying Patterns of Weight-Related Health Behaviors among US Adolescents, and Associated Risk of Obesity

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Report

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Abstract

Identifying Patterns of Weight-Related Health Behaviors among US adolescents, and Associated Risk of Obesity

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Little is known about the current complex pattern of weight-related health behaviors among adolescents in the US. The goal of this report was to develop and examine a comprehensive latent class analysis (LCA) model examining the prevalence of combined associations of physical activities sedentary behaviors, and eating behaviors with obesity among female and male US adolescents (n= 12,031). Four classes and five classes were identified for female and male adolescents, respectively. Among which, three were similar and were characterized as ‘Inactive/ Low screen time/ Poor eating habit’, ‘Inactive/ Moderately high screen time/ Poor eating habit’, and ‘Active/ Low screen time/ Poor eating habit'. Additionally, ‘Inactive/ Low screen time/Good eating habit’ was unique to female adolescents, while ‘Moderately active/ High screen time/ Good eating habit' and ‘Moderately active/ Low screen time/ Good eating habit' were unique to males. Furthermore, the proportion of normal weight, overweight, and obese in each class was examined across females and males. The results showed that male

adolescents had a higher proportion of people being obese than female adolescents in each class. The findings from this report provided insights on the current health needs of US adolescents and implied that gender-specific intervention strategies were required to reduce the risk of obesity among adolescents.

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Chapter 1: Introduction

1.1 Overview

In recent years, obesity has become one of the leading public health concerns since it may directly lead to developing of chronic diseases, such as diabetes, cardiovascular disease, joint problems *etc.* (1, 2). A research found that the rate of obesity among adolescents aged 12-19 years dramatically increased from 5% in 1980 to about 21% in 2012 (3). Obesity is a puzzling disease which is caused by a complex combination of risk factors. Weight-related lifestyle choices, such as overeating and sedentary lifestyle, are some of the most critical risk factors for obesity. The adolescent years are an ideal and crucial period to develop healthy behaviors. Many of the healthy lifestyle habits formed during this developmental stage usually last well into adulthood (4). It has been reported that extremely obese adolescent may continue to suffer from obesity as adults without intervention (5). Many previous studies have shown that the imbalance between energy intake and energy expenditure can be highly affected by a lot of weight-related behaviors, such as physical activities, sedentary behaviors, and eating behaviors (6-9). Poor eating habits, for example, drinking beverages rich in sugar and eating calorie-dense food or snacks, are associated with the risk of obesity (10, 11). Sedentary behaviors, such as television viewing or using a computer for a long time, also increase the risk of obesity. In contrast, a great deal of evidence has demonstrated that physical activity can reduce the risk of obesity.

1.2 Physical activity and obesity

Physical activities play a vital role in reducing the risk of obesity. Research conducted recently showed that poor physical fitness in adolescents strongly predicted the risk of obesity (OR 3.9, 95%CI: 1.4-10.9) and abdominal obesity (OR 4.8, 95%CI: 1.9-12.0) (12). Another report suggested that physical activities, such as resistance training, may promote a negative energy balance and may change body fat distribution (13). However, the physical activity level is declining all over the world contributing to the global obesity epidemic (14). The U.S. Department of Health and Human Services and other authorities established a guideline to promote physical activity in youth. The guideline recommends that adolescent should get at least 60 minutes of moderate and vigorous-intensity per day with at least three days of muscle-strengthening physical activities each week (15-17).

In this study, we examined the relationship between two physical activity variables: PA7DAY (physical activity at least 60 minutes per day on all 7 days of the week) and DLYPE (attended physical education classes on all 5 school days) with obesity.

1.3 Eating behaviors and obesity

A poor eating habit is also a contributing factor for increasing the risk of obesity. Eating habit can be developed during childhood and adolescents and will last into adulthood. Many pieces of research have demonstrated that obesity is highly associated with the intake of calories-dense food such as fast-food, sugar-sweetened beverages (10, 11), while on the other hand having breakfast and proper fruit and vegetable intake could

prevent obesity (18). A recent study developed by Yvonne C. Anderson *et al.* reported that 54% of New Zealand students age 5-17 years had daily energy intake above the recommended guidelines, while fruit and vegetable intake was below the guidelines (mean 3.5 vs 5 servings per day), and the mean weekly breakfasts were less than the national average (5.9 vs 6.5) (19).

