Clustering of Lifestyle and Health Behaviours in Australian Children and Their Relationship with Obesity, Self-Rated Health and Quality of Life

Kabir Ahmad (✉ kabir.ahmad@usq.edu.au)

University of Southern Queensland

Syed Afroz Keramat

University of Southern Queensland

Gail M. Ormsby

University of Southern Queensland

Enamul Kabir

University of Southern Queensland

Rasheda Khanam

University of Southern Queensland

Research Article

Keywords:

Posted Date: February 28th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1252320/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Abstract

Objective

This study identifies the clustering of lifestyle and health behaviours in a nationally representative sample of Australian children and adolescents and explores the association of the clusters with obesity, self-rated health and quality of life.

Methods

The study participants were 3127 children aged 14/15 years who participated in the 8th Wave of the birth cohort of the Longitudinal Study of Australian Children (LSAC). A latent class analysis (LCA) was conducted to identify clusters on the basis of the following health behaviours: physical activity, sedentary behaviour, alcohol consumption, smoking, diet, eating disorders, sleep problems, and weight-gain consciousness. Obesity, self-rated general health, and pediatric health related to quality of life were used in this study to compare the latent groups. Multinomial logistic regression was used to investigate the association among LCA clusters and health outcome variables.

Results

Based on the lifestyle and health behaviour characteristics, latent class analysis found better model fits for identifying distinct clusters among male and female children separately, rather than all children. The study identified five clusters for male children: healthy lifestyle cluster (n = 624, 38.9%), temperate cluster (n = 440, 27.4%), physically inactive cluster (n = 73, 4.6%), mixed lifestyle cluster (n = 347, 21.6%) and multiple risk factor cluster (n = 122, 7.6%). For female children, this study found following four clusters: healthy lifestyle cluster (n = 659, 43.3%), temperate cluster (n = 558, 36.7%), mixed lifestyle cluster (n = 63, 4.2%) and multiple risk factor cluster (n = 241, 15.8%). Children from the healthy lifestyle and temperate clusters reported low and moderately active health risk behaviours, respectively; mixed lifestyle or multiple risk factor clusters showed higher negative association on health-related quality of life score compared to healthy lifestyle clusters for both male and female children.

Conclusion

This current study identifies sex-segregated discernible patterns of lifestyle and health behaviours in Australian adolescents. The study findings lead to an improved classification strategy for children with different lifestyles and health related behaviours to identify characteristics of the vulnerable groups in relation to obesity, general health status and quality of life.

Introduction

It is well established that a healthy lifestyle can reduce morbidity rates for all sections of the population, including children [1–3]. However, while many studies have linked sub-optimal children's health and lifestyle environments with adult disease, few have focused on the association of identified clusters and obesity, self-rated health and quality of life in children [4–6]. For example, children who eat more, and are physically inactive are more likely to become obese adults [7]. The importance of understanding the risk factors associated with children's health is paramount to consider how they might affect children's long-term health [8].

Overweight and obesity in childhood are complex conditions [3, 9, 10]. To add to the complexity, appropriate measuring indicators are not clear or uniform. For example, Body Mass Index (BMI), as a standalone indicator, is not adequate to capture the nature of obesity [11] and may not guide the development of appropriate interventions [9, 10]. For pediatrics, the Edmonton Obesity Staging System classifies the functional limitations of obesity according to four domains: Metabolic, Mechanical, Mental Health and Social Millieu [11, 12]. Other classifications of obesity are based on the presence or absence of metabolic risk factors such as metabolically healthy obesity [13].

In some countries, the identification of specific clusters of the national population across age and gender have helped to identify homogeneous groups which can be targeted for specific public health intervention or prevention strategies [2, 14–17]. A Netherlands study (n = 4,395) investigated the clustering of health-compromising and delinquent behaviours in adolescents and adults. The results showed that there were two relevant clusters (alcohol and delinquency) for young adolescents but three clusters (alcohol, delinquency and health) for older adolescents [18]. A Finnish study of adolescents (n = 6,792), assessing lifestyle (physical activity, sedentary behaviour, smoking, sleeping problems, and overweight/obesity) and psychosocial problems identified various subgroups of 16-year-old adolescents. Differences were observed among boys and girls, and it was revealed that lifestyle and psychosocial factors divided the adolescents into distinct subgroups which persisted in the follow-up study at age of 18 years [19]. Gender differences were also observed in two studies among adolescents and pre-school children in the US and France, respectively [20, 21]. Children of different clusters differed by gender, age, lifestyle and socio-economic positions; however, their relationships with obesity, self-rated health and quality of life are still unclear [22]. There are limited studies set in the Australian context [21].

The World Health Organization (WHO) recommends a holistic approach to assessing the health risks of an individual. Thus, it is deemed necessary to consider how all possible patterns of risk behaviours might affect an individual's health rather than considering health behaviours in isolation, for example, patterns of eating, stress-related eating, trajectories of smoking or drinking or physical fitness risk behaviours [23–26]. Some discernible patterns have been identified in adults, further investigation is needed within population studies to determine other possible synergistic relationships among children with obesity [2, 14–16].

Therefore, the primary aim of this study is to examine the clustering of health behaviours in a nationally representative sample of Australian children and explore the association of defined clusters of lifestyles and health behaviours with obesity, self-rated health and quality of life. The lifestyle characteristics and health behaviours of children include physical activity, diet, sedentary behaviour, smoking, alcohol consumption, sleep problems, eating disorders and concerns regarding weight gain.

Methods

Setting and data

The data were obtained from the 8th Wave of the Longitudinal Study of Australian Children (LSAC). LSAC is a representative household survey of Australian children that biennially collects information on the health (physical and socio-emotional) and learning development of Australian children from their birth year based on the context of the bio-ecological framework of human development [27]. LSAC launched its survey of the 1st Wave in 2004 and completed the 8th Wave in 2018 when the children were 15–16 years old. The LSAC data was collected from the parents or caregivers of the children of participating households and from the children themselves (from age 12 onward), through self-completed questionnaires or face-to-face interviews with trained interviewers. A multi-stage sampling technique was used to select the LSAC respondents. The household was the primary sampling unit. Details of the LSAC survey are available elsewhere [27].

For the purpose of the cluster analysis, 3127 participants from the 8th Wave of LSAC dataset were included in this study. This is because children of this wave provided data on the wide variety of dimensions which are as follows: physical activity, sedentary behaviours, alcohol consumption and smoking, sleep, eating disorders, concerns on weight gain, obesity status, self-rated general health and quality of life.

Latent class analysis variables

The latent class analysis was conducted using lifestyles and health related behaviours of the children. Details of the variables are described in the following.

Physical Activity: LSAC collects data on how many days the children performed at least one hour's moderate to vigorous physical activity per week. From the data, participants were categorised as follows: no or less than two hours moderate or vigorous physical activity per week; two hours moderate to intense physical activity per week; and greater than three hours moderate to vigorous physical activity per week.

Sedentary behaviour: Sedentary behaviour was measured based on the two activities: by considering weekday and weekend hours they spend per week on electronic games (do not play, up to 3 hours, more than three hours), and how often they remained engaged to share/post items on social media (frequently or daily, weekly/monthly basis, never).

