



SICOM & AOCO 2024

SOMS International Conference on Obesity & Metabolism
in conjunction with Asia-Oceania Conference on Obesity

Hosted by

SOMS Society for Korean
Obesity and Metabolism Studies

Co-Hosted by



Empowering Health, Inspiring Change: Practical Solutions for Obesity

Date October 24 (Thu)~26 (Sat), 2024

Venue aT Center, Seoul, Republic of Korea (3F Segyero Room & 4F Changjo Room)

Intervention for Children and Adolescents with Moderate to Severe Obesity

Kyung Hee Park
Hallym University

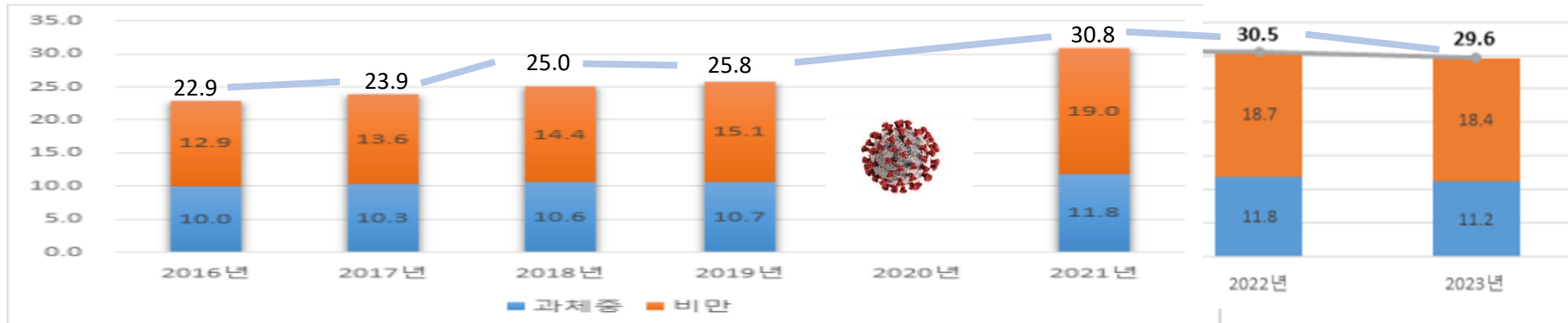


몸과 마음이 건강해지는 체중조절 프로그램
ICAAN 프로젝트



I . INTRODUCTION

Prevalence of obesity in children and adolescents



Overweight and obesity

† Based on 2017 Growth Chart

- Overweight : sex-age specific BMI percentiles 85th – 95th
- Obesity : sex-age specific BMI percentiles ≥ 95th

Reference: Ministry of Education. 2021, 2024

Prevalence of obesity in children and adolescents

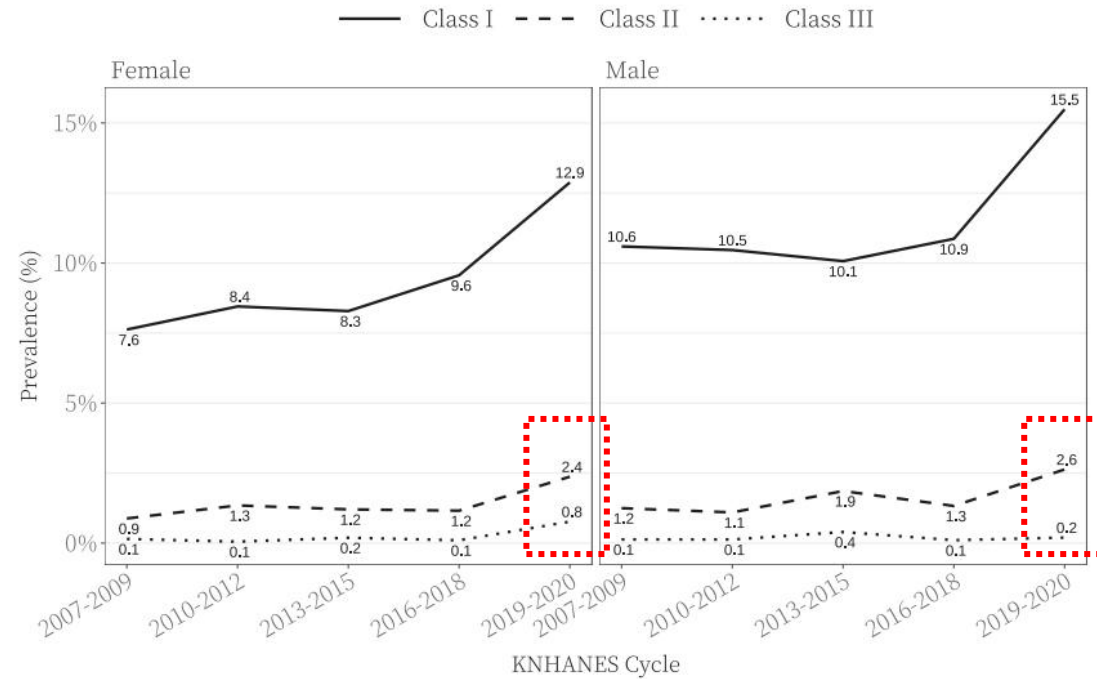


FIGURE 1 The prevalence of obesity and severe obesity in Korean children and adolescents across Korea National Health and Nutrition Examination Survey (KNHANES) cycles.

