

Evaluation of lifestyle interventions

OFFERED TO CHILDREN AND YOUTH WITH OVERWEIGHT OR OBESITY

Danish National Center for Obesity
More to life

CENTRE FOR CHILDHOOD HEALTH

UNIVERSITY OF COPENHAGEN

Evaluation of lifestyle interventions offered to children and youth with overweight or obesity

Authored by: The Danish National Center for Obesity
Department of Nutrition, Exercise and Sports, University of Copenhagen
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Contents

Foreword

Introduction

Report I: Evaluation of lifestyle interventions offered to children and youth with overweight or obesity

Report II: Lifestyle interventions for children and adolescents with overweight or obesity in the Danish municipalities: An overview

Conclusion

Perspectives

Foreword

All children and young people should have the opportunity to grow up healthy and thrive. For children and young people living with overweight or obesity, everyday life can present additional challenges. Children living with overweight, but especially obesity, often experience lower self-esteem, more bullying and a reduced overall quality of life as compared to other children. In addition, obesity continuing into adulthood may also affect their physical health. To focus solely on body weight is, however, too simplistic as many children and their families need support that addresses the child and family's life as a whole.

In Denmark, most municipalities offer programmes for children and young people with overweight or obesity. The programmes are family-centered and delivered by trained healthcare professionals, in order to support wellbeing, weight loss and weight maintenance. Yet we know surprisingly little about what these programmes include, how they work for the children and their families, and whether they reflect the best available evidence. It is therefore important to ask not only whether lifestyle interventions are effective in research settings, but also how they work in everyday practice, and for whom.

To address these questions, the Centre for Childhood Health commissioned the Danish National Center for Obesity and the Department of Nutrition, Exercise and Sports at the University of Copenhagen to bring together two complementary bodies of knowledge. The first part of the report provides an updated overview of international research on lifestyle interventions for children and young people with overweight or obesity, building on previous Danish reviews of the evidence. The second part maps the programmes currently offered by Danish municipalities. Together, these two perspectives provide a comprehensive picture of the scientific evidence as well as the everyday practice available in Danish municipal settings.

The report underlines that some approaches are more effective than others. Interventions that combine dietary changes, physical activity and behavioural strategies, involving the whole family, achieve the best results. However, the effects are generally modest, and evidence of long-term outcomes unfortunately remains limited. At the same time, Danish municipal programmes largely reflect the available evidence: they are family-centered and often delivered over extended periods. However, most programmes primarily provide basic guidance, their content varies considerably across municipalities, and the number of municipalities offering lifestyle interventions has declined over time. Furthermore, very few programmes have been evaluated.

These findings raise important questions. How can we ensure that existing programmes apply the best available evidence? How can we strengthen learning and knowledge-sharing across municipalities to ensure a flexible approach to children and their families? And how can we design programmes that support children with overweight or obesity without unintentionally reinforcing weight stigma or self-stigma?

Municipalities should not be expected to answer these questions alone. Overweight and obesity are complex conditions, founded on genetic factors and shaped by the environments in which children and families live, including access to healthy food and opportunities for physical activity, as well as social and economic circumstances. They therefore cannot be reduced to matters of individual lifestyle choices. Programmes for children with overweight or obesity are an important part of the solution, but they must be understood within the broader effort to create healthier environments for all children and their families. This requires collaboration among municipalities, regions, researchers, healthcare professionals, civil society and national policymakers.

This report provides an important new evidence base for that conversation. The need for action is particularly pressing: municipalities are now required to establish new programmes for the youngest children with severe obesity, while interest in new treatment approaches, including pharmacological options, continues to grow. At the Centre for Childhood Health, our ambition is for this report to do more than describe the current situation. We hope it will also help identify where further research, development and testing are needed, ultimately contributing to better and more coordinated support for children and young people with overweight or obesity and their families.

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Annegrete Juul
Director
Centre for Childhood Health

Introduction

In Denmark, the prevalence of overweight and obesity increases from 13% to 18% during early school years and reaches ~51 % in the adult population. The negative acute and long-term consequences for children's physical and especially mental health are well-known and efficient countermeasures need to be established to prevent excess weight gain and improve mental, social and physical health in children.

Several systematic overviews exist for well-controlled trials and initiatives in this area. In 2021, the *Council for Health Promotion and Disease Prevention* (*Vidensråd for Forebyggelse)* conducted a comprehensive literature search with the aim to investigate if it was possible to prevent children with normal weight (isoBMI 18.5-25 or BMI-SDS 0-1) from developing overweight (isoBMI >25 or BMI-SDS >1). No clear answer to the question was found, but several beneficial preventive measures were identified, including long-term, multi-component interventions involving child and family (Bruun *et al*., 2021). A recent systematic review has confirmed the results and conclusions from the latter report (Olsen *et al*., 2024). Several trials and intervention studies with the overall aim to reduce childhood overweight and obesity have been conducted, and a number of comprehensive systematic reviews investigates the effect of different childhood obesity interventions (Michalopoulou *et al.*, 2024). Overall, current evidence shows beneficial but small effects on children's' BMI and zBMI. Many interventions do not find any effects, and the evidence of long-term effects is limited. Simultaneously, a high number of local and less well-evaluated initiatives also exist, and it is assumed that mapping these initiatives can provide important inputs to future systematic strategies.

In a Danish setting, this calls for the combination of existing state-of-the-art knowledge about the effects of different lifestyle interventions including existing knowledge about local, ongoing, real-life interventions for children and adolescents with overweight and obesity. An obvious arena for this is the Danish municipalities that offer different kinds of health interventions, including lifestyle interventions for children and adolescents living with overweight and obesity. The insight obtained will potentially offer a better indication of the real-life possibilities for lifestyle interventions that will have positive effects on overall well-being and in parallel reduce the risk of developing overweight-related diseases for children and adolescents living with overweight and obesity.

Aim and hypothesis

This report adds to the aforementioned report from the *Council for Health Promotion and Disease Prevention* (Bruun *et al*., 2021) and the recent systematic review (Olsen *et al*., 2024) by aiming to generate a

solid knowledge base from which future study designs of preventive measures can be tested in real-life settings.

Existing studies and locally driven initiatives are very rarely large scale, randomized controlled trials, and often they are unable to efficiently evaluate the proposed countermeasures. The hypothesis of this report has been that combining different types of existing knowledge can support the design of novel and impactful interventions that efficiently can counter overweight and help advance physical, mental and social health in children.

Structure of the report

The report is made up of two independent but interrelated studies, Report I and II. Conjointly, the two reports provide an overview of internationally established and emerging strategies developed to counter overweight or obesity in children and youth (Report I), and offer insight into the real-life, ongoing interventions and projects for this target group provided by the Danish municipalities (Report II). The reports are followed by a joint discussion, and finally different perspectives are presented.

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Report I

Evaluation of lifestyle interventions offered to children and youth with overweight or obesity

Report I

Evaluation of lifestyle interventions offered to children and youth with overweight or obesity

A semi-systematic, structured review.

Authored by

Alexandr Parlesak, PhD
E-mail: alpa@nexs.ku.dk
Phone: +45 3042 9267

Signe Lücke Pedersen, MSc
E-mail: sipe@nexs.ku.dk

Inge Tetens, PhD, professor
Email: ite@nexs.ku.dk
Phone: + 45 3533 2127

Christian Mølgaard, MD, professor
E-mail: cm@nexs.ku.dk
Phone: +45 3533 2516

Department of Nutrition, Exercise and Sports
University of Copenhagen
Rolighedsvej 26
1958 Frederiksberg C
Denmark
CVR: 29979812