Alcohol consumption: Self-reported alcohol consumption data were collected from the study children aged 14/15 years. Respondents were classified based on alcohol consumption in the last 4 weeks using two categories: no (non-drinkers) and yes (drinkers).

Smoking

Respondents were asked if they smoked in the last 4 weeks; they were dichotomised as smokers or non-smokers based on whether they smoked cigarettes during the time period.

Diet: Diet was assessed by the intake frequency of fruit and vegetables, skim/low/no fat milk, high fat food, full cream milk products,, and high sugar drinks. Following the observance of the different dietary approaches, respondents were categorised according to their dietary intake. Fruit and vegetable intake and high fat food were categorized as: none, 1–2 times/day, 3–4 times/day, 5 + times/day. Whereas, full cream milk products, skim/low/no fat mild and high sugar drink were categorised as none, once/day, twice/day, three or more/day. These categories are performed based on the frequency of consumption per day.

Eating disorders: Eating disorders were assessed based on the following two questions of the LSAC questionnaire: 'Does the child has Partial Syndromal Anorexia and/or Bulimia?' and 'How often did the child lose control of eating?'. The latter question's response was categorized as none, around once a week and two or more days a week.

Sleep

From the data of LSAC, respondents sleep quality was regrouped as very well, well, not well; and sleep duration was regrouped as less than 8 hours, 8 to 9 hours and greater than 9 hours respectively.

Weight-gain consciousness: Under the weight-gain consciousness category, the following questions were asked to the study children: how would you feel if you gained one to two KG weight (no concern, a little concerned, would worry/upset me), frequency you have gone all day without eating to control weight (none, one day a week, two or more days a week), frequency exercised in order to control weight (none, one to three days a week, four or more days a week).

Health status related outcome variables

Several health-related variables were used in this study to compare the defined clusters of health status among children. These variables are obesity, self-rated general health, and pediatric health related quality of life.

Obesity

This health outcome is measured based on the BMI score of the children and categories as underweight (< 18.5 BMI), normal weight (> 18.5 and < 25.0 BMI), overweight (> 25.0 and < 30.0 BMI) and obese (> 30.0 BMI).

Self-rated general health: Children were asked to rate their general health in ordinal scale as follows: excellent, very good, good, fair and poor. Then these five categories were regrouped into three categories for this study which are as follows: excellent, very good and good/fair/poor.

Health-related quality of life (HRQoL): Pediatric health related quality of life is a reliable and responsive measure of the health outcomes of children [28]. Among the different sub-scales, this study considered the following subscales: (i) physical health summary score, (ii) psychosocial health summary score, (iii) emotional functioning score, (iv) school functioning score, and (v) social functioning subscale [29]. To calculate the scale scores, the score was computed as the sum of the items over the number of items answered and then converted to a 100-scale score; a higher value indicates better health. Details of the procedure are described elsewhere [28, 29].

Statistical Analysis

Clusters of health-related behaviours were identified among 3127 valid cases using the latent class analysis, a subcategory of structural equation modeling. This unsupervised machine language algorithm is designed to efficiently handle large datasets, is capable of handling categorical variables, and has features to aid in determining the optimal number of clusters from a set of observed variables (Stata, 2016). For the primary objective of this study, latent class analysis (LCA) was conducted to identify unobserved (latent) classes based on the categorical indicators of lifestyles and health-related behaviours described in this paper. The analytical method LCA designates each participant a 'best' class assignment based on their maximum likelihood of belonging to each of the identified distinct classes. Participants within the same class are regarded as homogeneous based on the indicator variables [3, 30]. Analyses were conducted using the LCA procedure in Stata version 16 software. Based on previous studies, models with one to eight classes were tested to select the optimal number of classes. No covariates were included in this procedure. To determine the optimal number of classes, consistent Bayesian information criteria (BIC) and Akaike information criteria (AIC) values for each model were compared, and the model with the lowest values was the best fit. Based on the stated procedures, latent class analyses found better model fits for identifying distinct clusters among male and female children separately, rather than all children. The study identified five clusters for male children and four clusters for female children, as shown in Table 1. The distributions of the item response probabilities were evaluated, and the identified classes were named based on which characteristics were more likely to be exhibited by members of the class. Participants were assigned to the class in which they had the highest probability of membership; that is, they exhibited the traits that are representative of that class.

Further, descriptive analyses of the responses for each of the 17 latent class variables of the health-related behaviours were performed and presented by sex and cluster groups. The associations between the identified latent classes and BMI categories or quality of life were evaluated using multinomial logistic regression adjusted for child age. The adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were reported. All analyses were conducted stratified by sex. Data was analysed in STATA (version 16.0).

Results

Sample characteristics

Among 3127 children aged 14 to 15 49% respondents were female. Regarding the health risk behaviours, around 2.37% children smoked cigarette, whereas alcohol consumption was prevailed among 6.75% children. Male children spent more time on exercise (>3 hours/week: 41.53%), weekday (up to 3 hours: 57.38%) and weekend electronic games (>3 hours/week: 58.78%). In contrast, female children spent more time on social media: daily (34.19%) or weekly/monthly basis (52.99%). However, fatty food intake and consumption of sweet drinks is low among female children; weight control without eating and with performing exercise and to be concerned of gaining weight were seen to be more prevalent among the female children (see Table 2).

Cluster profiles

From the cluster analysis, a five-class model for males and a four-class model for females was found based on the lower AIC and BIC values with the comparison of other models. The prevalence of 18 indicators on seven thematic areas, based on response probabilities of the defined clusters, is illustrated in Table 3. The authors named each of the clusters depending on the indicators having high response probability which are as follows: i) temperate, ii) physically inactive, iii) mixed lifestyle, iv) multiple risk factor, and v) healthy lifestyle. The healthy lifestyle cluster was determined as the reference category while multinomial regression models were devised. Figure 1 presents that among different clusters, the highest proportion of children fall into the normal BMI category (over 70%) from the healthy lifestyle clusters of both male and female children. Children of mixed lifestyle and multiple risk factor clusters contain more children in overweight (17-34%) and obese (9-14%) categories, compared to other clusters. Figure 2 shows the sex-segregated distribution of self-rated general health status across the clusters, which reveals that impoverish health status (poor/fair/good) are less prevailing in children of healthy lifestyle clusters (26% or less), compared to children of other clusters (27% to 46%). Figure 3 depicts average score of the five dimensions of the pediatric quality of life among the clusters of boys and girls. Children of the healthy lifestyle clusters gained higher scores in all the five dimensions, compared to other clusters.

Table 4 presents the association between cluster membership and obesity or general health status. Table 5 presents the association between cluster membership and pediatric quality of life (PedsQL) outcome scores. Based on the descriptive statistics and the results of the association of cluster membership and different health status shown in Table 4 and 5, details of the male and female clusters are presented in the following.

The male children's clusters are:

- i. **The Healthy lifestyle cluster** (n=624, 38.9%) reports the lowest levels of behaviour posing health risks (no smoking and almost no alcohol consumption), higher physical activity (>3 hours/week: 57.4%), low sedentary behaviour (33.7% children do not play e-games and 66.4% play e-games less than 3 hours

in a week, respectively), high sleep duration (>9 hours: 60.6%), healthy diet practices (78.7% children ate fruits and vegetables more than three times a day), almost no eating disorders for male children (see Table 3).