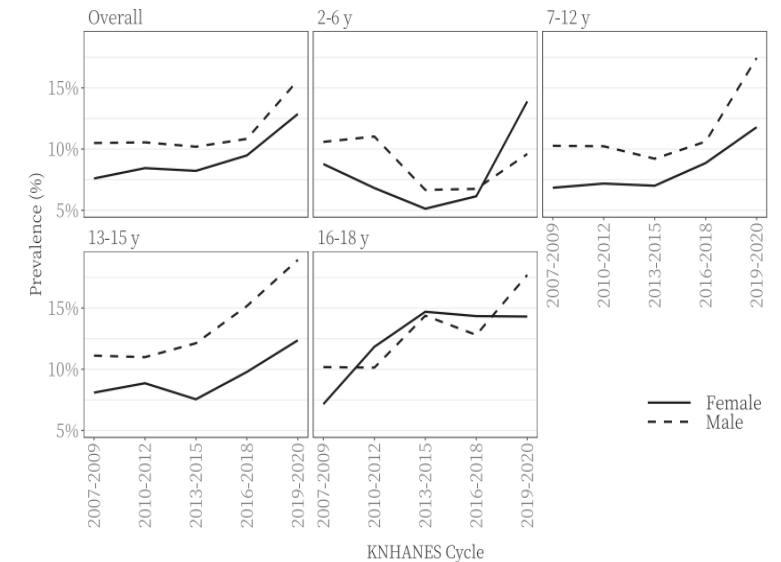
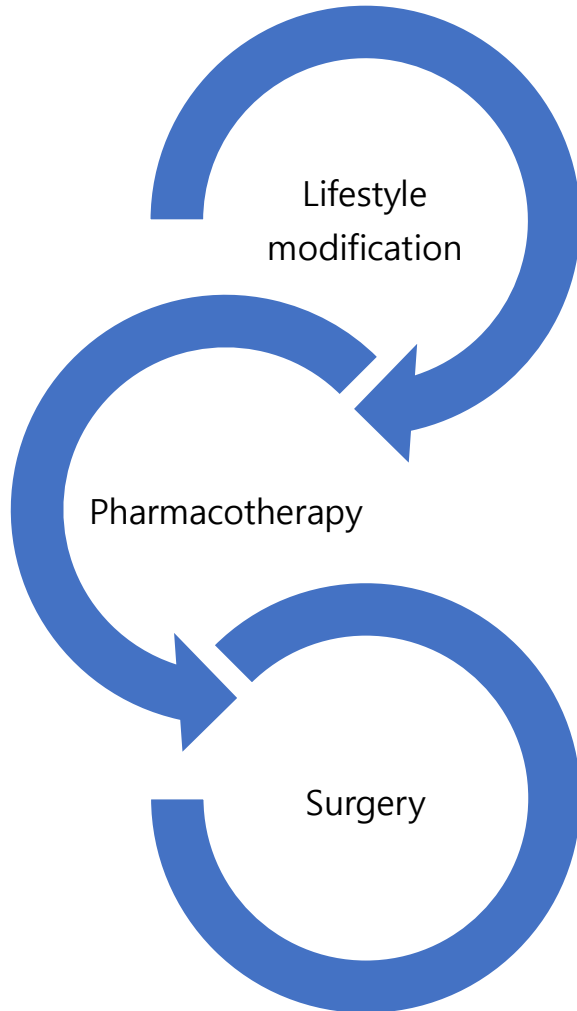


FIGURE 2 The prevalence of obesity in Korean children and adolescents according to age group and sex.

Clinical Practice Guideline in Korea

9. 소아청소년 비만



지침

1. 소아청소년 비만은 성인 비만으로 이행하기 쉽고 비만 동반 질환을 유발할 가능성이 크므로 예방과 치료를 권고한다. (A, class I)

2. 만 2세 이상의 소아청소년 비만을 진단할 때는 2017년 소아청소년 성장도표를 기준으로 성, 연령별 체질량지수 백분위수를 사용하고 체질량지수 85 백분위수 이상은 비만전단계(과체중), 95 백분위수 이상은 비만으로 판정하는 것을 권고한다. (A, class I)

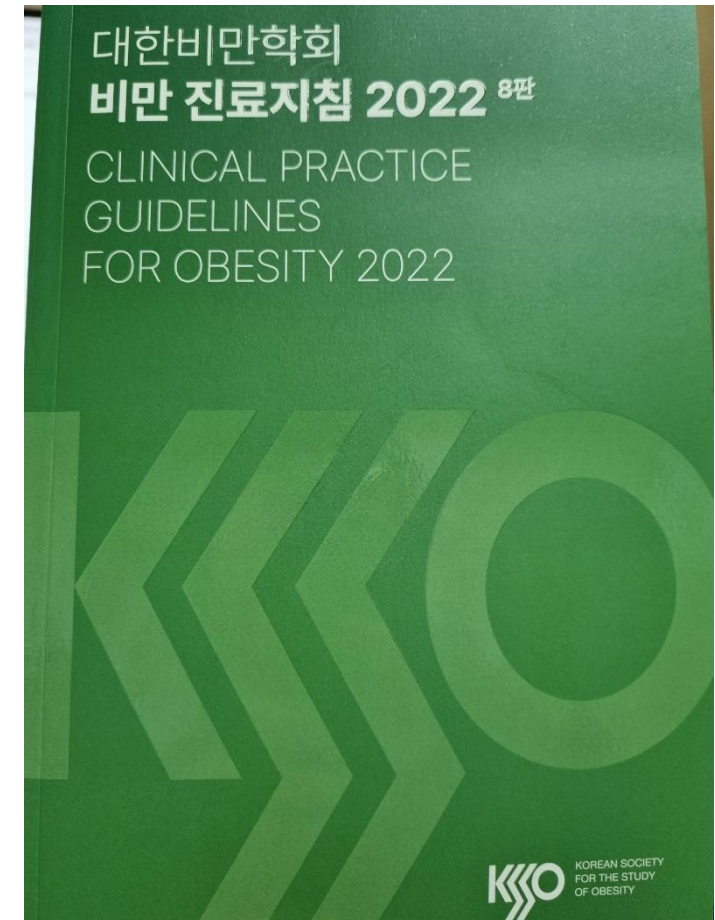
3. 비만전단계(과체중) 이상의 소아청소년에서는 개별화된 의학적 위험성을 평가하는 것을 고려한다. (B, class IIa)

4. 소아청소년 비만 치료는 정상적인 성장에 필요한 에너지와 영양소를 공급하고 적절한 생활습관을 익혀 적정 체중을 유지하는 것을 권고한다. (A, class I)

5. 소아청소년 비만 치료는 식사치료, 운동치료, 행동치료를 포함한 포괄적 생활습관 교정을 권고한다. (A, class I)

6. 집중적인 식사치료, 운동치료와 행동치료를 시행한 경우에도 지속적인 체중증가를 보이고 비만 동반 질환이 조절되지 않을 때, 경험 있는 전문의에 의한 약물치료를 고려한다. (B, class IIa)

7. 집중적인 다면적 치료와 약물치료에도 지속적인 체중증가와 비만 동반 질환이 조절되지 않을 때, 성장과 사춘기가 완료된 경우에 한해서 제한적으로 수술치료를 고려할 수 있다. (C, Class IIb)



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II. ICAAN study

ICAAN

(Intervention for **C**hildhood and **A**dolescent obesity via **A**ctivity and **N**utrition)

ICAAN

(Intervention for **C**hildhood and **A**dolescent obesity via **A**ctivity and **N**utrition)

Objectives

- Characteristics of severe obesity in Korea

• Designing and implementation of intervention program for children and adolescents with severe obesity



• Establishment of baseline network for long term follow up

✓ Grant : KDCA, NIH

✓ Principal Investigator : Kyung Hee Park (Hallym University)

ICAAN STUDY



Pilot

(2015.10-2016.10)

청소년 고도비만 증재 사전연구

ICAAN - 24Mo.