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Contents

List of abbreviations 4
1. Introduction 6
1.1 Background for this report 6
1.2 Aim of Report I 7
2. Methods 8
2.1 Overall approach 8
2.2 Literature search strategy 8
2.2.1 Aim and pre-defined outcomes of the current literature search 8
2.2.2 Strategies and steps of literature search 9
2.3 Timeline and milestones 11
3. Findings: interventions by type 12
3.1 Nutrition 12
3.1.1 Relevance of diet modification in weight loss management 12
3.1.2 Publications on the efficacy of diet modification in weight loss 12
3.1.3 Evidence on the efficiency of dietary interventions in weight loss initiatives 13
3.1.4 Evaluating conclusion on dietary interventions in weight loss programmes 14
3.2 Physical activity 14
3.2.1 Relevance of physical activity promotion in weight loss 14
3.2.2 Publications on the efficiency of physical activity in weight loss 14
3.2.3 Evidence on the efficiency of physical activity in weight loss 15
3.2.4 Evaluating conclusion on physical activity in weight loss strategies 16
3.3 Behavioural strategies 16
3.3.1 Relevance of behavioural strategies for weight loss interventions 16
3.3.2 Publications on behavioural strategies in weight loss interventions 17
3.3.3 Evidence on the efficacy of behavioural strategies in weight loss programmes 17
3.3.4 Evaluating conclusion on behavioural strategies in weight loss strategies 18
3.4 Interventions addressing nutrition, physical activity and behaviour at the same time 18
3.4.1 Relevance of combined methods for weight loss interventions 18
3.4.2 Publications on multi-component interventions on weight loss 18
3.4.3 Evidence on the efficacy of multi-component measures in weight loss programmes 19
3.4.4 Evaluating conclusion on the efficacy of multi-component measures in weight loss initiatives 23
3.5 Interventions on sleep duration and quality 23
3.5.1 Relevance of sleep duration for weight loss 23
3.5.2 Publications on the role of sleep duration in weight loss 24
3.5.3 Evidence on the efficacy of sleep regulation on weight loss 24
3.5.4 Evaluating conclusion on the efficacy of sleep regulation in weight loss initiatives ... 24
3.6 Weight loss interventions involving media 25

3.6.1 Interventions on reducing passive media consumption (screen time) in weight loss programmes 25
3.6.2 Technology-based interventions used in weight loss programmes 26
3.6.3 Community-based technology interventions 29
3.7 Board game inclusion in weight-loss programmes 30
3.7.1 Relevance of board gaming in weight loss interventions 30
2.7.2 Available publications on board gaming in weight loss studies 30
3.7.3 Evidence on the potential of board games' involvement in weight loss initiatives 30
3.7.4 Evaluating conclusion on board games in weight loss interventions 31
3.8 Parental involvement in weight loss management 31
3.8.1 Relevance of the involvement of parents in weight loss approaches 31
3.8.2 Considered publications on the role of parental involvement in weight loss initiatives 31
3.8.3 Evidence on the efficacy of including parents in weight loss programmes 31
3.8.4 Evaluating conclusion on parental involvement in children's weight loss programmes 34
3.9 Involvement of peers in weight loss initiatives 34
3.9.1 Relevance of peers in weight management 34
3.9.2 Evidence from publications 34
3.9.3 Evidence on the efficacy of peer involvement in weight loss interventions 35
3.9.4 Evaluating conclusion on the efficacy of peer involvement in weight loss programmes 35
3.10 Pharmacological interventions in weight loss approaches in children and adolescents 36
3.10.1 Relevance of medication in weight loss strategies 36
3.10.2 Publications on drugs in weight loss interventions 36
3.10.3 Results from evidence 36
3.10.4 Evaluating conclusion on the use of medication in strategies for weight loss in children and adolescents 37
3.11 Probiotic and synbiotic supplementation 38
3.11.1 Relevance of pro- and synbiotics in weight loss strategies 38
3.11.2 Publications on pro- and synbiotic interventions in weight loss management 38
3.11.3 Evidence on pro- and synbiotics' efficacy in intervention studies on weight loss 38
3.11.4 Evaluating conclusion on pro- and synbiotics in children's and adolescents' weight loss interventions 39
3. 12 Surgical interventions 40
3.12.1 Relevance of surgery in weight loss interventions 40
3.12.2 Publications on the efficacy of surgical interventions in weight loss initiatives 40
3.12.3 Evidence on the efficacy of surgery in weight loss interventions 40
3.12.4 Evaluating conclusion on surgery efficacy in weight loss studies 41
3.13 Acupuncture and acupressure 41

3.13.1 Relevance of acupuncture/acupressure in weight loss interventions 41
3.13.2 Publications on acupuncture in weight loss studies 41
3.13.3 Evidence on the efficacy of acupuncture and accupressure in in children's and adolescents' weight loss programmes 42
3.13.4 Evaluating conclusion on acupuncture/acupressure in weight loss interventions .. 42
4 Executive summary on components of strategies applied in intervention studies on reducing overweight and obesity in children and adolescents 43
References 45
Appendix A. 52
Appendix B 53

List of abbreviations

95% CI	95% Confidence interval
AI	Artificial intelligence
AVGs	Active video games (=exergames)
BMI	Body-mass index, unit: kg/m2
CBT	Cognitive behavioural therapy
CFUs	Colony-forming units
d	Cohen's d, difference between the means between an experimental group and a control group, divided by the expected standard deviation
ED	Estimated difference
EFSA ES	European Food Safety Authority Effect size
HOMA-IR	Homeostatic Model Assessment for Insulin Resistance
I^2	Index indicating the percentage of the total variability in a set of effect sizes due to true heterogeneity, used in meta-analyses (measure of between-studies variability
k	Number of independent groups included in a study
MA	Meta-analysis
MAD	Mean adjusted difference
MD	Mean difference
n	Number of studies or study participants
p	Significance level
PC	Parent-child
PO	Parent-only
PIETCOTSS	Name of table summarising information on studies by Population, Intervention or Exposure, Comparators, Outcomes, Timing, Setting, and Study design
Q	Statistical indicator of positive false discovery rate obtained from the Storey procedure
QoL	Quality of life
QRCT	Quasi-randomised (clinical) controlled trial
r	Estimate of Pearson product-moment correlation coefficient
R^2	Coefficient of determination (=measure of strength of association)
RCT(s)	Randomized controlled (clinical) trial(s)

SDS	Standard deviation score
SMART	Properties of goal settings: Specific, Measurable, Achievable, Relevant, and Time-bound
SMD	Standardised mean difference
SR	Systematic review
WMD	Weighted mean difference
z	z-score
zBMI	z-score of the BMI

1. Introduction

1.1 Background for this report

Children with obesity face increased risks of non-communicable diseases, cardiovascular issues, and metabolic disorders (Kiess *et al.*, 2015). The psychosocial implications are equally concerning, including stigmatization, reduced cognitive performance, low self-esteem, and emotional disorders (Latzer and Stein, 2013; Eriksen *et al.*, 2024). Factors contributing to obesity include genetic predisposition, energy-dense diets, sedentary lifestyles, and environmental influences and approaches to childhood obesity include both prevention and treatment, with prevention considered to be the superior strategy (J. Merlo and L. Yardley, 2011). Comprehensive approaches involving communities, schools, and families are recommended to address this issue (Widhalm, 2018). However, more knowledge about evidence-based preventive measures is needed to halt the rise of childhood obesity.
In Denmark, the prevalence of overweight and obesity has been a long-lasting issue, and a recent report from the working group of the Danish Council on Health and Disease Prevention has concluded that "there is insufficient evidence on how to prevent healthy-weight children and adolescents in Denmark from developing overweight and obesity" (Olsen *et al.*, 2024). In Denmark, the prevalence of overweight among children aged 6-7 years in high-income families is 11% compared to 26% in low-income families (Bruun *et al.*, 2021). Among children aged 14-15 years, the prevalence of overweight reaches almost 30% in families with a low socioeconomic background. The negative acute and long-term consequences for children's physical and especially mental health are well-known and account for substantial societal costs (Rasmussen *et al.*, 2020). Hence, also in Denmark, as at the international level, effective measures must be initiated and maintained, where an important part of the strategy should be preventing excessive weight gain, primarily the undesired increase of fat mass in primary school children and adolescents (Leung, Wong and Hon, 2024). To accomplish this task, a numerous broad range of local and less well-evaluated initiatives have been established. The working approach of this report is that mapping of these initiatives can provide important inputs to decisions on how to install evidence-based systematic strategies in the future.
In 2021, the Danish Scientific Council of Prevention conducted a comprehensive literature search on whether it is possible to prevent children with normal weight (isoBMI 18.5-25 or BMI-SDS 0-1) from developing overweight (isoBMI >25 or BMI-SDS >1). No clear answer to the question was found, though several beneficial preventive measures were identified, including long-term multi-component interventions involving child and family (Bruun *et al.*, 2021). Several (randomized controlled) trials aiming at reducing childhood overweight and obesity have been conducted. Moreover, the number of published comprehensive systematic reviews including meta-analyses and meta-regression analyses has been constantly rising over the past 15 years, facilitating the overall potential to come up with evidence- based conclusions on the different measures to prevent and treat childhood obesity (Wang

et al., 2015, 2018; Brown *et al.*, 2016; Mei *et al.*, 2016; Oosterhoff, Joore and Ferreira, 2016; Bleich *et al.*, 2018; Ells *et al.*, 2018; Verjans-Janssen *et al.*, 2018; Liu *et al.*, 2019; Olsen *et al.*, 2024). This is of particular relevance as many published studies, even RCTs, have divergent outcomes and a systematic, comparative evaluation of existing evidence is necessary to achieve as basis for sustainable approaches to tackle the problem of overweight and obesity in children and adolescents. This sustainability implicates also that long-term follow-up of included interventions is considered in the validity of the suggested intervention measures.