- ii. **The Temperate cluster** (n=440, 27.4%) shows moderate levels of behaviour posing health risks (6.6% drank alcohol and 1.6% smoked cigarette), physical activity (<2 hours exercise/week: 41.4% children), sleep (<8 hours sleep: 19.8% children), diet (only 30.4% children having vegetables/fruits 3+ times per day), eating disorder (a moderate 12.7% children lose control of eating one or more days per week) and weight-gain consciousness (a moderate 32.1% children are concerned about weight gain), although children of this cluster exhibits higher levels of sedentary behaviour at the weekend (96.1% children spend more than three hours on e-games during the weekend days). Compared to the healthy lifestyle cluster, male children belonging to this clusters are 2.31 times (OR=2.31) more likely to be obese. Further, male children of this cluster are 0.41 times and 0.22 times less likely to be in very good and excellent general health, compared to the healthy lifestyle cluster (see Table 4). In the case of pediatric quality of life, male children of this cluster are more likely to incur lower scores (b = - 6.93 for the physical health summary score and b = -5.80 for the psychosocial health summary score), compared to the healthy lifestyle cluster (see Table 5).
- iii. **The physically inactive cluster** (n=73, 4.6%) has been identified only among the male children with the lowest level of physical activity (89% children having <2 hours exercise/week) and having inadequate quality of sleep (65.8% children having not well sleep). Children of this cluster also show less healthy diet practices (almost none take any fruit or vegetables per day), and less weight-gain consciousness (almost none gone for less eating or exercising to control the weight). In comparison with the healthy lifestyle cluster, children of this cluster are more likely (OR=4.12) to be obese. Moreover, children of this cluster are 0.49 times and 0.67 times less likely to be in excellent and very good general health, respectively (see Table 4). In the case of pediatric quality of life, male children belonging to this cluster are more likely to have lower scores (b = -9.17 physical health summary score and b = -10.10 for psychosocial health summary score) compared to the healthy male cluster (see Table 5).
- iv. The **mixed lifestyle** (n=347, 21.6%) cluster's children has a miscellaneous routine regarding physical activity, health risk behaviour, sedentary behaviour, high quality sleep, healthy diet and weight-gain consciousness. For example, though majority of the children of this cluster perform 2 hours (43.8%) or more (38.3%) physical exercise per week, 10.1% children consume alcohol and 2.9% children smoke cigarette which is second highest among all the clusters. Furthermore, though around half of the children sleep 8-9 hours and take fruits or vegetables 3-4 times per day, over 80% children consume high fat food at least once per day (up to 4 times/day). On the contrary, over 80% children are concerned about weight gain and over half of the children perform exercise to control weight one to three days per week. However, around 60% children lose control of eating at least once a week and few children (7.2%) have Partial Syndromal Anorexia and/or Bulimia. Male children of this cluster are far more likely to be either overweight (OR=3.79) or obese (OR=5.38) as well as less likely to attain very good or excellent general health (OR = 0.37 for excellent health, OR = 0.67 for very good health) in comparison to the children of healthy lifestyle cluster (see Table 4 and 5).
- v. The **multiple risk factor** (n=122, 7.6%) cluster has the highest percentage of smokers (6.6%) and alcohol drinkers (15.6%) among the children in the cluster, compared to other clusters of male children. Male children of this cluster have high levels of sedentary behaviour: over 80% play e-games 3 hours or more in the weekdays and over 90% play e-games 3 hours or more in the weekends (see Table 3); engaging more with social media and shows indifference on the consciousness of weight gain. Male children of this cluster are less likely to attain very good (OR = 0.42) or excellent general health (OR = 0.48) in comparison to the children of healthy lifestyle cluster (see Table 4).

The female children's clusters are:

- i. **The healthy lifestyle** cluster (n=659, 43.3 %) reports lowest levels of behaviours exhibiting health risks (no smoking and almost no alcohol consumption), higher physical activity (around 80% children exercising 2 hours or more per week), low levels of sedentary behaviour (almost no children play e-games in the weekdays and 89.8% does not play e-games in the weekends), long sleep duration (90% children sleep 8 hours or more per night) with well quality sleep, healthy diet practices (over 97% children ate fruits and vegetables regularly) and almost no eating disorders (see Table 3).
- ii. **The temperate cluster** (n=558, 36.7 %) for female children consists of moderately active behaviour, physical activity (around 67% children perform 2 hours or more exercise per week), moderate hours of sleep (39% children sleep 8-9 hours and 52% children sleep more than 9 hours), healthy diet (65% children ate fruit and vegetables 3 times or more per day), less eating disorders, medium level weight-gain consciousness and low levels of sedentary behaviour during the weekend. Female children were more likely to be obese (OR=1.79) in this cluster, compared to the children of healthy lifestyle cluster (see Table 4).
- iii. **The mixed lifestyle** (n= 63, 4.2 %) cluster's female children lead a diversified lifestyle; none of them had the habit of smoking or alcohol consumption but engaged with less physical activity (90.5% children with less than 2 hours physical activity/week). Majority children of this cluster never used social media, sleep duration was good but sleep quality not well, had lower intake of inappropriate diet and low eating disorders and weight-gain consciousness. Female children were more likely (OR=2.93) to be obese in this cluster compared to the healthy lifestyle cluster (see Table 4). In the case of pediatric quality of life, female children of the mixed lifestyle cluster were more likely to acquire lower scores in health-related quality of life (b = -6.67 for the physical health summary Score and b = -6.73 for psychosocial health summary score) compared to the healthy lifestyle cluster (see Table 5).
- iv. **The multiple risk factor** (n=241, 15.8 %) cluster of female children shows multiple risks in various indicators including physical activity or exercise (42.3% greater than 2 hours but less than 3 hours/week). Female children of this cluster had high sedentary behaviour engaging social media several times a day and had the highest level of insufficient sleep and eating disorders. Female children were more likely (OR=3.44) to be obese in this cluster, compared to the children of healthy lifestyle cluster; further, female children of this cluster were 0.30 times and 0.58 times less likely to have excellent or very good general health (see Table 4). In the case of pediatric quality of life, female children were more likely to experience lower scores in health-related quality of life (b = -4.47 for the physical health summary score and b = -8.26 for psychosocial health summary score) compared to female children of the healthy lifestyle cluster (see Table 5).

Discussion

This study revealed a distinct pattern of health behaviours in Australian children. The present research identified five clusters for male children: healthy lifestyle cluster (38.9%), temperate cluster (27.4%), physically inactive cluster (4.6%), mixed lifestyle cluster (21.6%) and multiple risk factor cluster (7.6%); and for female children, four clusters: healthy lifestyle cluster (43.3%), temperate cluster (36.7%), mixed lifestyle cluster (4.2%) and multiple risk factor cluster (15.8%). Children from the healthy lifestyle and temperate clusters (healthier clusters) reported the lowest and moderately active health risk behaviours, respectively.