1.4 Sedentary behavior and obesity

In addition to physical activity and eating behavior, sedentary behavior is a factor in causing obesity. It has been reported that a lack of physical activity and more time spend on sedentary behavior will increase the risk of obesity (20). Because of the increased use of information and communication technology in modern society, the amount of time adolescents spend in sedentary activities has highly increased (21). Sedentary behaviors such as watching TV, playing digital games and computers using are critical risk factors affecting obesity prevalence (22). A computerized search developed by Lauren Arundell *et al.* showed that adolescents spent 57 % of the after-school period in sedentary time, and they spend 20 % of the period for TV viewing, 20% for non-screen based SB (including homework), 18% for screen-based SB (including TV viewing), 13% for homework/academics, 12% for motorised transport, 9% for social SB, and 6% for screen-based SB (excluding TV viewing) (23). A guideline established by the association of pediatric and experts recommend that adolescents limit television and other screen time ($\leq$ 2 hours per day) (8, 24), but the sedentary time spend by adolescents usually more than the guideline ($\geq$ 2.5 to 3 hours of television per day and to spend an additional 1.5 to 2 hours using the computer) (25). Understanding correlates of specific sedentary behaviors can inform the development of interventions to reduce obesity (26).

1.5 Latent class analysis

Latent class analysis (LCA) is a statistical method for identifying underlying subgroup among subjects using categorical and cross-sectional observed indicators. It is a subset of structural equation modelling. LCA assumes that each indicator has its probability distribution across the classes or subgroups and that the overall population follows a finite mixture model (27). Because of the complexity of weight-related behaviors, LCA was reported as one of the best methods to capture the meaningful key patterns of behaviors among the samples (28). LCA has been successfully employed in a great deal of studies. For example, it was used to study weight-related health behaviors among 2-year and 4-year college students (29), the association of obesity risk with eating and physical activity in children (30), and physical activity and sedentary activity associated with overweight and obesity (31). The results from those studies have demonstrated that LCA is an effective and valid approach in classifying individuals with similar characteristics.

In our project, LCA was used for two reasons. First, most of the variables in our data are categorical variables. Second, the purpose of our study was to identify the latent subgroups with patterns of physical activities, eating behaviors and sedentary behaviors and to examine the association of latent subgroups with obesity status.

Chapter 2 Data and Methodology

2.1 Sample

The data used in this report were obtained from the Youth Risk Behavior Surveillance System (YRBSS), 2015. This was a three-stage cluster sample design survey monitoring priority health risk behaviors and the prevalence of obesity of students from 9th – 12th grade in the USA. Students were asked for six types of health risk behaviors questions including physical activity, dietary behaviors, weight control, sexual behaviors, alcohol and drug use, tobacco use, and violence, *etc*. These data are available through the Centers for Disease Control of Prevention (CDC).

This 2015 national YRBS data contains a total of 15,624 responses. Missing values in gender, race, grade, body mass index (BMI), and physical activities, sedentary behaviors and eating behaviors were excluded, with the assumption that the pattern of these missing values is not related to the outcomes of the study. The final sample consisted of 12,031 adolescents were used in this study.

2.2 Measures

2.2.1 Weight-related behaviors

As shown in Table 1, eight weight-related behaviors were classified into three categories: physical activity, eating behavior, and sedentary behavior.

Physical activity included two variables: PA7DAY and DLYPE. PA7DA showed whether adolescents were physically active for at least 60 min per day on all 7 days of the week. DLYPE classified adolescents into either they attended physical education classes on all 5 school days or less than 5 school days.

Eating behaviors included four variables: FR3(ate fruit or drank 100% fruit juices three or more times per day), VEG3 (ate vegetables three or more times per day), SODA1 (drank a can, bottle, or glass of soda or pop one or more times per day), and BK7DAY (ate breakfast on all 7 days).