(2016.08- 2019.05)

고도비만 소아청소년 장기추적 증재

ICAAN_ON

(2019.3- 2021.12)

Community Care (교육지청-보건소-병원 연계) 기반 고도비만 증재 시범연구

ICAAN_M

(2022.06-2024.12)

건강관리 플랫폼 활용한 아동청소년 고도비만 증재 및 자원 확보

ICAAN STUDY

Study population

- 10-14 yrs old
- Age,sex-specific percentiles of BMI : \geq 97th



Primary endpoint

- BMI z score



Secondary endpoint

- Body composition, waist circumference, physical fitness
- Metabolic parameters (glucose, insulin, blood pressure, lipid profile)
- Nutritional parameters
- Psychosocial parameters



* Exclusion: Participants taking medications that may affect body weight(insulin, thyroid hormone, steroid..)

ICAAN STUDY

Health risk assessment



	Measurements	
Anthropometry /physical exam	- Height, body weight, waist/hip circumference, body composition(DXA, BIA), sexual maturation	
Health risk assessment	<ul style="list-style-type: none"> - Blood pressure (SBP/DBP) - Serum : glucose, insulin, lipid profile, AST/ALT/rGT , leptin, adiponectin, hsCRP - EKG, urine protein, stool (microbiome) - Liver MRI (3차, 4차), carotid sono (3차) 	
Questionnaires	Lifestyle	Kids: sleep, eating behavior, physical activity Parents : eating behavior, physical activity, smoking, alcohol
	Familial environment	Family function (Family APGAR),
	Psychosocial	Kids: depressiveness (CDI), self-esteem (Rosenberg), TCI, DEBQ Parents : depressiveness (CES-D)
	Birth	Birth weight, gestational weight gain, gestational diabetes/PIH
	Medical history	Past medical history (both)
Nutrition & physical fitness	<ul style="list-style-type: none"> - 3 days record (nutritional assessment), nutritional diagnosis (Nutrition Care Process)) - Muscular fitness : upper/lower 1RM - Cardiorespiratory fitness : step box test 	

ICAAN STUDY



Medical evaluation & counselling



Behavioral intervention (CBT, MI)



Nutritional education, counselling



Physical activity, Exercise education



Education program for parents







(APP) monitoring & feedback

STUDY RESULTS

– GENERAL CHARACTERISTICS

ICAAN STUDY

	Total (N=818)	Pilot (N=103)	ICAAN_24Mo (n=264)	ICAAN_ON (n=233)	ICAAN_M (n=218)
 Abnormal lipid profile	394 (48.17%)	54 (52.43%)	132 (50.00%)	105 (45.06%)	103 (47.25%)
 Abnormal fasting glucose	83 (10.15%)	8 (7.77%)	19 (7.20%)	38 (16.31%)	18 (8.26%)
 Abnormal liver function	169 (20.66%)	22 (21.36%)	48 (18.18%)	70 (30.04%)	29 (13.30%)
 Cardiovascular risk factor clustering (≥ 3)	281 (34.35%)	41 (39.81%)	102 (38.64%)	83 (35.62%)	55 (25.23%)

***abnormal lipid profile:**

1) LDL - cholesterol ≥ 130 mg/dL or 2) Triglyceride ≥ 130 mg/dL or 3) HDL-cholesterol < 40 mg/dL

***abnormal fasting glucose:**

glucose ≥ 100 mg/dL

***abnormal liver function :**

1) AST > 50 U/L(3~9yr), > 40 U/L(10~15yr), 2) ALT > 45 U/L

3) γ -GTP > 32 U/L(1~10yr), > 24 U/L(10~15yr),

***Cardiovascular risk factor clustering** (Modified NCEP-ATP III) : ≥ 3

1) Waist circumference $\geq 90^{\text{th}}$ percentiles

2) Blood pressure $\geq 90^{\text{th}}$ percentiles

3) triglyceride ≥ 110 mg/dL

4) HDL cholesterol < 40 mg/dL

5) Fasting blood glucose ≥ 100 mg/dL



Family Factors and Obesity in Relation to Mental Health Among Korean Children and Adolescents

Hye-Mi Noh¹ · Jane Park^{1,2} · Eun-Ju Sung³ · Young Soo Ju⁴ · Hye-Ja Lee⁵ · Yoon-Kyoung Jeong⁶ · Kyung Hee Park¹

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Table 2 Factors associated with higher levels of depressive symptoms in logistic regression analysis in boys

	Crude OR (95% CI)	Adjusted OR (95% CI)
Age (years)	1.29 (1.03–1.06)	1.19 (0.84–1.68)
Psychological well-being of mother		
Less distressed	1	1
Highly distressed	3.85 (1.50–9.87)	1.91 (0.62–5.86)
Family functioning		
Highly functioning	1	1
Poorly functioning	5.91 (3.01–11.61)	5.95 (2.54–13.93)
Parent–child relationship		
Good	0.21 (0.09–0.49)	0.30 (0.10–0.96)
Average or bad	1	1
Peer relationship		
Good	0.37 (0.19–0.71)	0.49 (0.21–1.19)
Average or bad	1	1
Academic achievement		
High grade	1	1
Middle grade	1.76 (0.86–3.61)	1.11 (0.40–3.05)
Low grade	2.98 (1.17–7.61)	1.61 (0.47–5.57)

CI confidence interval, OR odds ratio

Psychological well-being of parent was assessed by Psychosocial Well-Being Index Short-Form (PWI-SF), highly distressed ≥ 27 , and less distressed < 27 ; Family functioning was assessed by family adaptability, partnership, growth, affection, and resolve (APGAR) test, highly functioning ≥ 7 , and poorly functioning < 7

Table 3 Factors associated with higher levels of depressive symptoms in logistic regression analysis in girls