The healthy lifestyle cluster reported no smoking, little alcohol consumption, high physical activity, low sedentary behaviour, recommended sleep hours, healthy diet, and no eating disorder. The temperate cluster reported moderate physical activity, sleep time, diet, eating disorder, and weight-gain consciousness. However, children from unhealthy clusters (physically inactive, mixed lifestyle, and multiple risk factors) reported the lowest level of physical activity, sedentary behaviour on weekdays, poor sleep quality, less healthy diet, low level of consciousness regarding weight management, higher smoking and alcohol consumption rate. Clustering the distinct patterns of health-related behaviours is of immense importance since they affect health and longevity [31].

This study identified discernible clusters concerning obesity, self-perceived general health status, and pediatric HRQoL. The results showed that male children from temperate, physically inactive, and mixed lifestyle clusters; and female children from mixed lifestyle and multiple risk factor clusters were more like to be obese than their peers from healthy lifestyle clusters. Previous studies have also identified that unhealthy health behaviours were associated with higher BMI [22, 23, 32–34]. However, the reported results did not align with some cross-sectional study findings that showed an unexplained inverse relationship [35, 36] or no association [37] with unhealthy clusters. The possible reasons behind the inconsistency may be the nature and quality of information, geographical, behavioural, or methodological changes.

The study also found that male children with temperate, physically inactive, and mixed lifestyle behaviour and female children with mixed lifestyle and multiple risk factor behaviour were less likely to report very good or excellent general health than their counterparts with a healthy lifestyle. However, meagre literature is there to validate this finding. A study conducted in Ireland found higher odds of reporting negative perceptions about health in the healthier behaviour cluster than the healthier cluster [2]. Furthermore, earlier studies disclosed that healthy lifestyles ensure having very good or excellent general health [38–40]. Children with adverse health practices could have healthier cardiovascular profiles and lower peak bone masses, consequently delineating poor general health [41].

The present study further revealed that male children who had a temperate and physically inactive lifestyle, and female children who had mixed and multiple risk factor lifestyles reported lower quality of life than their fellows who had a healthy lifestyle. Unhealthy clusters, including those who had minimal physical activity, sedentary habits, slumber complications, slighter diet, and awareness, exhibited a reduced quality of life (HRQoL). Similar to findings identified in previous studies, individuals with undesirable lifestyles had a higher likelihood of revealing impaired HRQoL [2, 42, 43]. The probable explanation may be having bodily pain, inadequate energy supply to the body, and experiencing a psychosocial or emotional breakdown [40, 43]. In addition, clusters of unhealthy habits are accountable for depression, anxiety, violent behaviours, insufficient social support, and unpleasant perceptions of society, leading to report poor HRQoL [42].

The study also demonstrated that moderate constancy of health behaviour had a significant impact on male children but no effect on female children. The temperate cluster denoted by moderate health practices also had increased body fat, poor health, and lower HRQoL in male children, outcomes supported by consistent findings [2]. Male children are vulnerable more compared to females. However, insufficient literature to explain the causal relationships of the sex differences suggests that further large-scale investigation is required to consider unhealthy-to-moderate stability of lifestyles patterns through sex-stratified analyses.

This study revealed that there are specific clusters of children who lead an unhealthy lifestyle. Using longitudinal data, the present study also found that patterns of the children's health-related behaviours were associated with health outcomes. The current findings showed that children who had unhealthy lifestyles were more likely to be obese, less likely to report good or excellent general health, and lower HRQoL than peers from healthy lifestyle clusters. These findings have substantial public health implications. Health policymakers should focus on intervention strategies to promote a healthy lifestyle in children since healthier related behaviour is strongly positively associated with positive health outcomes. For example, policymakers may take up a multifaceted intervention approach for those children adopting unhealthy health-related characteristics, assuming that this would be an effective health strategy compared to intervening in a single risk factor. Future studies may observe different treatment effects on obesity-related clustering. In addition, future studies may see the impact of biological and family factors on health-related behaviour patterns over an extended period through further longitudinal research. The main strength of the present study lies in its relatively large sample size from the birth cohort, focusing on a comprehensive range of behaviours that are a risk to health and adverse child health outcomes. This is one of the first studies that involves clustering of a wide variety of child health behaviours and checks their association with three different health outcomes. Another strength of the study is that it has utilized the 8th Wave of LSAC data to capture the health outcomes of adolescents with different healthy and unhealthy behaviours. Additional strengths include the use of validated and well-accepted measures. For example, weight and height data to calculate BMI were collected through trained professionals. Moreover, using LCA is an advanced statistical approach that ensures diverse benefits to estimate more precisely [3].

The present study has some limitations that need to be discussed. First, this study provides a snapshot of the children's health behaviours and their association with obesity, self-rated health, and HRQoL using unbalanced longitudinal data. Therefore, causality cannot be drawn between different clusters and child health outcomes. Secondly, data on some variables (e.g., general health) used in the study were self-reported. Therefore, biases in responses might be an issue. Thirdly, the record of the children's health behaviour patterns is based on children's memory. It might be possible to forget past incidents, leading to bias, or over and underreporting [3, 22].

Conclusion

The current study identifies sex-segregated distinct classes of Australian children based on obesity related health risk behaviours. All the non-healthy clusters were associated with increased obesity, and lower levels of self-rated general health; however, the magnitude of risk varied depending on the risk-characteristics of the clusters. The study results suggest that understanding the clustering of lifestyles and health related risk behaviours may be important to consider by the policy makers when planning obesity prevention interventions. Future studies are needed to assess how the discernible classes of obesity related health behaviours may affect project interventions. Identification of distinct clusters because of their relationship with morbidity and lower quality of life scores is important for identifying health behaviour patterns in national and international settings, which may help to inform decision making in obesity prevention and improving quality of life.

Declarations

Acknowledgements

This paper uses the data from Wave-8 of the Longitudinal Study of Australian Children (LSAC). The authors thank the Australian Institute of Family Studies for providing the LSAC data. The authors also thank Dr Barbara Harmes for proofreading the manuscript before submission.

Authors' contributions

KA is the principal investigator, designed the study, conducted the data analysis, and drafted the manuscript. SAK and GO critically reviewed the manuscript and assisted with the final editing and writing of the manuscript. RK and EK contributed to the study supervision and editing. All authors read and approved the final manuscript.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. No author received payment for writing of this paper.

Competing interests

The authors declare that they have no known competing financial interest or personal relationships that could have appeared to influence the work reported in this paper.

Ethics approval and consent to participate

This study used the secondary data from the LSAC survey dataset, which was approved by the Australian Institute of Family Studies Ethics Committee. During the survey, LSAC authority obtained a "written Informed Consent" was obtained from all study children and/or their legal guardian(s). The de-identified unit record dataset was released to the current researchers at the University of Southern Queensland for the purposes of this doctoral research. To obtain this data, the authors completed and signed the Confidentiality Deed Poll and sent it to NCLD (nclresearch@dss.gov.au) and ADA (ada@anu.edu.au). In the study, all methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

The manuscript used secondary data and did not contain any identifiable individual person's data in any form. Hence, consent for publication is not applicable.