Sedentary behaviors included two variables: TV3 and COMP3. Students provided the number of hours they had spent on watching TV and using a computer for non-school work or playing video games on an average school day. These survey questions were used to classify TV3 (more than 3 hours TV viewing per day) and COMP3 (more than 3 hours using a computer or playing video game per day), respectively.

2.2.2 Body mass index

Body mass index (BMI) was calculated using a person's weight in kilograms divided by the square of height in meter. It can be used as an indicator to classify persons who were underweight, normal weight, and overweight or obese. Adolescents with high BMI (at or above 95th percentile) were considered obese (32).

Category	Description
Physical activity	
PA7DAY	Whether the student was physically active doing any kind of physical activity that increased their heart rate and breath depth for at least 60 min per day on all 7 past day.
DLYPE	Whether the students attended physical education classes on all 5 school days.
Eating behavior	
FR3	Whether the student ate fruit or drank 100% fruit juices more than 3 times per day during the past 7 days.
VEG3	Whether the student ate vegetables more than 3 times per day during the past 7 days.
SODA1	Whether the student drank soda more than one times per day during past 7 days.
BK7DAY	Whether the student ate breakfast on all 7 days during the past 7 days.
Sedentary behavior	
TV3	Whether the students watched TV for more than 3 hours per day on an average school day.
COMP3	Whether the students used a computer for something that was not school work or played video games for more than 3 hours per day on an average school day

Table 1: Weight-related behavior categories and descriptions

2.3 Statistical analysis

We fitted a set of LCA models with different number of latent class (1 to 7) to identify the model that best described distinct subgroups of weight-related behaviors among female and male adolescents. The number of classes of the best model was determined by a combination of two aspects. The first aspect was the criterion for model selection. Bayesian Information Criterion (BIC) was chose as a criterion in this study, because it was reported as the best indicator for determining the number of latent classes when compared models in LCA (33). A lower value of BIC indicates a better model. The second aspect was interpretability. Each latent class should not be near-zero in size, and should be meaningful and distinguishable from the others based on the item-response probability.

All LCA analyses were conducted using poLCA package in R software.

Charter 3 Results

3.1 Descriptive Statistics

Table 2 showed the descriptive characteristics of all variables of the sample. A total of 12,031 US adolescents was included in this study. The ages ranged from 12 to 18 years old. Of all the participants, 6,093 (50.6%) were females and 5,938(49.4%) were males. No obvious gender differences were found among grades, race, or age. However, more male adolescents (18.4%) than female (12%) adolescents were obese. In addition, two categories of weight-related behaviors, physical activity and eating behavior, showed significant gender differences. Higher percentages of male adolescents had PA7DAY (35.6%), DLYPE (35.6%), FR3 (22.7%) and VEG3(16.4%) in comparison to female adolescents who had 16.5%, 26.3%, 18.4% and 13.2% respectively. No obvious gender disparity in sedentary behaviors (TV3 and COMP3) was found.

3.2 Inter-correlations

Table 3 showed the inter-correlations of variables of our interest. The results showed that the relationship of most of variables were significantly correlated with each other, except for two pairs: TV3 and VEG3, DLYPE and COMP3. Fruit (FR3) and vegetable (VEG3) had strongest correlation among these variable ($r = 0.394$). Physical activity (PA7DAY) was positively correlated with FR3 ($r = 0.137$), VEG3 ($r = 0.118$), and BK7DAY ($r = 0.154$), but was negatively correlated with TV3 ($r = -0.023$) and COMP3 ($r = -0.095$).

3.3 Latent Class analysis

3.3.1 Latent class profiles

To determine the optimal number of latent classes, a different number (1-7) of classes of weight-related behaviors for female and male adolescents were tested, and the results were showed in Table 4 and Table 5, respectively. The analysis yielded a 4-class model for female adolescents and 5-class model for male adolescents. These models had the lowest BIC (50598.62 for female and 55239.04 for male) and can be practically interpreted the distinct classes of individuals with respect to weight-related behaviors.