	Crude OR (95% CI)	Adjusted OR (95% CI)
Age (years)	1.15 (0.93–1.42)	
Obesity severity		
Overweight	1	1
Obese	1.23 (0.41–3.68)	1.54 (0.38–6.17)
Severely obese	4.22 (1.29–13.80)	4.74 (1.01–19.84)
Psychological well-being of mother		
Less distressed	1	1
Highly distressed	2.44 (0.87–6.82)	2.04 (0.64–6.51)
Family functioning		
Highly functioning	1	1
Poorly functioning	3.65 (1.61–8.28)	3.16 (1.19–8.38)

CI confidence interval, OR odds ratio

Psychological well-being of parent was assessed by Psychosocial Well-Being Index Short-Form (PWI-SF), highly distressed ≥ 27 , and less distressed < 27 ; Family functioning was assessed by family adaptability, partnership, growth, affection, and resolve (APGAR) test, highly functioning ≥ 7 , and poorly functioning < 7

ICAAN STUDY

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Factors associated with the perception of parents and children regarding obesity-related terminology used by healthcare professionals in a sample of Korean children and adolescents with obesity

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ARTICLE INFO

Keywords:
 Pediatric obesity
 Obesity-related terminology
 Body size
 Externalized problem
 Internalized problem

ABSTRACT

Objective: This study aimed to compare how children with overweight or obesity and their parents perceive obesity-related terms used by healthcare professionals and investigate the factors associated with perceptions.
Methods: Children and adolescents aged 8–16 years with overweight or obesity (n = 192) and their parents participated in the cross-sectional study by responding to a 5-point Likert-scale questionnaire on 10 related terms, including “chubby,” “weight problem,” “weight,” “overweight,” “BMI,” “obese,” “heavy,” “fleshy,” “fat,” and “severely obese.”

A B S T R A C T

Objective: This study aimed to compare how children with overweight or obesity and their parents perceive the obesity-related terms used by healthcare professionals and investigate the factors associated with these perceptions.

Methods: Children and adolescents aged 8–16 years with overweight or obesity (n = 192) and their parents participated in the cross-sectional study by responding to a 5-point Likert-scale questionnaire on 10 obesity-related terms, including “chubby,” “weight problem,” “weight,” “overweight,” “BMI,” “obese,” “heavy,” “fleshy,” “fat,” and “severely obese.”

Results: For both children and parents, “chubby” was the most desirable term (mean ± standard deviation: 3.50 ± 1.12 and 2.95 ± 0.83, respectively), and “severely obese” was the least acceptable term (2.83 ± 1.17 and 2.02 ± 1.02, respectively). Although the parents preferred all the terms less than the children did (p < 0.001), “weight problem” was considered most motivating for a child to lose weight (3.93 ± 0.94). Among children, older age and a larger self-perceived body size were associated with a more positive response towards obesity-related terms, whereas having internalized or externalized problems were negatively associated with these terms. Parents with a history of cardiovascular disease considered “severely obese” (β = −0.419, [95% CI: −0.739, −0.099]) and “fat” (β = −0.457, [95% CI: −0.750, −0.164]) less desirable.

Conclusions: Children and adolescents had a higher preference for obesity-related terms than their parents and preferred that healthcare professionals use euphemistic terms such as “chubby,” or neutral terms such as “weight problem.” Children with larger self-perceived body sizes or older age had a higher preference for obesity-related words. The terms used by healthcare professionals to describe excess weight must be motivating and respectful for all family members participating in the treatment.

STUDY RESULTS– EFFECTIVENESS

ICAAN STUDY - Effectiveness

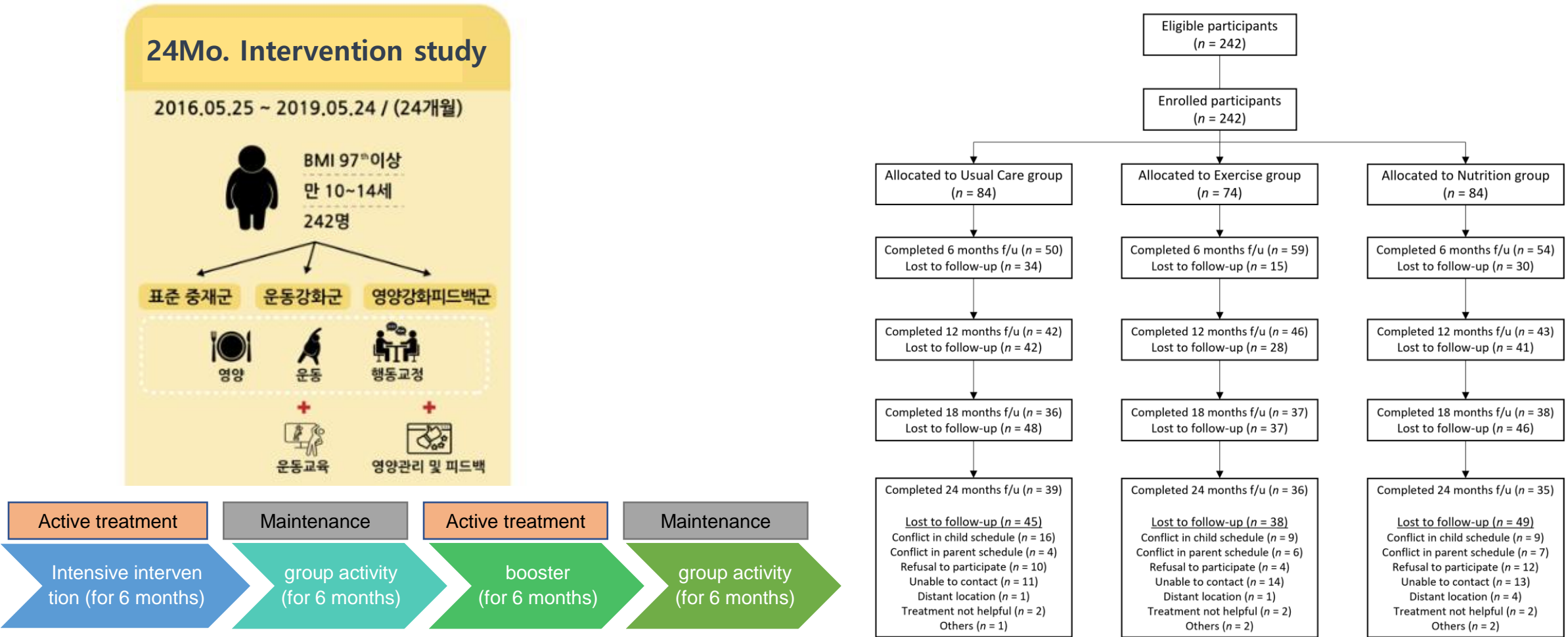


Figure 1. Flowchart of participant allocation.