Availability of data and material

The data analysed during this study were collected from the Longitudinal Study of Australian Children, managed by the National Centre for Longitudinal Data. The authors cannot share the data publicly as there are some restrictions on the use of this data and the data application's approval is subject to a signed confidentiality deed. However, the data that support findings of this study are available at the National Centre for Longitudinal Data (NCLD), Australia; anyone who interested in accessing this data should contact the NCLD authority through the following email: nclresearch@dss.gov.au, or lodge an online application from the following web link: <https://growingupinaustralia.gov.au/data-and-documentation/accessing-lsac-data>. Please contact the corresponding author (email: kabir_ahmad2000@yahoo.com) for further information if someone wants to request the data from this study.

References

1. Abdel-Qadir HM, Lee DS: **The contribution of familial and heritable risks in heart failure**. *Current Opinion in Cardiology* 2007, **22**(3):214–219.
2. Conry MC, Morgan K, Curry P, McGee H, Harrington J, Ward M, Shelley E: **The clustering of health behaviours in Ireland and their relationship with mental health, self-rated health and quality of life**. *BMC Public Health* 2011, **11**(692).
3. Anderson LN, Sandhu R, Keown-Stoneman CDG, De Rubeis V, Borkhoff CM, Carsley S, Maguire JL, Birken CS: **Latent class analysis of obesity-related characteristics and associations with body mass index among young children**. *Obes Sci Pract* 2020, **6**(4):390–400.
4. Obel C, Linnet KM, Henriksen TB, Rodriguez A, Jarvelin MR, Kotimaa A, Moilanen I, Ebeling H, Bilenberg N, Taanila A *et al*: **Smoking during pregnancy and hyperactivity-inattention in the offspring—comparing results from three Nordic cohorts**. *Int J Epidemiol* 2009, **38**(3):698–705.
5. O'Reilly JR, Reynolds RM: **The risk of maternal obesity to the long-term health of the offspring**. *Clin Endocrinol (Oxf)* 2013, **78**(1):9–16.

6. Ou L, Chen J, Hillman K, Eastwood J: **The comparison of health status and health services utilisation between Indigenous and non-Indigenous infants in Australia.** *Aust N Z J Public Health* 2010, **34**(1):50–56.
7. Park MH, Falconer C, Viner RM, Kinra S: **The impact of childhood obesity on morbidity and mortality in adulthood: a systematic review.** *Obes Rev* 2012, **13**(11):985–1000.
8. Schulenberg JE, Bryant AL, O'MALLEY PM: **Taking hold of some kind of life: How developmental tasks relate to trajectories of well-being during the transition to adulthood.** *Development and psychopathology* 2004, **16**(4):1119–1140.
9. Freedman DS, Wang J, Maynard LM, Thornton JC, Mei Z, Pierson RN, Dietz WH, Horlick M: **Relation of BMI to fat and fat-free mass among children and adolescents.** *Int J Obes (Lond)* 2005, **29**(1):1–8.
10. Sharma AM, Kushner RF: **A proposed clinical staging system for obesity.** *Int J Obes (Lond)* 2009, **33**(3):289–295.
11. Hadjiyannakis S, Buchholz A, Chanoine J-P, Jetha MM, Gaboury L, Hamilton J, Birken C, Morrison KM, Legault L, Bridger T: **The Edmonton Obesity Staging System for Pediatrics: a proposed clinical staging system for paediatric obesity.** *Paediatrics & child health* 2016, **21**(1):21–26.
12. Hadjiyannakis S, Ibrahim Q, Li J, Ball GDC, Buchholz A, Hamilton JK, Zenlea I, Ho J, Legault L, Laberge A-M *et al*: **Obesity class versus the Edmonton Obesity Staging System for Pediatrics to define health risk in childhood obesity: results from the CANPWR cross-sectional study.** *The Lancet Child & Adolescent Health* 2019, **3**(6):398–407.
13. Blüher S, Schwarz P: **Metabolically healthy obesity from childhood to adulthood - Does weight status alone matter?** *Metabolism* 2014, **63**(9):1084–1092.
14. Schuit AJ, van Loon AJ, Tijhuis M, Ocke M: **Clustering of lifestyle risk factors in a general adult population.** *Prev Med* 2002, **35**(3):219–224.
15. Berrigan D, Dodd K, Troiano RP, Krebs-Smith SM, Barbash RB: **Patterns of health behavior in U.S. adults.** *Preventive Medicine* 2003, **36**(5):615–623.
16. Poortinga W: **The prevalence and clustering of four major lifestyle risk factors in an English adult population.** *Prev Med* 2007, **44**(2):124–128.
17. Ahmad K, Kabir E, Ormsby GM, Khanam R: **Clustering of asthma and related comorbidities and their association with maternal health during pregnancy: evidence from an Australian birth cohort.** *BMC Public Health* 2021, **21**(1):1952.
18. van Nieuwenhuijzen M, Junger M, Velderman MK, Wiefferink KH, Paulussen TW, Hox J, Reijneveld SA: **Clustering of health-compromising behavior and delinquency in adolescents and adults in the Dutch population.** *Prev Med* 2009, **48**(6):572–578.
19. Heikkala E, J. R, Paananen M, Taimela S, Auvinen J, Karppinen J: **Accumulation of lifestyle and psychosocial problems and persistence of adverse lifestyle over two-year follow-up among Finnish adolescents.** *BMC Public Health* 2014.
20. Pate RR, Heath GW, Dowda M, Trost SG: **Associations between physical activity and other health behaviors in a representative sample of US adolescents.** *American journal of public health* 1996, **86**(11):1577–1581.
21. Saldanha-Gomes C, Marbac M, Sedki M, Cornet M, Plancoulaine S, Charles MA, Lioret S, Dargent-Molina P: **Clusters of diet, physical activity, television exposure and sleep habits and their association with adiposity in preschool children: the EDEN mother-child cohort.** *Int J Behav Nutr Phys Act* 2020, **17**(1):20.
22. Leech RM, McNaughton SA, Timperio A: **Clustering of diet, physical activity and sedentary behaviour among Australian children: cross-sectional and longitudinal associations with overweight and obesity.** *Int J Obes (Lond)* 2015, **39**(7):1079–1085.
23. Huh J, Riggs NR, Spruijt-Metz D, Chou CP, Huang Z, Pentz M: **Identifying patterns of eating and physical activity in children: a latent class analysis of obesity risk.** *Obesity (Silver Spring)* 2011, **19**(3):652–658.
24. Daw J, Margolis R, Wright L: **Emerging Adulthood, Emergent Health Lifestyles: Sociodemographic Determinants of Trajectories of Smoking, Binge Drinking, Obesity, and Sedentary Behavior.** *J Health Soc Behav* 2017, **58**(2):181–197.
25. Tabacchi G, Faigenbaum A, Jemni M, Thomas E, Capranica L, Palma A, Breda J, Bianco A: **Profiles of Physical Fitness Risk Behaviours in School Adolescents from the ASSO Project: A Latent Class Analysis.** *Int J Environ Res Public Health* 2018, **15**(9).
26. Jääskeläinen A, Nevanperä N, Remes J, Rahkonen F, Järvelin M: **Stress-related eating, obesity and associated behavioural traits in adolescents: a prospective population-based cohort study.** *BMC Public Health* 2014.
27. Soloff C, Lawrence D, Johnstone R: **Technical Paper no. 1: Sample design.** In: *Growing Up in Australia*. Australian Institute of Family Studies; 2005.
28. Varni JW, Burwinkle TM, Rapoff MA, Kamps JL, Olson N: **The PedsQL™ in Pediatric Asthma: Reliability and Validity of the Pediatric Quality of Life Inventory™ Generic Core Scales and Asthma Module.** *Journal of Behavioral Medicine* 2004, **27**(3).
29. Susan Clifford, Sarah Davies, Alanna Gillespie, Katherine Lange, Melissa Wake: **Longitudinal Study of Australian Children's Child Health CheckPoint Data User Guide – December 2018.** In: Melbourne: Murdoch Children's Research Institute; 2018.
30. Schreiber JB: **Latent Class Analysis: An example for reporting results.** *Res Social Adm Pharm* 2017, **13**(6):1196–1201.
31. Khaw K-T, Wareham N, Bingham S, Welch A, Luben R, Day N: **Combined impact of health behaviours and mortality in men and women: the EPIC-Norfolk prospective population study.** *PLoS medicine* 2008, **5**(1):e12.
32. Liu J, Kim J, Colabianchi N, Ortaglia A, Pate RR: **Co-varying Patterns of Physical Activity and Sedentary Behaviors and Their Long-Term Maintenance Among Adolescents.** *Journal of Physical Activity and Health* 2010, **7**(4):465–474.
33. Magee CA, Caputi P, Iverson DC: **Patterns of health behaviours predict obesity in Australian children.** *J Paediatr Child Health* 2013, **49**(4):291–296.
34. Gubbels JS, Kremers SP, Goldbohm RA, Stafleu A, Thijs C: **Energy balance-related behavioural patterns in 5-year-old children and the longitudinal association with weight status development in early childhood.** *Public Health Nutr* 2012, **15**(8):1402–1410.
35. Sanchez A, Norman GJ, Sallis JF, Calfas KJ, Cella J, Patrick K: **Patterns and correlates of physical activity and nutrition behaviors in adolescents.** *Am J Prev Med* 2007, **32**(2):124–130.