1.2 Aim of Report I

The aim of this report is to provide an overview, and an evaluation of lifestyle and other interventions strategies offered to children and adolescents aged 5-18 years with overweight or obesity. As outcomes of the intervention studies, anthropometric indicators of overweight or obesity (indicated by absolute body weight or the body mass index, BMI) and/or adiposity (indicated by excess percentage of body fat) along with indicators of well-being were considered as primary outcomes. The selection of studies was not limited by region, as the goal of the report has been to provide a structured, evidence-based overview of internationally applied strategies to reduce or treat overweight and obesity in children and adolescents. This part of the report is meant to provide an overview of international strategies on this topic as a basis for comparing them with those applied in Denmark, i.e. at the municipality level, which will be presented in Report II.

The Research questions are explicated in Detail in APPENDIX A in the form of a PIETCOTSS table. This type of table, frequently used in summarising a list of studies on a certain topic, e.g. for High Level Protocols for the EFSA, indicates for each study the Population, the Intervention, the Comparator group, the Outcomes, the Timing, the Setting, and the Study design.

2. Methods

2.1 Overall approach

The overall approach to achieve the goal described above builds first of all on the identification of objective scientific evidence in the form of intervention studies, which were published in renowned scientific journals and are registered in trustworthy publication registries such as PubMed or Web of Science from the Institute of Scientific Indexing (ISI). The basis for this report focussed on intervention studies only, as they provide the highest level of scientific evidence to provide an evidence-based foundation for future decisions on strategies addressing obesity in children and adolescents in Denmark. The main approach was primarily to identify existing studies at large scale, considering their design, and hereby to efficiently establish evidence for future countermeasures. The literature search was conducted with the aim at providing a solid body of evidence that supposedly can serve as basis to achieve effective strategies to address the issue of childhood and adolescent obesity at the national and international level.

2.2 Literature search strategy

2.2.1 Aim and pre-defined outcomes of the current literature search

The aim of the literature search for this report has been to provide an overview of all relevant literature for a mapping and evaluating lifestyle interventions offered to children and youth with overweight or obesity aged 5-18 years with anthropometric indicators of overweight or obesity (indicated by absolute body weight or the body mass index, BMI) and/or adiposity (in the vast majority of cases indicated by excess percentage of body fat) along with indicators of well-being as primary outcomes.

As a primary approach, umbrella and narrative review articles on children's and adolescents' overweight and obesity with affiliated health problems were screened to obtain a framing network on relevant measures of weight loss interventions. These articles summarise the evidence on the efficacy of a certain intervention across several studies, not falling in the overall assessment for erroneous study settings of individual publications. Moreover, in many instances, systematic reviews comprise a fully quantitative evaluation, which includes measures of the overall tendency of the included studies such as the central tendency of change (BMI, body weight, percentage of body fat etc.), confidence intervals, significance levels for the overall change, and indicators of the homogeneity of the outcomes across the studies (I^2). A list of 13 relevant topics emerged from this approach comprising the following measures by which children's and adolescents' overweight and obesity has been approached in intervention studies: (i) nutrition, (ii) physical activity, (iii) behavioural strategies, (iv) multicomponent interventions addressing nutrition, physical activity, and behavioural change, (v) sleep duration and quality, (vi) reduction of passive media consumption, (vii) board games, (viii) parental involvement, (ix)

involvement of peers, (x) pharmacological interventions, (xi) application of probiotics and synbiotics, (xii) surgical interventions, ad (xiii) acupuncture and acupressure.

Consequently, in-depth literature searches using different methods were run, focussing on intervention studies that included each of the measures mentioned above in tackling overweight and obesity in children and adolescents. Literature searches were run separately on each of the listed topics, always in relation to address overweight/obesity issue. These searches were not limited by region, as the goal of the report has been to provide a structured, evidence-based overview of internationally applied strategies to fight overweight and obesity in children and adolescents.

As this report has been intended to include the cutting-edge state of the art for each identified (systematic) review, the end of the search period was documented and a new literature search was run for the period after the period considered by the corresponding review. Therefore, the provided evidence builds on (i) (systematic/umbrella) reviews and (ii) on randomized controlled trials (RCTs) that were published after the most recent review on the same topic.

2.2.2 Strategies and steps of literature search

The aim of the literature search on the topic explicated above is to provide all relevant literature sources to be able to map a comprehensive picture on the type, efforts, and efficacy, which are associated with the interventions mentioned above. Of note, efficacy is used to describe the effect of each type of intervention within a study setting, in contrast to efficiency, which would describe the effect occurring at population level outside of trials as part of a public health intervention. Naturally, only study outcomes are used in this report. To achieve the goal of this report, four elemental literature search strategies were applied:

1. Finding (systematic) reviews, preferentially including meta-analyses and umbrella reviews on the topic using (narrowed traditional) searches with pre-fixed search terms in common scientific databases such as Google Scholar, Web of Science, and PubMed. An example of search terms. A typical combination of search terms is given in Table 1.
2. Screening of reference lists of relevant publications, i.e. (systematic) and umbrella reviews including these references.
3. Extended searches for relevant papers using extended search options such as “Clinical Queries” in PubMed, which helps to identify publications on the topic of interest, but which fail to get identified by the search strategies mentioned above. This intrinsic tool has the advantage to consider closely affiliated terms and synonyms for the “traditional”, narrowed spectrum of search terms.
4. Usage of the AI-based literature search assistant “Elicit” (elicit.org), which uses machine learning methodology to identify articles of interest. In this case, research questions in variations were used as search terms (e.g., "Which interventions with the primary goal to reduce the prevalence of overweight and obesity in children and adolescents have been

applied?" and "Which interventions have been applied to reduce the prevalence of overweight and obesity in children and adolescents?").

Table 1 Example of a combination of search terms applied when screening publication databases such as PubMed, Web of Science, or Google Scholar

Category 1: overweight/obesity overweight OR obesity OR "weight loss" OR slimming OR "body weight" OR "body fat" OR adiposity OR BMI OR slimming OR body mass
Category 2: intervention intervention* OR program* OR initiative* OR strateg* OR treatment
Category 3: study participants children OR adolescent* OR child* OR childhood OR schoolchildren OR teen OR teenager* OR puberty OR pubertal
Category 4: intervention target physical activity OR sedentary OR MET OR PAL OR nutritional education OR school OR Treatment OR therapy OR treating OR diet OR dieting OR diets OR fasting OR exercise OR movement therapy OR exercise therapy OR motor activity OR activity-based OR physical education OR training, behavioral therap* OR behavioural therap* OR behaviour modification* OR behavior modification* OR family therapy OR physical activities OR sedentary behavior OR lifestyle OR energy balance OR diet(s) OR dietary, food OR nutrition OR (un)healthy food OR (un)healthy eating OR energy intake OR dietary OR nutrition OR nutritional OR eating OR food OR foods OR protein OR proteins OR lipid OR lipids OR fat OR fats OR macronutrient OR macronutrients OR micronutrient OR micronutrients OR vitamin OR vitamins OR milk OR dairy OR fruit OR fruits OR vegetable OR vegetables OR meat OR poultry OR fish OR grain OR grains OR legumes OR juice OR breakfast OR dinner OR water OR alcohol OR beverage OR beverages OR coffee OR tea OR chocolate OR sweet OR sweets OR exercise OR "physical activity"

Primarily identified publications were then shortlisted based on our criteria listed in APPENDIX 1 as a PIETCOTSS table for further investigation. In summary, publications fulfilled the inclusion criteria if they were (i) published in English; (ii) published within the years 2017-2024; as a continuation of a report published 2018 (Vendelbo Lind *et al.*, 2018); (iii) based on obesity reduction or management (iv) included apparently healthy children and adolescents of both sexes under 18 years inside and outside of Denmark; (v) were systematic reviews, umbrella reviews, or meta-analyses including interventional studies or were RCTs published after the period of publication considered in the most recent review; (vi) used interventions targeting weight reduction, such as nutritional, physical activity, health education, pharmacological, counselling, surgical, screen-based, behaviour strategies, sleep, e-health interventions, or other interventions or any combination of these; (vii) included intervention vs. no intervention as comparator group (e.g., no treatment, wait-list control, usual care); (vii) had as primary outcome a change in body mass index (BMI; absolute change, percentage of change, percentile of change, or z-score change) or change in weight (absolute change, percentage of change,

or percentile of change). Interventions of any duration lasting at least three months and in any settings were included.