The probability of each weight-related behavior of each latent class were shown in Table 6 (female adolescents) and Table 7 (male adolescents). Higher probabilities in physical activities suggested that this subgroup had a higher likelihood of being physically active; higher probabilities in sedentary behavior items indicated that this subgroup was more likely to have more screen time; and higher probabilities in eating behaviors (fruit, vegetable) indicated a higher likelihood of having good eating habits. The results showed that female adolescents had unique Class 1, while male adolescents had unique Class 1 and Class 5. The rest of classes (Class 2, 3 and 4) were very similar across females and males.

3.3.1.1 Latent classes for female adolescents

Class 1 of females (label: Inactive/ Low screen time/ Good eating habit) contained 12.5% of female adolescents. The students in this class were unlikely engaging in physical activity (with 27% and 29% probability of saying yes to PA7DAY and DLYPE, respectively). However, these students had low screen time (27% for TV3 and 38% for

COMP3) and good eating habits (75% for FR3, 73% for VEG3, but only 31% for SODA1).

Class 2 of females (label: Inactive/ Low screen time/ Poor eating habit) was the largest subgroup that had 44.4 % female. The individuals in this subgroup were not physically active (15% for PA7DAY and 18% for DLYPE), as well as being unlikely to have a healthy diet (9% for FR3 and 6% for VEG3), but they spent less time on TV watching (9% for TV3) and computer using (31% for COMP3).

Class 3 of females (label: Inactive/ Moderately high screen time/ Poor eating habit) was characterized by moderately high probabilities of engaging in sedentary behaviors (41% for TV3 and 59% for COMP3), and low probabilities of being engaged in physical activity (5% for PA7DAY and 27% for DLYPE) and having healthy diet (10% for FR3 and 4% for VEG3). Class 3 was the smallest subgroups that had only 4.8% female adolescents.

Class 4 of females (label: Active/ Low screen time/ Poor eating habit) included individuals who were physically active (100% for PA7DAY and 79% for DLYPE) and unlikely to spend excess screen time (28% for TV3 and 45% for COMP3), but they had poor eating habits (22% for FR3 and 9% for VEG3). This class was comprised of 38.4% female adolescents.

The graphical display of the probability of each weighted-related behavior for each subclass of females was shown in Appendix A.

3.3.1.2 Latent classes for male adolescents

Class 1 of males (label: Moderately active/ High screen time/ Good eating habit) contained 19 % of male adolescents. The students in this class were moderately physical

active (with 56% for PA7DAY and 55% for DLYPE), and had good eating habits (73% for FR3, 54% for VEG3). However, these students had excess screen time (81% for TV3 and 75% for COMP3).

Class 2 of males (label: Inactive/ Low screen time/ Poor eating habit) was the largest subgroup that had 40.2 % males. The individuals who were not physically active (0% for PA7DAY and 29% for DLYPE), had poor eating habits (10% for FR3 and 4% for VEG3), but they had a low level of screen time (23% for TV3 and 43% for COMP3).

Class 3 of males (label: Inactive/ Moderately high screen time/ Poor eating habit) had a moderately high level of screen time (32% for TV3 and 57% for COMP3) and were unlikely to engage in physical activity (13% for PA7DAY and 23% for DLYPE). Also, they had a bad eating diet (9% for FR3, 10% for VEG3, and 73% for SODA1). Class 3 had 23.1 % male adolescents.

Class 4 of males (label: Active/ Low screen time/ Poor eating habit) included individuals who were physically active (100% for PA7DAY and 51% for DLYPE) and had a low level of screen time (22% for TV3 and 31% for COMP3). However, these students had bad eating habits (13% for FR3 and 6% for VEG3). This class was comprised of 11% male adolescents.

Class 5 of males (label: Moderately active/ Low screen time/Good eating habit) had a high probability of being engage in healthy life style. They were physically active (59% for PA7DAY and 39% for DLYPE), spending a low level of screen time (5% for TV3 and 23% for COMP3) and having a healthy diet (83% for FR3 and 74% for VEG3). It contained only 6.7% of male adolescents.

The graphical display of the probability of each weight-related behavior for each subclass of males were showed in Appendix B.