36. van der Sluis ME, Lien N, Twisk JW, Steenhuis IH, Bere E, Klepp KI, Wind M: **Longitudinal associations of energy balance-related behaviours and cross-sectional associations of clusters and body mass index in Norwegian adolescents.** Public Health Nutr 2010, **13**(10A):1716–1721.
37. Cameron AJ, Crawford DA, Salmon J, Campbell K, McNaughton SA, Mishra GD, Ball K: **Clustering of obesity-related risk behaviors in children and their mothers.** Ann Epidemiol 2011, **21**(2):95–102.
38. Harrington J, Perry IJ, Lutonski J, Fitzgerald AP, Shiely F, McGee H, Barry MM, Van Lente E, Morgan K, Shelley E: **Living longer and feeling better: healthy lifestyle, self-rated health, obesity and depression in Ireland.** Eur J Public Health 2010, **20**(1):91–95.
39. Akpinar A: **Urban green spaces for children: A cross-sectional study of associations with distance, physical activity, screen time, general health, and overweight.** Urban Forestry & Urban Greening 2017, **25**:66–73.
40. Sanders TAB: **Diet and General Health: Dietary Counselling.** Caries Research 2004, **38**(suppl 1)(Suppl. 1):3–8.
41. Boreham C, Riddoch C: **The physical activity, fitness and health of children.** J Sports Sci 2001, **19**(12):915–929.
42. Chen X, Sekine M, Hamanishi S, Wang H, Gaina A, Yamagami T, Kagamimori S: **Lifestyles and health-related quality of life in Japanese school children: a cross-sectional study.** Prev Med 2005, **40**(6):668–678.
43. Wu XY, Han LH, Zhang JH, Luo S, Hu JW, Sun K: **The influence of physical activity, sedentary behavior on health-related quality of life among the general population of children and adolescents: A systematic review.** PLoS One 2017, **12**(11):e0187668.

Tables

Table 1
Model fit statistics of the LCA models

Model	N	Loglikelihood	df	AIC	BIC
For male children					
One class	1606	-24527.86	38	49131.72	49336.22
Two class	1606	-24041.07	74	48230.14	48628.37
Three class	1606	-23755.00	98	47706.00	48233.39
Four class	1606	-23568.01	138	47412.02	48154.67
Five class*	1606	-23403.70	175	47157.40	48099.16
Six class	1606	-23336.56	210	47093.12	48223.24
Seven class	1606	-23225.17	249	46948.34	48288.33
Eight class	1606	-23151.64	278	46859.28	48355.33
For female children					
One class	1521	-23868.59	38	47813.18	48015.61
Two class	1521	-23472.68	75	47095.36	47494.89
Three class	1521	-22745.39	115	45720.78	46333.4
Four class*	1521	-22475.41	133	45216.82	45925.33
Five class	1521	-22311.89	190	45003.77	46015.93
Six class	1521	-22214.14	207	44842.28	45944.99
Seven class	1521	-22135.76	244	44759.52	46059.33
Eight class	1521	-22042.32	277	44638.64	46114.26
* Based on model fit characteristics, five class and four class LCA classifications were adopted for male and female children respectively.					

Table 2
Distribution of the attributes of the latent class variables by gender

Description	Values	Total (n = 3127)		Male (n = 1606)		Female (n = 1521)	
		n	%	n	%	n	%
Consumed alcohol in the last 4 weeks	No	2916	93.25	1500	93.4	1416	93.1
	Yes	211	6.75	106	6.6	105	6.9
Smoked in the last 4 weeks	No	3053	97.63	1581	98.44	1472	96.78
	Yes	74	2.37	25	1.56	49	3.22
Partial Syndromal Anorexia and/or Bulimia	No	97.09	97.09	1568	97.63	1468	96.52
	Yes	91	2.91	38	2.37	53	3.48
Exercise hour per week	< 2 hours/week	808	25.84	401	24.97	407	26.76
	2 hours/week	1128	36.07	538	33.5	590	38.79
	> 3 hours/week	1191	38.09	667	41.53	524	34.45
Weekday hours on e-games	Does not play with it on weekdays	1199	38.34	336	20.92	863	56.74
	Up to 3 hours	1529	48.9	928	57.78	601	39.51
	More than 3 hours	399	12.76	342	21.3	57	3.75
Weekend hours on e-games	Does not play with it on week-end days	883	28.24	127	7.91	756	49.7
	Up to 3 hours	1128	36.07	535	33.31	593	38.99
	More than 3 hours	1116	35.69	944	58.78	172	11.31
How often share/post on social media	Frequently or several times a day	1038	33.19	518	32.25	520	34.19
	Weekly or monthly basis	1597	51.07	791	49.25	806	52.99
	Never	492	15.73	297	18.49	195	12.82
Sleep quality	Very well	868	27.76	478	29.76	390	25.64
	Well	1824	58.33	943	58.72	881	57.92
	Not well	435	13.91	185	11.52	250	16.44
Sleep duration	< 8 hours	408	13.05	207	12.89	201	13.21
	8–9 hours	1223	39.11	627	39.04	596	39.18
	> 9 hours	1496	47.84	772	48.07	724	47.6
Frequency ate fruit and vegetables	None	336	10.75	201	12.52	135	8.88
	1–2 times/day	849	27.15	474	29.51	375	24.65
	3–4 times/day	1033	33.03	516	32.13	517	33.99
	5 + times/day	909	29.07	415	25.84	494	32.48
Frequency ate high fat food	None	608	19.44	287	17.87	321	21.1
	1–2 times/day	1599	51.14	774	48.19	825	54.24
	3–4 times/day	674	21.55	385	23.97	289	19
	5 + times/day	246	7.87	160	9.96	86	5.65
SC had full cream milk products	None	1082	34.6	491	30.57	591	38.86
	Once/day	1126	36.01	561	34.93	565	37.15
	Twice/day	618	19.76	344	21.42	274	18.01
	Three or more/day	301	9.63	210	13.08	91	5.98
SC had skim/low/no fat milk	None	1924	61.53	992	61.77	932	61.28
	Once/day	762	24.37	367	22.85	395	25.97
	Twice/day	301	9.63	157	9.78	144	9.47