Publications were excluded if they were (i) not in English; (ii) had no reliable outcomes; (iii) had participants with physical or mental illnesses, children with any pre-existing health conditions (e.g., diabetes and kidney disease), or eating disorders, (iv) study participants were pregnant or were breast feeding (in case of adolescents); (v) Included interventions aiming exclusively at preventing overweight or obesity; (vi) Included only observational studies; or (vii) did not include an appropriate control (comparator) group.

The content of all studies used as body of evidence coming from interventions studies (only) are summarised in chronological order in APPENDIX B.

2.3 Timeline and milestones

The project has been initiated by February 1st, 2024. The literature search strategy development along with the creation of the framework for the report has been achieved during February 2024. The literature search, lasted until ultimo of June 2024. First drafts were written in July 2024, and the revised version of the report was ready by primo November 2024.

3. Findings: interventions by type

3.1 Nutrition

3.1.1 Relevance of diet modification in weight loss management

Nutrition interventions in weight loss programs for children and adolescents focus on promoting what is considered to adhere to "healthy" eating habits, primarily focusing on nutrition composition and control of consumed portion size along with energy intake. However, changes in nutrition routines cannot be achieved without behavioural changes such as mindful eating, development of behavioural strategies, involving the family and school environment. With respect to this, an overlap has to be considered to exist with strategies declared to focus on behavioural change (see chapter on this topic below). Hence, multi-level approaches including at least some parts of the spectrum of the behavioural changes mentioned above seem mandatory, as sole nutrition advice or education are unlikely to provide major effects while being part of multi-level approaches, changes in nutrition show significant effects (Hassapidou *et al.*, 2023). Sustainable changes with a persistent adaptation of everyday decision, supported by psychological and social support in dietary changes seem to be prerequisites of long-term success in fighting childhood and adolescent obesity. Nutritional changes may be achieved through individual advice and education including individualized nutrition plans but also may happen through environmental and food policy changes, for example by adaptation of school meal plans, information campaigns and altered taxation. Sectors involved in the environmental change for weight-loss support entail also the retail and food supply sector (Crawford, 2020).

3.1.2 Publications on the efficacy of diet modification in weight loss

The impact of nutritional interventions in the treatment of overweight and obesity in children and adolescents for the period considered here has been covered by 10 relevant publications, including three meta-analyses (Karalexi *et al.*, 2018; Kalaitzopoulou *et al.*, 2023; Wang *et al.*, 2024), three systematic reviews (Psaltopoulou *et al.*, 2019; Lassale *et al.*, 2022; Park and Kim, 2023), two umbrella reviews (Andela *et al.*, 2019; Goldthorpe *et al.*, 2020), one more recent non-controlled trial (Jebeile *et al.*, 2019), and one meeting abstract (Espinosa *et al.*, 2023). The duration of the interventions considered varies considerably, spanning from 2 to 30 months, with follow-up periods ranging from 6 months to 10.5 years, underscoring the heterogeneity in intervention lengths and measurement of long-term outcomes. The studies further cover a wide range of nutritional interventions, such as the increase of fruit consumption, application of non-nutritive sweeteners, implementation of diets being low in their glycaemic index/load, changes in macronutrient distribution ranges, establishment of the Mediterranean diet, improvement of school-based nutrition programs, very-low-energy diets, and intermittent energy restriction. Notably, two meta-analyses (Karalexi *et al.*, 2018; Espinosa *et al.*, 2023) and one systematic review (Psaltopoulou *et al.*, 2019) include data from observational and interventional studies, the latter

further examining both treatment and prevention interventions. One non-controlled trial (Jebeile *et al.*, 2019) lacks a precisely described comparator group.

3.1.3 Evidence on the efficiency of dietary interventions in weight loss initiatives

Fruit intake interventions significantly increased fruit consumption by ~79 g/day but had an insignificant effect on the reduction of BMI [mean difference (MD) = -0.27 kg/m^2, 95% confidence interval (95% CI): -0.59 to 0.05 kg/m^2, p = 0.101] and BMI z-scores (MD = -0.15, 95% CI: -0.36 to 0.07, p = 0.177, 7 studies). Interventions on the increase of fruit intake effectively reduced waist circumference (MD: -0.65 cm, 95% CI: -1.15 to -0.05 cm, p < 0.05) and the prevalence of overweight/obesity compared to controls was significantly reduced (odds ratio, OR = 0.74, 95% CI: 0.60 to 0.90, p < 0.05, 7 studies) (Wang *et al.*, 2024). The usage of non-nutritive sweeteners (NNS) showed mixed results; observational studies linked NNS consumption to an increased BMI (OR 1.15 kg/m^2, 95% CI: 1.06-1.25 kg/m^2), while randomized controlled trials (Espinosa *et al.*, 2023) indicated that an NNS intake of 25–2400 mg/day from food and beverages resulted in a reduced BMI gain over the intervention period (standardized mean difference, SMD: -0·42 kg/m²; 95% CI: -0·79 to -0·06 kg/m^2; I² = 89%) compared to food and beverage intake where sugar was used, particularly in adolescents and participants with obesity (Karalexi *et al.*, 2018). Sugar-sweetened beverages were weakly associated with an increase in BMI (effect size, ES: 0.017 kg/m^2 change in BMI (95% CI: -0.009 to 0.044 kg/m^2) and replacing SSBs with noncaloric beverages showed a modest BMI reduction by 0.34 kg/m^2 (95% CI: -0.50 to -0.18 kg/m^2) (Psaltopoulou *et al.*, 2019). Dietary interventions with low glycaemic index/load diets did not show significant changes in obesity measures of the body weight (MD: -0.14 kg; 95% CI: -1.93 to 1.64 kg, 5 trials), the BMI (MD: -0.31 kg/m²; 95% CI -0.85 to 0.23 kg/m², 6 trials), the BMI z-score (MD: -0.03; 95% CI -0.09 to 0.02, 5 trials), and the waist circumference (MD: -0.52 cm; 95% CI: -2.35 to 1.31 cm, 5 trials) (Kalaitzopoulou *et al.*, 2023). In contrast, macronutrient modifications with hypocaloric diets (Park and Kim, 2023) demonstrated improvements in body composition and metabolic markers in Korean children, regardless of the type of altered macronutrient distribution, reported to be effective for weight loss. The Mediterranean diet (Lassale *et al.*, 2022) showed potential benefits in BMI reduction, but evidence was weakened by methodological inconsistencies. Improving diet alone through school-based interventions showed no effect on weight loss but had modest effects on reducing overall food consumption or energy intake (Cohen's d = 0.12) and BMI (Cohen's d = -0.075), with multicomponent interventions showing promising results in modifying obesogenic behaviours (Goldthorpe *et al.*, 2020). Very low-energy diets [≤ 3360 kJ/day (≤800 kcal/day) or <50% estimated energy requirements] were highly effective in short- to medium-term interventions aiming at weight loss with durations ranging from 3 to 20 weeks (pooled mean difference, -10.1 kg; 95% CI: -11.4 to -8.7 kg, p < 0.001; I^2 = 92.3%, 20 studies), with significant reductions in BMI sustaining at follow-up ranges from 5 up to 14.5 months from baseline (pooled mean

difference, -5.3 kg; 95% CI, -8.0 to -2.5 kg, $p < 0.001$; $I^2 = 50.6\%$), especially in adolescents (Andela *et al.*, 2019). Finally, intermittent energy restriction led to significant reductions in BMI percentiles and body fat percentage, with improvements in quality-of-life measures in participants who reduced vs. not reduced their weight (Jebeile *et al.*, 2019).