ICAAN STUDY - Effectiveness

Table 5. Between-group differences in outcomes over time.

Outcome Measure	Model 1		Model 2		Model 3	
	β (95% CI)	p-value	β (95% CI)	p-value	β (95% CI)	p-value
BMI z-score						
Usual care group	reference		reference		reference	
Exercise group	-0.12 (-0.20 to -0.047)	0.002	-0.11 (-0.20 to -0.023)	0.013	-0.11 (-0.18 to -0.038)	0.003
Nutritional group	-0.057 (-0.13 to 0.021)	0.15	-0.060 (-0.15 to 0.030)	0.19	-0.056 (-0.13 to 0.016)	0.129
%BMI_{p95th}						
Usual care group	reference		reference		reference	
Exercise group	-1.03 (-1.05 to -1.01)	0.001	-1.03 (-1.05 to -1.01)	0.007	-1.03 (-1.04 to -1.01)	0.001
Nutritional group	-1.01 (-1.03 to 1.01)	0.17	-1.01 (-1.03 to 1.01)	0.19	-1.01 (-1.03 to 1.00)	0.13
Waist circumference, cm						
Usual care group	reference		reference		reference	
Exercise group	-1.90 (-4.03 to 0.23)	0.080	-1.30 (-3.86 to 1.25)	0.32	-1.73 (-3.68 to 0.22)	0.083
Nutritional group	-2.37 (-4.54 to -0.21)	0.032	-3.47 (-6.06 to -0.89)	0.009	-3.71 (-5.68 to -1.74)	<0.001
Adiponectin, $\mu\text{g}/\text{mL}$						
Usual care group	reference		reference		reference	
Exercise group	1.28 (1.08 to 1.51)	0.005	1.31 (1.08 to 1.58)	0.005	1.27 (1.10 to 1.47)	0.001
Nutritional group	-1.00 (-1.19 to 1.18)	0.97	-1.08 (-1.30 to 1.12)	0.44	-1.08 (-1.25 to 1.07)	0.30

Abbreviations: BMI, body mass index; %BMI_{p95th}, percentage of the 95th percentile of age- and sex-specific body mass index.

Model 1: group \times time interaction effects adjusted for age and sex in the mixed effects linear regression models (random intercept: individual).

Model 2: group \times time interaction effects adjusted for age, sex, parental obesity, parental education, monthly household income, living with both parents, and sleep time in the mixed effects linear regression models (random intercept: individual).

Model 3: group \times time interaction effects adjusted for age, sex, parental obesity, parental education, monthly household income, living with both parents, sleep time, and baseline values in the mixed effects linear regression models (random intercept: individual).

ICAAN STUDY - Effectiveness

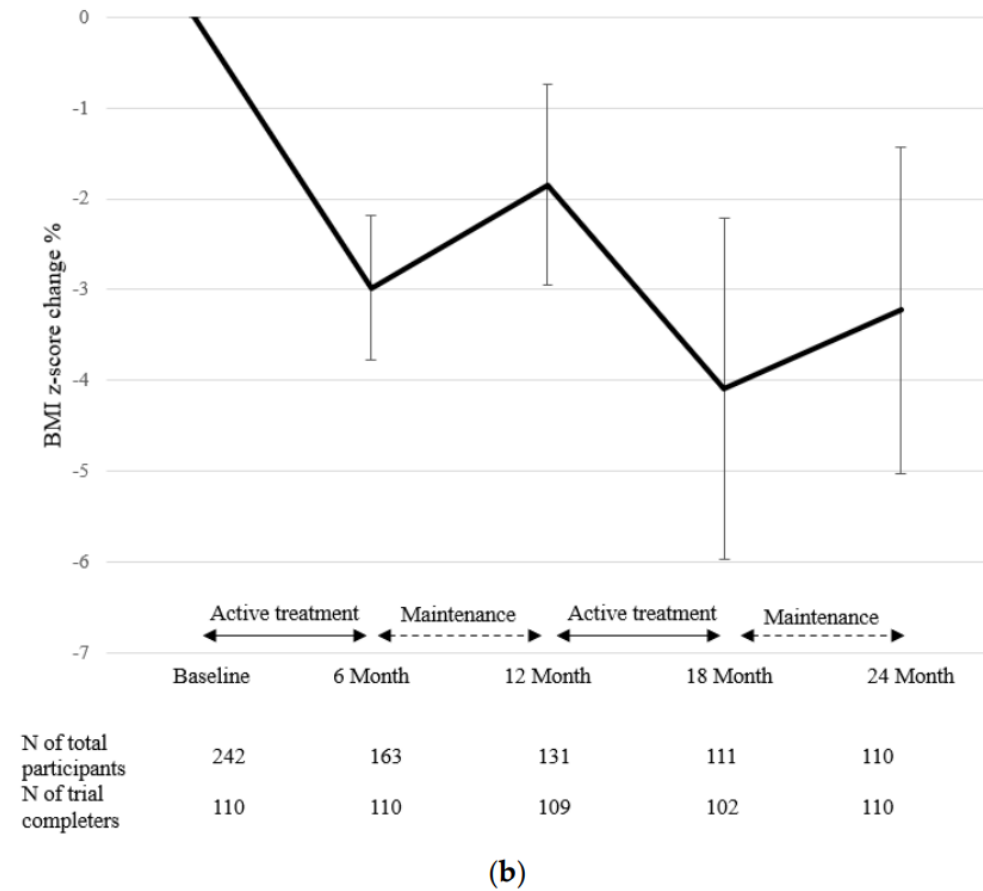
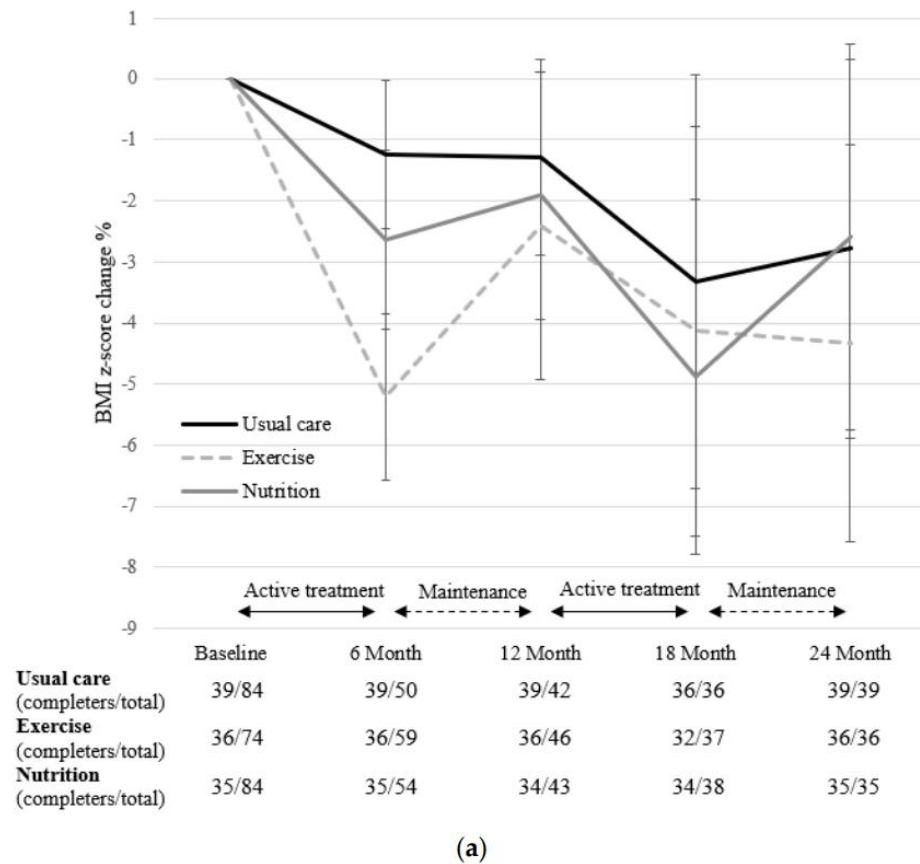