		Total (n = 3127)		Male (n = 1606)		Female (n = 1521)	
	Three or more/day	140	4.48	90	5.6	50	3.29
Frequency drank high sugar drinks	None	1395	44.61	650	40.47	745	48.98
	Once/day	843	26.96	430	26.77	413	27.15
	Twice/day	498	15.93	284	17.68	214	14.07
	Three or more/day	391	12.5	242	15.07	149	9.8
How often did you lose control of eating	None	2167	69.3	1264	78.7	903	59.37
	Around Once a week	598	19.12	264	16.44	334	21.96
	Two or more days a week	362	11.58	78	4.86	284	18.67
How would you feel if you gained one to two KG weight	No concern	1542	49.31	1006	62.64	536	35.24
	A little concerned	806	25.78	391	24.35	415	27.28
	would worry/upset me	779	24.91	209	13.01	570	37.48
Frequency you have gone all day without eating to control weight	None	2826	90.37	1503	93.59	1323	86.98
	One day a week	231	7.39	89	5.54	142	9.34
	Two or more days a week	70	2.24	14	0.87	56	3.68
Frequency exercised in order to control weight	None	1678	53.66	949	59.09	729	47.93
	One to three days a week	922	29.49	399	24.84	523	34.39
	Four or more days a week	527	16.85	258	16.06	269	17.69

Table 3

Percentage distributions of the prevalence of the characteristics by the thematic group of lifestyle and health behaviours based on the response probabilities of identified male and female clusters

			Male Clusters (n = 1606)					Female Clusters (n = 1521)				
			Cluster #	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 1	Cluster 2	Cluster 3	Cluster 4
			Cluster Name	Temperate	Physically inactive	Mixed lifestyle	Multiple risk factor	Healthy lifestyle	Temperate	Healthy lifestyle	Multiple risk factor	Mixed lifestyle
			N (%)	440 (27.4)	73 (4.6)	347 (21.6)	122(7.6)	624(38.9)	558 (36.7)	659 (43.3)	241 (15.8)	63 (4.0)
Behaviour group	Variable description	Categories	%	%	%	%	%	%	%	%	%	%
Physical activity	Exercise hour per week	< 2 hours	41.4	89.0	17.9	16.4	11.5	27.4	20.6	25.3	90.5	
		2 hours	33.6	4.1	43.8	33.6	31.1	41.9	38.1	42.3	4.8	
		> 3 hours	25.0	6.9	38.3	50.0	57.4	30.7	41.3	32.4	4.8	
Sedentary behaviour	Weekday hours on e-games	Does not play with it on weekdays	0.2	20.6	25.7	17.2	33.7	5.9	99.4	55.6	65.1	
		Up to 3 hours	40.7	54.8	64.0	59.8	66.4	87.1	0.6	38.2	30.2	
		More than 3 hours	59.1	24.7	10.4	23.0	0.0	7.0	0.0	6.2	4.8	
	Weekend hours on e-games	Does not play with it on week-end days	0.0	11.0	8.9	9.0	12.3	3.1	89.8	48.1	49.2	
		Up to 3 hours	3.9	35.6	36.0	27.9	53.4	75.1	10.2	34.9	36.5	
		More than 3 hours	96.1	53.4	55.0	63.1	34.3	21.9	0.0	17.0	14.3	
	How often share/post on social media	Frequently or several times a day	33.0	2.7	36.9	45.1	30.1	29.4	34.3	53.9	0.0	
		Weekly or monthly basis	47.3	4.1	52.7	45.1	54.8	58.4	58.0	40.3	1.6	
		Never	19.8	93.2	10.4	9.8	15.1	12.2	7.7	5.8	98.4	
Health risk behaviour	Alcohol consumption in the last 4 weeks	No	93.4	100.0	89.9	84.4	96.3	97.1	96.2	73.4	100.0	
		Yes	6.6	0.0	10.1	15.6	3.7	2.9	3.8	26.6	0.0	
	Smoked in the last 4 weeks	No	98.4	100.0	97.1	93.4	100.0	98.9	99.9	82.6	100.0	
Yes		1.6	0.0	2.9	6.6	0.0	1.1	0.2	17.4	0.0		
Sleep	Sleep quality	Very well	28.4	9.6	20.5	30.3	38.1	31.9	27.8	10.8	4.8	
		Well	57.5	24.7	69.5	57.4	57.9	60.6	62.2	52.7	9.5	
		Not well	14.1	65.8	10.1	12.3	4.0	7.5	10.0	36.5	85.7	
	Sleep duration	< 8 hours	19.8	9.6	16.1	25.4	4.2	9.0	9.6	33.2	12.7	
		8–9 hours	42.1	43.8	43.5	32.0	35.3	39.1	40.5	37.3	33.3	
		> 9 hours	38.2	46.6	40.4	42.6	60.6	52.0	49.9	29.5	54.0	
Diet	Frequency ate fruit and vegetables	None	16.8	100.0	3.8	10.7	4.5	4.1	2.7	12.9	100.0	
		1–2 times/day	52.7	0.0	32.0	21.3	16.8	30.8	21.1	26.6	0.0	