3.3.2 Composition differences across classes

Table 8 and Table 9 showed weight status across latent classes of female and male adolescents, respectively. Both class 2 and class 4 in females has the highest proportion of students being obese (14.1%), while class 5 in males had the highest proportion of students being obese (20.9%). For both female and male students, the most prevalent of a normal weight was in class 3 (female: 75.4%, male: 68.7%).

Characteristic	Total (n = 12031) %	Female (n = 6093) %	Male (n = 5938) %
Grade			
9th	24.6	24.8	24.3
10th	25.3	25.4	25.2
11th	25.6	25.2	26.0
12th	24.5	24.6	24.5
Race			
White	42.1	42.7	41.5
Hispanic	35.9	35.6	36.1
Black/African American	10.9	11.1	10.6
Asian	4.5	4.3	4.8
Others	6.7	6.4	7
Age			
12 or under	0	0	0.1
13	0.1	0.1	0.1
14	9.2	10	8.4
15	24	24.6	23.5
16	26	26	26
17	25.8	25.8	25.7
18 or older	14.8	13.4	16.3
Weight status			
Normal weight (5 to < 85th percentile)	65.6	68.8	62.2
Overweight (85 to < 95th percentile)	16.6	17.2	16.1
Obese (≥95th percentile)	15.2	12.0	18.4
Weight-related Behaviors			
TV3 (≥ 3h/day of TV viewing)	26.4	26.2	26.5
COMP3(≥ 3h/day of computer/video game)	43.8	44.8	42.8
FR3 (≥ 3 times fruits/day)	20.5	18.4	22.7
VEG3 (≥ 3 times vegetables/day)	14.8	13.3	16.4
SODA1(≥ 1 soda/day)	21.7	17.6	25.9
BK7DAY(All 7 days breakfast consumption)	34.9	30.4	39.6
PA7DAY (≥ 60min/day of physical activity)	25.9	16.5	35.6
DLYPE (All 5 days physical education class)	30.9	26.3	35.6

Table 2: Sample characteristics and descriptive statistics of weight-related behaviors

TV3	1							
COMP3	0.132**	1						
FR3	0.02*	-0.019*	1					
VEG3	0	-0.041**	0.394**	1				
SODA1	0.124**	0.088**	0.1**	0.134**	1			
BK7DAY	-0.018*	-0.045**	0.119**	0.11**	-0.043**	1		
PA7DAY	-0.023*	-0.095**	0.137**	0.118**	0.058**	0.154**	1	
DLYPE	0.045**	0.009	0.063**	0.025**	0.035**	0.039**	0.192**	1
	TV3	COMP3	FR3	VEG3	SODA1	BK7DAY	PA7DAY	DLYPE

Table 3: Inter-correlation of eight weight-related behaviors.

*:p-value < 0.05 ; ** : p-value < 0.01

Female (n = 6093)	
Number of class	BIC value
1-class	51675.17
2-class	50845.8
3-class	50774.01
4-class	**50598.62**
5-class	50599.8
6-class	50642.15
7-class	50699.86

Table 4: Determining the number of latent classes for male US adolescents using LCA

Male (n=5938)	
Number of class	BIC value
1-class	56942.27
2-class	55662.62
3-class	55397.38
4-class	55274.83
5-class	**55239.04**
6-class	55252.78
7-class	55281.13

Table 5: Determining the number of latent classes for female US adolescents using LCA

	Female (n =6093) 4 latent class			
	Class 1 Inactive/ Low screen time/ Good eating habit (12.5%)	Class 2 Inactive/ Low screen time/ Poor eating habit (44.4%)	Class 3 Inactive/ Moderately high screen time / Poor eating habit (4.8%)	Class 4 Active/ Low screen time/ Poor eating habit (38.3%)
TV3 (≥ 3h/day of TV viewing)	0.27	0.09	0.41	0.28
COMP3 (≥ 3h/day of computer/video game)	0.38	0.31	**0.59**	0.45
FR3 (≥ 3 times fruits/day)	**0.75**	0.09	0.1	0.22
VEG3 (≥ 3 times vegetables/day)	**0.73**	0.06	0.04	0.09
SODA1 (≥ 1 soda/day)	0.31	0.01	0.27	0.23
BK7DAY (All 7 days breakfast consumption)	0.48	0.37	0.18	0.41
PA7DAY (≥ 60min/day of physical activity)	0.27	0.15	0.05	1
DLYPE (All 5 days physical education class)	0.29	0.18	0.27	**0.79**