Figure 3. The course of BMI z-score change percentage from baseline according to the treatment stages. Linear mixed model adjusted for sex, age, attendance rate, calorie intake, and physical activity (METs). Figure shows means with standard error bars.

(a) change % according to the intervention groups. Group effect ($p = 0.772$), time effect ($p = 0.043$), group \times time interaction effect ($p = 0.976$).

(b) change % in total, adjusted for intervention groups: time effect ($p = 0.042$).

STUDY RESULTS

– FACTORS ASSOCIATED WITH.....

ICAAN - Dropout



Factors associated with dropout in a lifestyle modification program for weight management in children and adolescents



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Table 2

Factors associated with dropout in the intervention at 6-month.

	6-month follow-up			
	Crude OR (95% CI)		^a Adjusted OR (95% CI)	
Gender				
Boys	1.05	(0.61–1.82)	1.01	(0.52–1.99)
Girls	1		1	
Age	1.01	(0.89–1.15)	0.91	(0.78–1.07)
Monthly household Income				
Lowest (< 3 million KRW)	1		1	
Middle (3–6 million KRW)	1.06	(0.49–2.32)	1.31	(0.51–3.41)
Highest (>6 million KRW)	0.88	(0.40–1.95)	1.38	(0.52–3.72)
Family functioning (APGAR)				
Lower functioning	2.63	(1.46–4.73)	2.30	(1.18–4.46)
Higher functioning	1		1	
Intervention type				
Usual care	1		1	
Exercise	0.37	(0.18–0.76)	0.36	(0.15–0.86)
Nutrition	0.82	(0.44–1.52)	.669	(0.31–1.45)
Initial attendance rate				
Low sporadic attendee	6.55	(3.40–12.63)	6.09	(2.94–12.6)
High sporadic attendee	1		1	
Self-referral				
No	2.12	(1.07–4.20)	2.35	(1.05–5.27)
Yes	1		1	

Notes. Depressive symptoms of participants were assessed using the Child Depression Inventory (CDI): highest (third) tertile group of scores (≥ 12) indicates higher level of depressive symptoms, and the first and second tertile groups indicate lower levels of depressive symptoms; Family functioning was assessed using the family adaptability, partnership, growth, affection, and resolve (APGAR) test, score ≥ 7 indicates higher functioning, and score < 7 indicates lower functioning; CI: confidence interval; OR: odds ratio; Initial attendance rate was categorized by their attendance rate in the first three months of the intervention, with those in the highest tertile of attendance classified as high sporadic attendees and the remaining participants classified as low sporadic attendees.

^a Gender, age, and monthly household income were adjusted.

ICAAN - Dropout

Table 3

Factors associated with dropout in the intervention fitted by GEE.

	24-month follow-up			
	Crude OR (95 % CI)		^a Adjusted OR (95% CI)	
Gender				
Boys	0.93	(0.55–1.56)	0.89	(0.47–1.69)
Girls	1		1	
Age	1.10	(0.98–1.23)	1.01	(0.88–1.16)
Income				
Lowest (< 3 million KRW)	1		1	
Middle (3–6 million KRW)	0.40	(0.18–0.85)	0.35	(0.14–0.89)
Highest (>6 million KRW)	0.49	(0.23–1.06)	0.50	(0.19–1.30)
Maternal work status				
Working	1.21	(0.70–2.11)	1.36	(0.71–2.62)
Non-working	1		1	
Depressive symptoms				
Higher	1.75	(1.12–2.75)	1.43	(0.85–2.39)
Lower	1		1	
Family functioning (APGAR)				
Lower functioning	2.05	(1.32–3.18)	1.71	(1.06–2.77)
Higher functioning	1		1	
Intervention type				
Usual care	1		1	
Exercise	0.92	(0.49–1.71)	1.18	(0.58–2.44)
Nutrition	1.21	(0.66–2.24)	1.20	(0.58–2.51)
Initial attendance rate				
Low sporadic attendee	3.69	(2.16–6.31)	2.06	(1.12–3.81)
High sporadic attendee	1		1	

Notes. Depressive symptoms of participants were assessed using the Child Depression Inventory (CDI): highest (third) tertile group of scores (≥ 12) indicates higher level of depressive symptoms, and the first and second tertile groups indicate lower levels of depressive symptoms; Family functioning was assessed using the family adaptability, partnership, growth, affection, and resolve (APGAR) test, score ≥ 7 indicates higher functioning, and score < 7 indicates lower functioning; CI: confidence interval; OR: odds ratio; Initial attendance rate was categorized by their attendance rate in the first three months of the intervention, with those in the highest tertile of attendance classified as high sporadic attendees and the remaining participants classified as low sporadic attendees.