3.1.4 Evaluating conclusion on dietary interventions in weight loss programmes

Fruit intake interventions had little effect on BMI or BMI z-scores. Non-nutritive sweeteners (NNS) showed mixed outcomes, with observational studies linking NNS to increased BMI, while randomized trials showed that NNS reduced BMI gain compared to sugar. Sugar-sweetened beverages were weakly associated with BMI increase but replacing them with noncaloric beverages led to modest BMI reductions. Dietary interventions such as low glycaemic index diets had limited effects on obesity, while hypocaloric and intermittent energy restriction diets, especially in adolescents, were effective for weight loss and improved body composition. These findings highlight the need to implement only effective, potentially multi-faceted approaches to effectively manage and prevent obesity in children and adolescents.

3.2 Physical activity

3.2.1 Relevance of physical activity promotion in weight loss

Numerous health-related effects of physical activity (PA) suggest involving it in weight loss programs for overweight and obesity in children and adolescents. Besides the obvious effects, namely the increase of caloric expenditure to promote weight loss, PA, if regularly applied, improves metabolic health, primarily insulin sensitivity, hereby reducing the risk of developing type 2 diabetes. When PA is implemented early in life, it can contribute to reduce the risk of adverse health consequences during the life course such as cardiovascular risk, high blood pressure and other features of the metabolic syndrome. Additional physiological benefits of PA are an increased muscle strength, an elevated basal metabolic rate, and better bone health (Whooten, Kerem and Stanley, 2019). Physical activity has also been associated with improved mood, reducing symptoms of depression and anxiety, improved well-being, and a strengthened self-esteemed and self-esteemed body image. This, in turn, can partly be translated into social benefits by higher acceptance rates in society and social interaction and teamwork (Fitzgerald *et al.*, 2022). Typically, programs implementing PA are tailored to the age group in question, aiming at being enjoyable and engaging.

3.2.2 Publications on the efficiency of physical activity in weight loss

The scientific evidence on the efficiency of physical activity as an effective treatment component for overweight and obesity in children and adolescents builds on the results of six meta-analyses (Kelley,

Kelley and Pate, 2019; Cao *et al.*, 2021; Chen *et al.*, 2021; Lee, 2021; Méndez-Hernández *et al.*, 2022; Huang *et al.*, 2023), two are systematic reviews (Psaltopoulou *et al.*, 2019; Soares *et al.*, 2023), two are umbrella reviews (Goldthorpe *et al.*, 2020; Salam *et al.*, 2020), and two are recent randomized controlled trials (RCT) (Lee *et al.*, 2019; Meng *et al.*, 2022). Studies were heterogenous with respect to the intervention duration, ranging from 3 weeks (Cao *et al.*, 2021) to 36 weeks (Lee, 2021), and intervention frequency, ranging between twice and three times per week, and duration periods, ranging between ten and 90 minutes per session (Chen *et al.*, 2021). One systematic review focussed on the effect of long-term physical activity interventions in school settings, as identified in RCTs (Mei *et al.*, 2016).

3.2.3 Evidence on the efficiency of physical activity in weight loss

As with dietary interventions alone, existing evidence suggests implementing physical activity components into programs comprising also dietary improvements and behaviour therapy to be most successful in weight management (Goldthorpe *et al.*, 2020). However, some studies have found exercise alone might significantly reduce BMI z-score (MD: -0.13; 95% CI: -0.20 to -0.06; 12 studies; 1084 participants; I^2 = 0%; moderate quality evidence), BMI (MD: -0.88 kg/m^2; 95% CI: −1.27 to -0.50 kg/m^2; 34 studies; 3846 participants; I^2 = 72%) and body weight (MD: -3.01 kg; 95% CI: -5.56 to -0.47 kg; 16 studies; 1701 participants; I^2 = 78%; low quality evidence) when compared to the control group (Salam *et al.*, 2020). Especially, when employing strength training as the exercise of choice, a significant impact on percentage of body fat was observed ($p < 0.01$, $z = 6.92$, $Q = 42.63$) (Méndez-Hernández *et al.*, 2022).

Other studies have investigated different exercise modalities. While a combination of aerobic and resistance exercise has been suggested to improve obesity outcomes measured as BMI, and adiposity measured as body fat percentage compared to controls in some studies (Kelley, Kelley and Pate, 2019; Psaltopoulou *et al.*, 2019; Chen *et al.*, 2021), Lee and colleagues (Lee *et al.*, 2019) only observed significant reductions in BMI (Cohen's d = -0.56, 95% CI: -1.08 to -0.03 kg/m^2, p = .04, k = 8), percentage of body fat (d = -0.54%, 95% CI: -0.95 to -0.14%, p = .01, k = 12), free fat mass (d = -0.86 kg, 95% CI: -1.36 to -0.36 kg, $p < 0.01$, k = 4), waist circumference (WC: -0.38 cm, 95% CI: -0.63 to -0.13 cm, $p < 0.01$, k = 4) in children participating in aerobic exercise. In line with this, similar findings were recently reported in the RCT by Lee and colleagues (Lee *et al.*, 2019), who found that combined aerobic and resistance exercise compared to aerobic exercise alone is similarly beneficial in reducing ectopic fat and improving insulin sensitivity in adolescents with overweight. When combined with different exercise intensities, a meta-analysis from Huang and colleagues (2023) reported that high-intensity combined exercise yielded the most efficient reduction in BMI (MD = -1.65 kg/m^2, 95% CI: -3.27 to -0.02 kg/m^2) and in fat mass (MD: -2.87 kg, 95% CI: -4.84 to -0.91 kg), compared to blank controls. In the same analysis, moderate intensity combined exercise emerged as the optimal mode for weight loss (MD = -4.58 kg, 95% CI: -5.94 to -3.22 kg) and reduction of body fat percentage (MD = -

2.52%, 95% CI: -3.83 to -1.20%), compared to controls. This result confirmed findings from another systematic review on effective physical activity intervention published in the same year (Soares et al., 2023). In contrast to these two studies, however, when compared to moderate intensity exercise, high intensity exercise caused no significant differences in body weight, BMI, body fat percentage, abdominal fat, blood insulin, or HOMA-IR (Cao *et al.*, 2021). Similar findings were reported by Meng and colleagues (Meng *et al.*, 2022), who observed no significant differences between high and moderate intensity exercise in terms of BMI, body fat, HOMA-IR, or visceral adipose tissue in boys following a 12-week school-based training program, though all the considered studies reported significant losses in weight or BMI by the end of the intervention period. All these rather recent findings confirmed results from a more previously conducted systematic review on RCTs applying long-term school-based physical activity interventions (Mei *et al.*, 2016). The outcome of this review including 22,381 primary school children, with intervention durations ranging from 12 to 72 months, indicated that the BMI dropped on average by 2.23 kg/m^2 in the intervention groups compared to the controls ($p < 0.05$, $I^2 = 99.8$ %).

3.2.4 Evaluating conclusion on physical activity in weight loss strategies

Thus, although a combination of interventions of physical activity along with diet and behaviour therapy is recommended, certain types of physical activity interventions alone, especially when applying a combination of aerobic and resistance exercise, has been shown to be effective in reducing BMI and body fat percentage. Furthermore, combining high-intensity exercise with moderate intensity activity is effective in reducing BMI and fat mass, while moderate intensity exercise appears optimal for absolute weight loss and the reduction of body fat percentage.