Table 6: Four-class model of weight-related health behaviors among female US adolescents

	Male (n=5938) 5 latent classes				
	Class 1 Moderately active/ High screen time/ Good eating habit (19%)	Class 2 Inactive/ Low screen time/ Poor eating habit (40.2%)	Class 3 Inactive/ Moderately high screen time / Poor eating habit (23.1%)	Class 4 Active/ Low screen time/ Poor eating habit (11%)	Class 5 Moderately active / Low screen time/ Good eating habit (6.7%)
TV3 (≥ 3h/day of TV viewing)	**0.81**	0.23	0.32	0.22	0.05
COMP3 (≥ 3h/day of computer/video game)	**0.75**	0.43	**0.57**	0.31	0.23
FR3 (≥ 3 times fruits/day)	**0.73**	0.1	0.09	0.13	**0.83**
VEG3 (≥ 3 times vegetables/day)	**0.54**	0.04	0.1	0.06	**0.74**
SODA1 (≥ 1 soda/day)	**0.61**	0	**0.73**	0.19	0.34
BK7DAY (All 7 days breakfast consumption)	**0.6**	0.34	0.22	0.49	**0.59**
PA7DAY (≥ 60min/day of physical activity)	**0.56**	0	0.13	**1**	**0.56**
DLYPE (All 5 days physical education class)	**0.55**	0.29	0.23	**0.51**	0.39

Table 7: Five-class model of weight-related health behaviors among male US adolescents

	Female (n =6093) 4 latent class			
	Class 1 Inactive/ Low screen time/ Good eating habit	Class 2 Inactive/ Low screen time/ Poor eating habit	Class 3 Inactive/ Moderately high screen time / Poor eating habit	Class 4 Active/ Low screen time/ Poor eating habit
	%	**%**	**%**	**%**
Weight status				
Normal	71.8	65.4	75.4	67.8
Overweight	16.5	18.3	15.2	16
Obese	9.8	14.1	8	14.1

Table 8: Weight status among Latent Classes in female US adolescents

	Male (n=5938) 5 latent classes				
	Class 1 Moderately active/ High screen time/ Good eating habit	Class 2 Inactive/ Low screen time/ Poor eating habit	Class 3 Inactive/ Moderately high screen time / Poor eating habit	Class 4 Active/ Low screen time/ Poor eating habit	Class 5 Moderately active / Low screen time/ Good eating habit
	%	%	%	%	%
Weight status					
Normal	67.7	63.1	68.7	61.6	58.4
Overweight	15.4	17.4	13.7	14.6	16.9
Obese	14.6	16.5	16.6	19.5	20.9

Table 9: Weight status among Latent Classes in male US adolescents

Chapter 4 Discussion

According to the correlation test of weight-related variables, we found physical activities were positively correlated with eating behaviors and negatively correlated to sedentary behaviors, suggesting that people who were physically active were more likely maintaining a healthy diet and spending less sedentary time. However, a study reported that people who were active may not decrease the level of sedentary time or have poor eating habits (34). The LCA results in this study showed that the level of physical activity and the level of sedentary time had negative relationship in two subgroups (class 3,4) of females and three subgroups (class 3,4 5) of males, but were positively related in other subgroups. Also, the LCA showed that the levels of physical activities and eating habits were positively related in two subgroups (class 2, 3) of females and four subgroups (class 1, 2, 3, 5) of males, but had a negative relationship in other subgroups.

Gender disparity among these weight-related behaviors were found in this study. According to Table 2, male adolescents had a higher proportion of people being physically active and maintain healthy diets, but had lower proportion of people who had excessive level of sedentary time, when compared to female adolescents. This finding was in line with studies which reported that female adolescents had lower levels of physical activity, higher levels of sedentary time, and less healthy diets than male adolescents (31, 35, 36).