^a Gender, age, and monthly household income were adjusted.

ICAAN – non-response to intervention program

European Journal of Clinical Nutrition

www.nature.com/ejcn

ARTICLE

Nutrition in acute and chronic diseases

Parent and child characteristics associated with treatment non-response to a short- versus long-term lifestyle intervention in pediatric obesity

Sarah Woo¹, Hong Ji Song², Jung-Kook Song³, YoonMyung Kim⁴, Hyunjung Lim⁵ and Kyung Hee Park²✉

Check for updates

Table 3. Factors associated with treatment non-response at 6 months according to binary logistic regression.

	Non-responders (BMI z-score increase)			
	Crude OR (95% CI)		Adjusted OR (95% CI)	
Sex				
Male	1		1	
Female	0.93	(0.49–1.75)	0.75	(0.35–1.64)
Age				
Children (6–11 years)	1		1	
Adolescents (>11 years)	2.50**	(1.31–4.74)	2.40*	(1.10–5.22)
Intervention types				
Usual care	1		1	
Exercise group	0.44	(0.20–0.97)	0.48	(0.20–1.21)
Nutrition group	0.93	(0.43–2.02)	0.81	(0.33–1.97)
Baseline weight status				
Overweight to moderately obese	1		1	
Severely obese	1.12	(0.57–2.18)	1.29	(0.57–2.87)
Maternal education				
Secondary or lower	1		1	
Higher than secondary	0.48*	(0.24–0.94)	0.53	(0.24–1.16)
Total calorie intake				
Lower	1		1	
Higher	2.29*	(1.21–4.36)	2.28	(0.99–5.26)
Maternal psychosocial stress				
Lower	1		1	
Higher	3.32**	(1.67–6.59)	2.34*	(1.07–5.11)

ORs (95% CI) were computed through logistic regression analysis. Reference group was participants with BMI z-score decrease (low responders and responders).

Total calorie intake was classified as lower if ≤2140 (median), and higher if >2140. Maternal psychosocial stress was assessed with Psychological Well-being Index-Short Form (PWI-SF). Score below median (≤16) indicate lower degree of stress, and >16 indicate higher level of stress.

Sex, age, intervention types, and baseline weight status were adjusted in the multivariate model.

*p < 0.05; **p < 0.01.

ICAAN – non-response to intervention program

Table 4. Factors associated with treatment non-response at 24 months according to binary logistic regression.

	Non-responders (BMI z-score increase)	
	Crude OR (95% CI)	Adjusted OR (95% CI)
Sex		
Male	1	1
Female	1.66 (0.77–3.58)	2.22 (0.81–6.10)
Age		
Children (6–11 years)	1	1
Adolescents (>11 years)	1.65 (0.77–3.54)	1.23 (0.46–3.32)
Intervention types		
Usual care	1	1
Exercise group	0.96 (0.39–2.38)	0.63 (0.19–2.02)
Nutrition group	0.51 (0.20–1.29)	0.42 (0.14–1.29)
Baseline weight status		
Overweight to moderately obese	1	1
Severely obese	1.11 (0.50–2.50)	0.94 (0.34–2.61)
Baseline vegetable intake		
1.05 (0.98–1.12)	1.03 (0.94–1.12)	
Vegetable consumption change		
No change	1	1
Deteriorated	1.51 (0.48–4.68)	0.71 (0.17–3.10)
Improved	0.34* (0.13–0.90)	0.21* (0.07–0.69)
Sleeping duration change (weekend)		
Lowest	1	1
Middle	0.42 (0.15–1.19)	0.33 (0.09–1.19)
Highest	0.23** (0.08–0.65)	0.14** (0.04–0.53)

ORs (95% CI) were computed through logistic regression analysis. Reference group was participants with BMI z-score decrease.

Vegetable intake change was classified as deteriorated if vegetable intake per week was ≥ 5 servings (median) at baseline and < 5 at 24 months; improved if < 5 at baseline and ≥ 5 at 24 months; no change if ≥ 5 or < 5 at baseline and ≥ 5 or < 5 at 24 months, respectively. Sleeping duration change (weekend) at 24 months was calculated compared with baseline and classified as lowest (< -30 min/day), middle (-30 to 60 min/day), and highest tertile (≥ 60 min/day).

Sex, age, intervention types, baseline weight status, and baseline vegetable intake were adjusted in the multivariate model.

* $p < 0.05$; ** $p < 0.01$

ICAAN – behavioral phenotype

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Woo et al

Original Paper

Exploring the Effect of the Dynamics of Behavioral Phenotypes on Health Outcomes in an mHealth Intervention for Childhood Obesity: Longitudinal Observational Study

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Abstract

Background: Advancements in mobile health technologies and machine learning approaches have expanded the framework of behavioral phenotypes in obesity treatment to explore the dynamics of temporal changes.

Objective: This study aimed to investigate the dynamics of behavioral changes during obesity intervention and identify behavioral phenotypes associated with weight change using a hybrid machine learning approach.

Methods: In total, 88 children and adolescents (ages 8-16 years; 62/88, 71% male) with age- and sex-specific BMI ≥ 85 th percentile participated in the study. Behavioral phenotypes were identified using a hybrid 2-stage procedure based on the temporal dynamics of adherence to the 5 behavioral goals during the intervention. Functional principal component analysis was used to determine behavioral phenotypes by extracting principal component factors from the functional data of each participant. Elastic net regression was used to investigate the association between behavioral phenotypes and weight change.

Results: Functional principal component analysis identified 2 distinctive behavioral phenotypes, which were named the *high or low adherence level* and *late or early behavior change*. The first phenotype explained 47% to 69% of each factor, whereas the second phenotype explained 11% to 17% of the total behavioral dynamics. *High or low adherence level* was associated with weight change for adherence to screen time ($\beta = -.0766$, 95% CI $-.1245$ to $-.0312$), fruit and vegetable intake ($\beta = .1770$, 95% CI $.0642$ -.2561), exercise ($\beta = -.0711$, 95% CI $-.0892$ to $-.0363$), drinking water ($\beta = -.0203$, 95% CI $-.0218$ to $-.0123$), and sleep duration. *Late or early behavioral changes* were significantly associated with weight loss for changes in screen time ($\beta = .0440$, 95% CI $.0186$ -.0550), fruit and vegetable intake ($\beta = -.1177$, 95% CI $-.1441$ to $-.0680$), and sleep duration ($\beta = -.0991$, 95% CI $-.1254$ to $-.0597$).