3.3 Behavioural strategies

3.3.1 Relevance of behavioural strategies for weight loss interventions

Behavioural strategies comprise a wide field of different interventions that can be applied on its own or in combination with other interventions. Without claiming exhaustiveness, behavioural approaches to promote weight loss in overweight and obese children and adolescents include: (i) Specific, Measurable, Achievable, Relevant, and Time-bound (SMART) goal settings, (ii) self-monitoring strategies such as food diaries and activity logs, (iii) positive reinforcement implementation such as non-food rewards, praise and encouragement, (iv) parental and family involvement including parents' role models and family meals, (v) structured meal plans including regular meal times and portion control, (vi) structured increase of physical activity along with reduced screen time, (vii) cognitive behavioural therapy (CBT) and group therapy, (viii) promotion of nutritional education and cooking skills, (ix) elevation of problem-solving skills and coping mechanisms, and (x) routine development approaches through gradual changes (Ells *et al.*, 2018). Additionally, behavioural strategies can include the involvement of

school programs and community resources. Due to the multitude of components and the much higher number of potential combinations of the single elements, behavioural strategies cannot be considered as “one” isolated method.

3.3.2 Publications on behavioural strategies in weight loss interventions

One systematic review and meta-analysis including 30 RCTs/QRCTs with 4093 participants (Baygi *et al.*, 2023), one SR comprising 66 meta-analyses (Psaltopoulou *et al.*, 2019), and one umbrella review (Salam *et al.*, 2020) investigated the use of (cognitive) behaviour theory for weight management in children and adolescents younger than 19 years. A variety of interventions examining behaviour therapy were included. All studies considered applied multi-component psychological interventions based on either nutritional, physical activity and/or behavioural programs for weight reduction.

3.3.3 Evidence on the efficacy of behavioural strategies in weight loss programmes

A synthesis of interventional and observational evidence showed that behavioural modification strategies resulted in a small-scale reduction in BMI z-score (effect size (ES) = -0.07, 95% CI: -0.10 to -0.03, found in 2 MA), in BMI alone (ES = -0.09 kg/m^2, 95% CI -0.16 to -0.03 kg/m^2, 2 MA) and in the prevalence of overweight and obesity (relative risk = 0.94, 95% CI: 0.89 to 0.99, 2 MA). Combinations of behavioural modification (change of the diet, and/or physical activity) with additional components (e.g., parental involvement, or education) yielded more effective results than behavioural modification programmes alone. Mixed behavioural interventions, including a combination of a minimum of two components such as diet and physical activity, were especially effective in reducing indicators of obesity when parents were included (WMD: 0.30; SE: 0.11, p = 0.027). Additionally, sole educational interventions were found to induce BMI reduction (ES = -0.18 kg/m^2, 95% CI: -0.30 to -0.05) but did not affect body fat percentage (ES: 0.13%; 95% CI: -0.04 to + 0.3%) (Psaltopoulou *et al.*, 2019). Similar results were observed by Salam and colleagues (2020), where behavioural therapy alone seemed to reduce BMI z-score when compared to the control group (mean difference, MD: -0.07; 95% CI: -0.14 to -0.00; 19 studies; 8569 participants; I^2 = 76%; low quality evidence). When investigating the effectiveness of multi-component psychological interventions on anthropometric measures, Baygi et al. (2023) detected a statistically significant reduction in the BMI z-score (standardized mean difference, SMD: -0.39, 95% CI: -0.69, -0.09, I^2 = 88.6%), BMI (SMD: -0.79 kg/m^2, 95% CI: -1.48, -0.09 kg/m^2, I^2 = 97.8%), fat mass (SMD: -0.96 kg, 95% CI: -1.54, -0.38 kg, I^2 = 85.0%), and body fat percentage (SMD: -0.81%, 95% CI: -1.30, -0.33%, I^2 = 69.3%). Specifically, a subgroup analysis demonstrated a significant reduction in BMI z-scores (SMD -0.66, 95% CI: -1.15, -0.17) and in waist circumference (SMD -0.53 cm, 95% CI: -1.03, -0.04 cm) in interventions that centred on motivational interviewing and cognitive behavioural therapy, respectively. Mean BMI and waist circumference did not differ

significantly between post-treatment and last follow-up measurement, indicating a maintaining effect on these two parameters.

3.3.4 Evaluating conclusion on behavioural strategies in weight loss strategies

Thus, the provided evidence supports the effectiveness of behavioural therapy interventions in weight loss programmes for children, especially those consisting of multiple components and those involving parents. By effect size, strategies approaching weight loss from a behavioural perspective, seem to be superior to strategies focussing on single factors assumed to influence the BMI, such as nutrition or physical exercise. Including motivational interviewing and cognitive behavioural therapy may therefore be an effective part in strategies in paediatric weight management.

3.4 Interventions addressing nutrition, physical activity and behaviour at the same time

3.4.1 Relevance of combined methods for weight loss interventions

As also shown in the previous chapters, interventions combining diet, physical activity, and behavioural changes are considered to be superior in weight reduction programmes in overweight and obese children and adolescents over studies that implicate the intervention types mentioned above alone (Mayor, 2017). These multicomponent interventions can contribute to well-being by improving executive functions and school achievements (Martin *et al.*, 2018). Effective programs typically involve structured approaches addressing nutrition, physical activity, and behavioural skills, with longer durations showing better results (Bondyra-Wiśniewska, Myszkowska-Ryciak and Harton, 2021). Family involvement has been considered to be crucial for reinforcing positive behaviour (De Miguel-Etayo *et al.*, 2013). These interventions not only aid in weight loss but also improve cardiometabolic parameters such as lipid profiles and blood pressure (Vitaliati and Darmawan, 2024).

3.4.2 Publications on multi-component interventions on weight loss

A fairly large and recent body of evidence addressed the application of multicomponent lifestyle-based weight loss interventions for weight management in children and adolescents aged 2-18 years. The studies included in this report encompass six systematic reviews and meta-analyses (Elvsaas *et al.*, 2017; A. Hamid and Sazlina, 2019; Pamungkas and Chamroonsawasdi, 2019; Jacob *et al.*, 2021; Aceves-Martins *et al.*, 2022; Li *et al.*, 2022), six systematic reviews (O'Connor *et al.*, 2017; Moores *et al.*, 2018; Adom *et al.*, 2019; Psaltopoulou *et al.*, 2019; Albornoz-Guerrero *et al.*, 2021; Bondyra-Wiśniewska, Myszkowska-Ryciak and Harton, 2021), one umbrella review (Salam *et al.*, 2020), one scoping review (Mead *et al.*, 2017), and one overview of Cochrane reviews (Ells *et al.*, 2018). Some reviews focus on the implementation of combined intervention measures in school settings (Brown *et*

al., 2016; Mei *et al.*, 2016; Oosterhoff, Joore and Ferreira, 2016; Bleich *et al.*, 2018; Verjans-Janssen *et al.*, 2018).

The duration of interventions varied between 1 week and 3 years with one study only involving interventions shorter than six months and one study including only interventions longer than 12 months (Albornoz-Guerrero *et al.*, 2021). In studies reporting follow-up, periods ranged from a minimum of 12 weeks to 24 months. The included interventions spanned various approaches addressing childhood obesity, predominantly focussing on lifestyle changes such as diet, physical activity, and behavioural strategies. These multicomponent and multidisciplinary interventions incorporated elements like health education, parental involvement, digital tools, participatory learning approaches, and sedentary behaviour reduction.