The LCA results showed that the proportion of students in all classes were different across the female and males groups. In addition, we found male adolescents had a higher proportion of people being obese than female adolescents in each class. Males in Class 1 (Moderately active/ High screen time/ Good eating habit), who were physically active and had relatively high levels of screen time and healthy diets compared to other

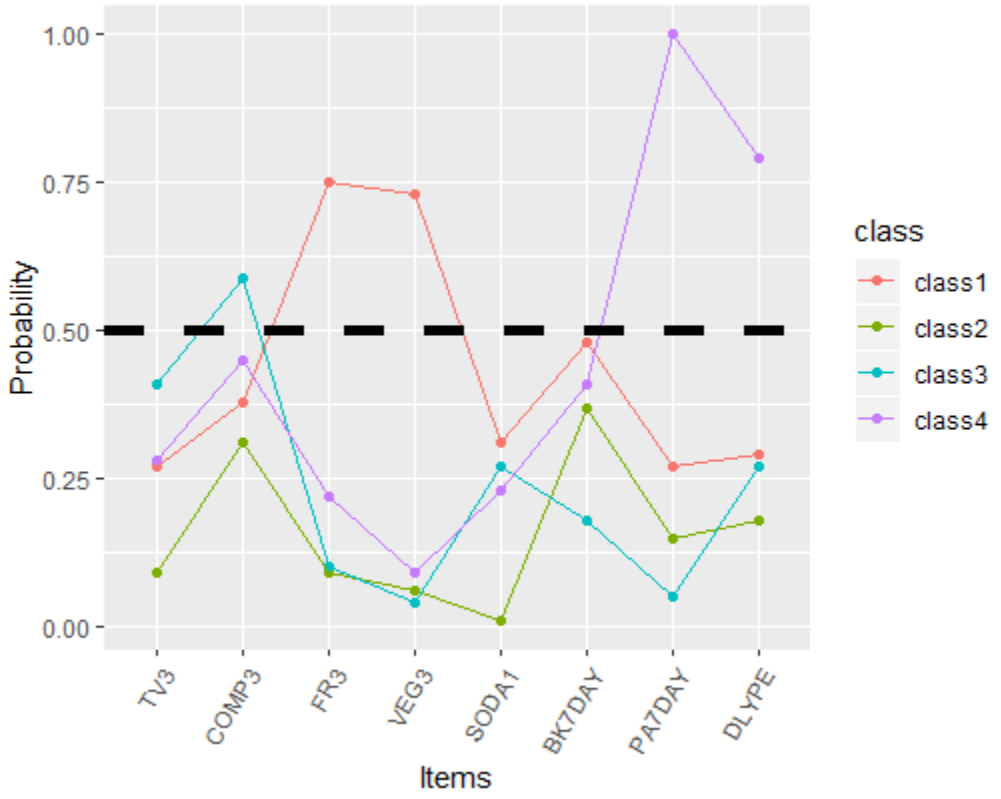
classes, had the lowest proportion of obese in males. It was possible that sedentary behavior was not such an important factor for the risk of obesity in this class for males. Class 2 (Inactive/ Low screen time/ Poor eating habit) was the largest for both females (44.4%) and males (40.2%). This class had the highest proportion of obese adolescents for females (14.1%), and had the second lowest percentage of adolescents being obese for males (16.5%). Class 3 (Inactive/ Moderately high screen time/ Poor eating habit), which was considered as the highest risk class for obesity, was significantly larger for males (23.1%) compared to females (4.8%). However, females had the lowest proportion (8%) of obese people, while males had 16.6%. Additionally, we found some classes which considered as the low risk group for obesity, had high percentages of adolescents being obese. For example, Class 4 (Active/ Low screen time/ Poor eating habit), had 14.1% obese female (the highest in females) and 19.5% obese males (second highest in males); Class 5 (Moderately active/ Low screen time/Good eating habit), a unique class for males, had the highest proportion (20.9%) of obese adolescents. The possible explanation for this counterintuitive finding could be that the adolescents in these classes were obese to begin with, but they were changing to a healthier life style before they filled out the survey. Therefore, a longitudinal study is required in the future.