Conclusions: Overall level of adherence, or the *high or low adherence level*, and a gradual improvement or deterioration in health-related behaviors, or the *late or early behavior change*, were differently associated with weight loss for distinctive obesity-related lifestyle behaviors. A large proportion of health-related behaviors remained stable throughout the intervention, which indicates that health care professionals should closely monitor changes made during the early stages of the intervention.

Trial Registration: Clinical Research Information Science KCT0004137; <https://tinyurl.com/ytxr83ay>

Figure 2. Smoothing splines of each participant's behavioral dynamics (mission 1). PC: principal component.

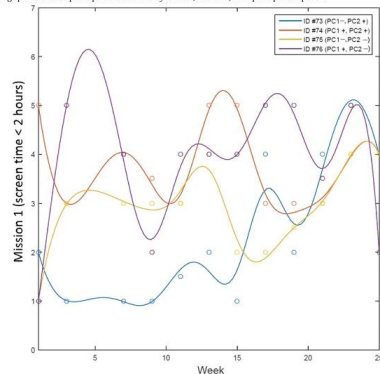
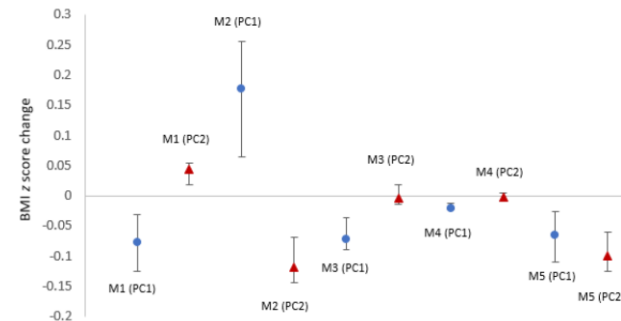
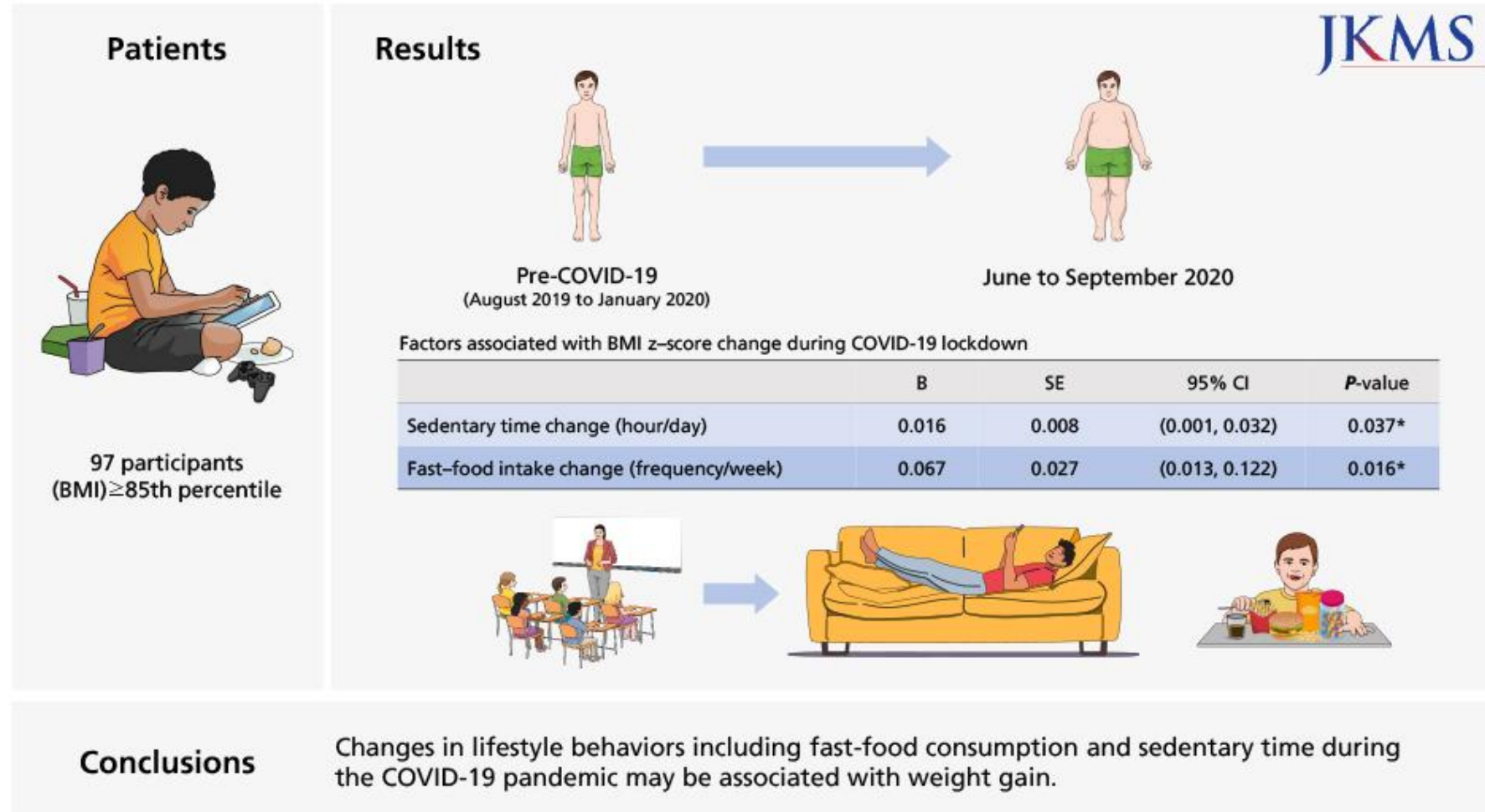


Figure 5. Effect of behavioral phenotypes on BMI z score change. PC: principal component; M1: screen time less than 2 hours; M2: eating more than 5 servings of fruits and vegetables; M3: exercising for more than 1 hour; M4: drinking water or plain milk; M5: sleeping for more than 8 hours; PC 1=high or low adherence level; PC 2=late or early behavioral change. Data were presented as standardized β coefficients and standard regression coefficients with 95% CIs. M: mission.



ICAAN – Weight Gain During COVID-19 Lockdown



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