			Male Clusters (n = 1606)				Female Clusters (n = 1521)				
		3–4 times/day	24.3	0.0	43.2	19.7	37.7	35.0	35.5	36.5	0.0
		5 + times/day	6.1	0.0	21.0	48.4	41.0	30.1	40.7	24.1	0.0
	Frequency ate high fat food	None	12.7	98.6	13.8	0.8	17.6	10.9	21.7	22.4	100.0
		1–2 times/day	50.7	1.4	54.5	1.6	57.5	61.7	55.4	48.1	0.0
		3–4 times/day	30.2	0.0	28.2	16.4	21.5	20.4	19.3	19.9	0.0
		5 + times/day	6.4	0.0	3.5	81.2	3.4	7.0	3.6	9.5	0.0
	SC had full cream milk products	None	33.2	100.0	33.1	5.7	24.0	33.0	36.4	43.2	100.0
		Once/day	41.8	0.0	37.8	23.0	34.9	36.7	41.7	35.3	0.0
		Twice/day	13.6	0.0	23.9	30.3	24.2	23.3	16.8	13.7	0.0
		Three or more/day	8.4	0.0	5.2	41.0	16.8	7.0	5.0	7.9	0.0
	SC had skim/low/no fat milk	None	65.2	100.0	55.6	45.9	67.4	58.8	57.8	66.4	100.0
		Once/day	23.9	0.0	31.7	9.8	22.4	26.3	28.2	25.7	0.0
		Twice/day	6.4	0.0	12.7	20.5	9.6	11.3	11.2	2.9	0.0
		Three or more/day	4.6	0.0	0.0	23.8	6.6	3.6	2.7	5.0	0.0
	Frequency drank high sugar drinks	None	37.7	97.3	36.0	5.7	46.2	38.5	55.1	43.6	98.4
		Once/day	26.4	1.4	35.2	0.0	29.5	34.1	25.6	22.4	0.0
		Twice/day	26.1	1.4	18.7	14.8	13.8	16.7	11.5	18.3	1.6
		Three or more/day	9.8	1.4	10.1	79.5	10.6	10.8	7.7	15.8	0.0
Eating Disorder	How often did you lose control of eating	None	87.3	97.3	40.1	80.3	91.7	66.7	66.8	11.6	100.0
		Around Once a week	10.2	2.7	44.7	13.1	7.4	23.1	20.6	28.6	0.0
		Two or more days a week	2.5	0.0	15.3	6.6	1.0	10.2	12.6	59.8	0.0
	Partial Syndromal Anorexia and/or Bulimia	No	99.6	100.0	92.8	95.9	100.0	100.0	98.2	83.0	100.0
		Yes	0.5	0.0	7.2	4.1	1.0	0.0	1.8	17.0	0.0
Weight-gain consciousness	How would you feel if you gained one to two KG weight	No concern	68.0	50.7	17.3	80.3	82.1	43.9	38.1	5.0	44.4
		A little concerned	22.1	27.4	49.9	9.0	14.4	34.2	27.6	10.4	27.0
		would worry/upset me	10.0	21.9	32.9	10.7	3.5	21.9	34.3	84.7	28.6
	Frequency you have gone all day without eating to control weight	None	94.8	98.6	85.6	90.2	97.3	94.3	95.3	44.4	98.4
		One day a week	5.0	1.4	11.8	6.6	2.7	5.7	3.8	35.3	0.0
		Two or more days a week	0.2	0.0	2.6	3.3	0.0	0.0	0.9	20.3	1.6
	Frequency of exercise to	None	75.9	97.3	8.1	51.6	72.6	53.4	48.6	19.9	100.0

			Male Clusters (n = 1606)					Female Clusters (n = 1521)			
	control weight	One to three days a week	18.9	2.7	55.0	36.9	12.5	35.3	33.2	44.4	0.0
		Four or more days a week	5.2	0.0	36.9	11.5	14.9	11.3	18.2	35.7	0.0

Table 4
Association between cluster membership and obesity or general health status

Association between cluster membership and obesity or general health status												
Obesity Status							General Health Status					
Cluster name	Overweight			Obese			Very Good			Excellent		
	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value	OR	95% CI	p-value
Models for boys' clusters												
Class 1 Temperate	1.34	0.93–1.93	0.120	2.31	1.29–4.11	0.005	0.41	0.30–0.56	0.000	0.22	0.15–0.32	0.000
Class 2 Physically inactive	1.66	0.83–3.33	0.150	4.12	1.71–9.90	0.002	0.67	0.36–1.23	0.193	0.49	0.24–0.99	0.047
Class 3 Mixed lifestyle	3.79	2.69–5.37	0.000	5.38	3.04–9.51	0.000	0.67	0.46 – .95	0.025	0.37	0.25–0.56	0.000
Class 4 Multiple risk factor	1.36	0.78–2.35	0.276	1.98	0.86–4.53	0.104	0.42	0.25–0.69	0.001	0.48	0.28–0.81	0.006
Class 5 Healthy lifestyle (ref.)												
Models for girls' clusters												
Class 1 Temperate	1.17	0.88–1.56	0.270	1.79	1.03–3.12	0.039	0.86	0.66–1.14	0.302	0.84	0.61–1.17	0.313
Class 2 Healthy lifestyle (ref.)												
Class 3 Multiple risk factor	1.41	0.98–2.02	0.062	3.44	1.91–6.18	0.000	0.58	0.42–0.82	0.002	0.30	0.18–0.48	0.000
Class 4 Mixed lifestyle	1.45	0.78–2.72	0.240	2.93	1.09–7.86	0.032	1.20	0.64–2.26	0.570	1.08	0.51–2.28	0.846

Table 5
Association between cluster membership and pediatric quality of life (PedsQL) outcome scores

Clusters	PHS Score		PSYHS Score		EMOF Score		SCHF Score		SOCF Score	
	b	95% CI	b	95% CI	b	95% CI	b	95% CI	b	95% CI
Models for Boys clusters										
Class 1 Temperate	-6.93	-9.46 to -4.39	-5.80	-7.65 to -3.95	-5.39	-7.41 to -3.37	-4.30	-6.53 to -2.07	-6.30	-8.19 to -4.41
Class 2 Physically inactive	-9.17	-14.33 to -4.01	-10.10	-13.87 to -6.33	-8.78	-12.91 to -4.65	-6.52	-11.07 to -1.97	-9.66	-13.51 to -5.81
Class 3 Mixed lifestyle	-2.51	-5.20 to 0.19	-2.99	-4.96 to -1.02	-2.99	-5.15 to -0.84	-1.74	-4.12 to 0.64	-2.77	-4.78 to -0.76
Class 4 Multiple risk factor	-7.76	-11.77 to -3.75	-5.47	-8.4 to -2.54	-4.65	-7.86 to -1.44	-7.49	-11.04 to -3.94	-6.49	-9.48 to -3.50
Class 5 Healthy lifestyle (ref.)										
Models for Girls clusters										
Class 1 Temperate	-1.50	-3.81 to 0.82	-0.82	-2.63 to 0.99	-0.38	-2.40 to 1.64	-1.19	-3.30 to 0.93	-1.13	-2.90 to 0.64
Class 2 Healthy lifestyle (ref.)										
Class 3 Multiple risk factor	-4.47	-7.50 to -1.43	-8.26	-10.63 to -5.89	-9.42	-12.07 to -6.76	-7.44	-10.21 to -4.66	-6.59	-8.91 to -4.27
Class 4 Mixed lifestyle	-6.67	-12.01 to -1.33	-6.73	-10.91 to -2.55	-9.56	-14.23 to -4.89	-9.74	-14.63 to -4.85	-6.72	-10.80 to -2.64

Abbreviations: PHS Score, Physical Health Summary score; PSYHS Score, Psychosocial health summary score; EMOF Score, Emotional functioning score; SCHF Score, School functioning score; SOCF Score, Social functioning score.

Figures

Figure 1

Percentage of BMI categories by clusters among boys and girls

Figure 2

Percentage of general health categories by clusters among boys and girls

Figure 3

Pediatric quality of life average scores by clusters among boys and girls