The interpretation of the finding in this study have certain limitations. First, because of data limitation, we cannot rule out other confounding factors, such as previous weight-related behaviors and weight status. Second, all participants self-reported their information. Some data may be overestimated or underestimated. For example, adolescents may overestimate the time of physical activity or underestimate the sedentary time which would cause bias. Finally, the obesity status may be not accurate since it was determined by self-reported height and weight. To strengthen the validity of the finding

in the future, these weight-related behaviors and other variables need to be objectively measured.

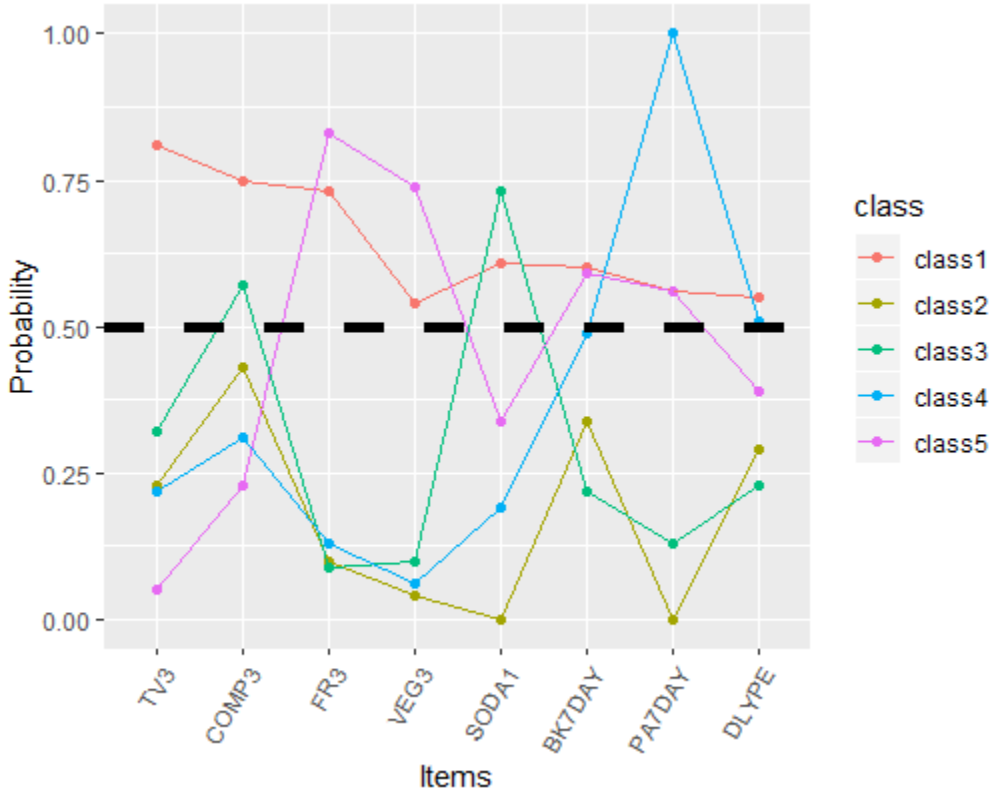
Appendices

Appendix A. Graphical display of the latent classes for female adolescents.



	Label
Class 1	Inactive/ Low screen time/ Good eating habit
Class 2	Inactive/ Low screen time/ Poor eating habit
Class 3	Inactive/ Moderately high screen time/ Poor eating habit
Class 4	Active/ Low screen time/ Poor eating habit

Appendix B. Graphical display of the latent classes for male adolescents



	Label
Class 1	Moderately active/ High screen time/ Good eating habit
Class 2	Inactive/ Low screen time/ Poor eating habit
Class 3	Inactive/ Moderately high screen time/ Poor eating habit
Class 4	Active/ Low screen time/ Poor eating habit
Class 5	Moderately active/ Low screen time/Good eating habit

References

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