3.4.3 Evidence on the efficacy of multi-component measures in weight loss programmes

Behavioural interventions, particularly those integrated with dietary and physical activity components, have demonstrated significant potential in managing childhood obesity. Salam et al. (Salam *et al.*, 2020) found that a blend of interventions including modifications of the diet and exercise combined with behavioural therapy led to a more pronounced decrease in waist circumference (MD: -1.54 cm; 95% CI: -2.56 to -0.52 cm; 11 studies; 3018 participants; $I^2 = 63\%$; low quality evidence), and BMI z-scores compared to individual components alone (mean difference, MD: -0.09; 95% CI: -0.14 to -0.05; 13 studies; 2995 participants; $I^2 = 12\%$; moderate quality evidence) compared to controls. The same conclusion was drawn for BMI z-scores where exercise was combined with behavioural therapy interventions (MD: -0.08; 95% CI: -0.16 to -0.00; 8 studies; 466 participants; $I^2 = 49\%$; moderate quality evidence) as well as dietary modifications applied along with behavioural therapy interventions (MD: -0.16; 95% CI: -0.26 to -0.07; 4 studies; 329 participants; $I^2 = 0\%$; moderate quality evidence). Diet in combination with exercise was comparably reported to reduce waist circumference (MD: -2.03 cm; 95% CI: -3.50 to -0.56 cm; 8 studies; 2234 participants; $I^2 = 87\%$; low quality evidence). These more recent findings and evaluations corroborate previous findings. Elvsaas et al. (Elvsaas *et al.*, 2017) demonstrated significant reductions in BMI and BMI z-scores after 6 months of multicomponent interventions (BMI: MD -0.99 kg/m^2, 95% CI: -1.36 to -0.61 kg/m^2; BMI z-score: MD -0.12 (95% CI -0.17 to -0.06), 12 months (BMI: MD -0.67 kg/m^2, 95% CI -1.01 to -0.32 kg/m^2; BMI z-score: MD -0.16 (95% CI: -0.21 to -0.11), and 24 months (BMI: MD −0.96 kg/m^2, 95% CI: −1.63 to −0.29 kg/m^2; BMI z-score: MD -0.16, 95% CI: -0.21 to -0.10) in favour of multicomponent lifestyle interventions compared to standard, minimal, or no treatment. Similarly, an updated Cochrane review concluded that behaviour-changing interventions involving diet, physical activity, and behavioural therapy in parallel to no treatment or usual care were effective in reducing the BMI (MD: -0.53 kg/m^2, 95% CI: -0.82 to -0.24 kg/m^2; $p < 0.00001$; 24 trials; 2785 participants; low-quality evidence), the BMI z-score (MD: -0.06, 95% CI: -0.10 to -0.02; $p = 0.001$; 37 trials; 4019 participants; low-quality evidence), and weight

(MD: -1.45 kg, 95% CI: -1.88 to -1.02 kg; $p < 0.00001$; 17 trials; 1774 participants; low quality evidence). Additionally, reductions were noted in waist circumference (MD -2.41 cm, 95% CI: -3.59 to -1.23 cm; $p < 0.0001$; 11 trials; 1325 participants). However, there were no significant changes in percentage of overweight in the involved groups or health-related quality of life. When comparing behaviour-changing interventions with an additional component versus without, there was a modest reduction in BMI (MD: -0.75 kg/m²; 95% CI: -1.42 to -0.09 kg/m²; $p = 0.03$; 4 trials; 195 participants), but no significant differences were found for the BMI z-score or body weight. Maintenance interventions following weight reduction aiming to help children sustaining the achieved weight loss showed no significant effect on BMI z-scores (MD: -0.07; 95% CI -0.19 to 0.04; $p = 0.22$; 2 trials; 263 participants). However, these studies comprised only a low number of participants, so no clear conclusions can be drawn on the efficiency of behaviour-changing interventions to maintain weight loss after the intervention period up to six months follow-up (Mead *et al.*, 2017). In similar interventions, Ells et al. (2018) noted that multicomponent lifestyle interventions incorporating behavioural elements along with diet and physical activity modifications yielded significant reductions in BMI z-scores in pre-school children aged up to 6 years, when lasting 6-12 months (MD: -0.3, 95% CI: -0.4 to -0.2), 12-18 months (MD: -0.4, 95% CI: -0.6 to -0.2), and at 2 years (MD: -0.3, 95% CI: -0.4 to -0.1), compared to control groups. Likewise, multicomponent interventions in children aged 12 years and older significantly reduced the BMI (-1.18 kg/m^2, 95% CI: -1.67 to -0.69 kg/m^2, 28 studies) and BMI z-scores (−0.13, 95% CI: -0.21 to -0.05, 20 trials), with sustained benefits observed at long-term follow-up of 18-24 months with MDs of -1.49 kg/m² (95% CI: -2.56 to -0.41 kg/m²) for the BMI and -0.34 units (95% CI: -0.66 to -0.02) for the BMI z-score. Additionally, improvements in health-related quality of life (QoL), measured with different tools such as the SF36 Health Questionnaire, were observed over a period of 6-24 months with a standardized mean difference (SMD) of 0.44 points (95% CI: 0.09 to 0.79). This aligns with recent findings from a Chinese RCT showing significant differences in the psychological ($B = 1.883$, $SE = 0.646$, $P = 0.004$), social, and pubertal dimensions ($B = 0.853$, $SE = 0.296$, $p = 0.004$), and in total QoL ($B = 3.024$, $SE = 1.214$, $P = 0.013$) after 1 year of obesity-related health education, physical exercise, and diet control with the effect found to be more substantial in boys than in girls (Diao *et al.*, 2020). Likewise, Moores et al. (Moores *et al.*, 2018) reported significant improvements in adolescent self-esteem/self-perception or QoL at follow-up in interventions including a psychological component in addition to a healthy lifestyle component. Improvements in QoL as measured using the Pediatric Quality of Life Inventory, the Child Health Questionnaire, or DISABKIDS were not observed in the scoping review of randomized clinical and non-randomized controlled trials by O'Connor and colleagues (O'Connor *et al.*, 2017).

When examining different intervention combinations, Psaltopoulou and colleagues (Psaltopoulou *et al.*, 2019) emphasized that exercise combined with dietary modifications produced better outcomes than exercise alone or no intervention group in children older than 5 years, though it was not superior to diet alone. However, when compared to dietary interventions alone, resistance training alone or combined

with diet reduced body fat percentage significantly by 2.73% (95% CI: -4.38 to -1.09%). Additionally, when behavioural interventions were delivered in a school setting, in which dietary habits were improved and physical activity was increased, they effectively reduced obesity-related indices in a dose-responsive manner (correlation coefficient r = 0.128, 95% CI: 0.126–0.171, P < 0.001), especially regarding absolute body weight (SMD: -0.29 kg, 95% CI: -0.45 to -0.14 kg, p = 0.0002), BMI, and BMI z-scores (-1.09, 95% CI: -1.84 to -0.34, p < .001). Accordingly, Psaltopoulou and colleagues (Psaltopoulou *et al.*, 2019) concluded that multicomponent interventions combining an improved physical activity, education, and nutrition resulted in a small reduction in BMI (MD: -0.10 kg/m^2, 95% CI -0.16 to -0.04 kg/m^2).

School-based programs combining elements related to the diet and physical activity had a minor effect, resulting in a weak correlation between intervention intensity and weight indicators in children and adolescents up to the age of 19 years (correlation coefficient, r = 0.047, 95% CI 0.023–0.070, p < .001). Furthermore, physical exercise combined with diet and behavioural therapy reduced the BMI z-score by 0.25 units (95% CI: -0.36 to -0.14) but the studies included showed a high heterogeneity coefficient (I^2 = 100%) (Psaltopoulou *et al.*, 2019). A systematic review on school-based multicomponent interventions highlighted that "school-based interventions with combined diet and physical activity components and a home element (n=41) had greatest effectiveness" (Bleich *et al.*, 2018). The same systematic review pointed out that preschool-based (n=6), community-based (n=7), and home-based (n=2) interventions provided only limited evidence due to a paucity of studies and heterogeneity in study designs. Another large systematic review covering intervention studies conducted from 2007 to 2016 in full-time elementary schools, which were delivered to the whole class, and included dietary and physical activity components (Brown *et al.*, 2016). Results in this study indicate that from the included 15 studies, 9 yielded a reduction or stabilisation in BMI or BMI *z*-score, either in the entire intervention group and/or in subgroups. Programmes lasting between 6 and 12 months that involved multiple environmental, educational, and physical strategies appeared to be most likely to result in BMI or BMI *z*-score improvement. Additional moderators potentially contributing to a reduction in BMI were increased physical activity, decreased sugar sweetened beverages intake, and increased fruit intake. Another systematic review including a meta-analysis assessed the impact of school-based multicomponent interventions, targeting schoolchildren aged 4 to 12 years (Oosterhoff, Joore and Ferreira, 2016). Pooled effects in multivariate analyses indicated a rather moderate decrease in BMI (MD: -0.054 kg/m^2; 95% CI: -0.131 to 0.022). Parental involvement accentuated the beneficial effects of interventions, when implemented.

Evidence from a broad range of studies suggests that interventions promoting lifestyle behaviours considered by the authors to be "healthy", such as adopting a "nutritious" diet (reduced consumption of fat and sugar and an increased intake of fruits and vegetables along with fibre), engagement in physical activity, and minimizing sedentary habits, effectively reduce the BMI and the BMI z-score. This effect has been shown to be further enhanced by the involvement of parents and a nutrition expert (Pamungkas

and Chamroonsawasdi, 2019; Bondyra-Wiśniewska, Myszkowska-Ryciak and Harton, 2021) and when performed in a home setting. However, the effects of home-based lifestyle interventions were mixed when following the persistence effect of the intervention with 73% of the included studies demonstrating a sustained positive impact on BMI z-scores while six studies found no significant difference in BMI z-scores between intervention and control groups after certain periods post-intervention (Pamungkas and Chamroonsawasdi, 2019).

In contrast, Hamid & Sazlina (A. Hamid and Sazlina, 2019) found no significant effect of interventions on the BMI z-score when lifestyle changes such as diet, physical activity, or both, and behavioural strategies such as coping and problem solving skills with family involvement on weight related outcomes were incorporated (SMD: -0.14; 95% CI: -0.87 to 0.60; p = 0.72), along with waist circumference (SMD: -0.25 cm; 95% CI: -0.51 to 0.01 cm; p = 0.06), or body fat percentage (SMD: 0.30%; 95% CI: -0.17 to 0.76%; p = 0.21), when compared with controls. However, the authors' narrative synthesis suggested that interventions integrating behavioural skills led to positive outcomes. In line with this claim, O'Connor et al. (O'Connor *et al.*, 2017) reported significant reductions in the BMI z-score compared to controls, with a SMD of -1.10 (95% CI: -1.30 to -0.89), when lifestyle-based weight loss interventions were conducted over a period of 6 to 12 months. Studies with a higher number of contact hours, particularly those exceeding 26 hours in total, demonstrated larger effects. Likewise, a similar RCT reported a significantly larger decrease in the z-score of the BMI of Mexican-American children receiving a school-based obesity intervention exerted on 3 or 5 days per week (-0.19 per year; 95% CI: -0.28 to -0.11 per year; and -0.18 per year; 95% CI, -0.27 to -0.10 per year, respectively, both $p < .001$), compared to controls with no differences found in such interventions conducted between 3 and 5 days per week (Arlinghaus *et al.*, 2022). Jacob et al. (Jacob *et al.*, 2021) supported the claim of effectiveness of health education interventions delivered in school settings on achieving significant reductions in BMI z-scores (-0.06, 95% CI: -0.10 to -0.03). However, results of multicomponent school-based interventions were more inconsistent when investigated in children of African origin (Adom *et al.*, 2019).

Li et al. (Li *et al.*, 2022) found that combined lifestyle interventions, which include physical activity and diet, lead to a significantly reduced BMI among Chinese children with a mean difference (MD) of -1.49 kg/m^2 (95 % CI: -2.20 to -0.77 kg/m^2; $p < 0.001$). Stronger effects were observed when health education was included in the intervention along with diet and physical activity (mean difference = -2.03 kg/m^2), compared to physical activity only and health education only. Particularly lifestyle interventions seemed to significantly reduce BMI in adolescents ≥12 years old (MD: -1.90 kg/m^2; 95% CI: -3.37 to -0.43 kg/m^2). In children aged 6-12 years, the effect was smaller but still significant (MD: -0.79 kg/m^2; 95% CI: -1.04, -0.55 kg/m^2). This effect was even more remarkable with intervention periods lasting more than 1 year compared to shorter ones (MD: -1.19 kg/m^2; 95% CI: -1.93 to -0.44 kg/m^2) (Li et al., 2022). Similarly, Aceves-Martins and colleagues (Aceves-Martins *et al.*, 2022) reported a significant short-term reduction in BMI in Mexican children when the intervention lasted 6

months or less (MD: -1.52 kg/m^2; 95% CI: -2.15 to -0.89 kg/m^2; I^2 = 66%). The effect was less pronounced but still significant at a follow-up after 12 months (-1.31 kg/m^2; 95%CI, -1.73 to -0.89 kg/m^2; I^2 = 50%). Sustained long-term effects were also found when evaluating multicomponent interventions including home environment changes, behavioural counselling, and community involvement after school team sports among low-income households from Latin American communities in the USA over one year with a mean adjusted difference (MAD) of -0.73 kg/m^2 (95% CI: -1.07, -0.39 kg/m^2, Cohen's d = -0.55) and after two years (MAD: -0.63 kg/m^2; 95% CI: -1.13 to -0.14 kg/m^2, d = -0.33), but lacked sustained statistically significant effects after three years compared to health education interventions alone (MAD: -0.25 kg/m^2, 95% CI: -0.90 to 0.40 kg/m^2, d= -0.10, p = 0.45). In a clinical trial not covered by the reviews mentioned above, comparable post-trial changes of indicators of secondary measures of adiposity, percent of median BMI for age and sex, waist circumference, waist-to-height ratio, triceps skinfold thickness, and estimated percent body fat were measured (Robinson *et al.*, 2021). An eight-year follow-up on a two-year school-based nutrition and physical activity intervention indicated moderately significant differences between groups over time, as the increase in BMI was moderately higher in the control group compared to the intervention group at eight years of follow up, with a difference of 0.68 kg/m^2 (95% CI: 0.02 to 1.34 kg/m^2; p = 0.045) (Recasens *et al.*, 2019).

3.4.4 Evaluating conclusion on the efficacy of multi-component measures in weight loss initiatives

The large and recent body of evidence thus suggests that multicomponent lifestyle-based weight loss interventions are effective to reduce the prevalence of overweight and obesity in children and adolescents. Studies indicate that combining diet and physical activity with behavioural therapy leads to more substantial weight loss outcomes compared to individual components alone. School-based interventions and those involving higher contact hours show particularly promising, add-on results. However, the quality of evidence is generally low in the evaluated studies, and effects vary based on intervention duration and included intervention components. In some studies, the intervention further led to improvements in quality of life and self-esteem, although results from some reviews and more recent studies are partly contradictory. Studies including follow-up of several years after the end of the trials indicate that the significant differences at the end of the interventions level out, though many of the studies indicate still a significant difference over a few years of follow-up.

3.5 Interventions on sleep duration and quality

3.5.1 Relevance of sleep duration for weight loss

Improved sleep quality is considered to support weight loss in overweight and obese children and adolescents through several mechanisms. Adequate sleep supports proper regulation of hormones that

control hunger and appetite. Specifically, better sleep quality moderates the release of ghrelin, a hormone that stimulates appetite, and increases the release of leptin, a hormone that signals fullness (Maddison *et al.*, 2014). Poor sleep quality is associated with insulin resistance, which can lead to weight gain and increased risk of type 2 diabetes (Spiegel *et al.*, 2005). Secondary benefits from sufficient sleep are a more likely engagement of children and adolescents in physical activities as fatigue from insufficient sleep can lead to decreased physical activity and increased consumption of high-calorie, high-sugar foods for quick energy. Additionally, poor sleep can lead to emotional eating to cope with tiredness and stress (Liu *et al.*, 2024).

3.5.2 Publications on the role of sleep duration in weight loss

The impact of sleep on weight management was investigated in one systematic review, including one meta-analysis (5 RCTs; 2,231 participants from seven countries) (Liu *et al.*, 2024). Interventions ranged from 4 weeks to 3 years in length and were mostly multi-component incorporating a sleep component alongside other factors such as diet, physical activity, sedentary behaviour, media consumption, stress management, parenting, and screen time. One study investigated sleep as a stand-alone intervention.

3.5.3 Evidence on the efficacy of sleep regulation on weight loss

One study being part of the meta-analysis mentioned above reported a significant effect of sleep as an intervention on weight when the usual calorie intake in the intervention and control group was reduced by 500 kcal in adolescents aged 14 to 18 years. The decrease in weight and waist circumference was greater in the intervention group compared to the control group (Moreno-Frias et al., 2019). However, when sleep was incorporated as part of a multicomponent intervention, it yielded no significant effect on the BMI or other weight-related outcomes (Cohen's d = 0.18, 95% CI = -0.04 to 0.40, Z = 1.56, p = 0.11, 5 studies) (Liu *et al.*, 2024).

3.5.4 Evaluating conclusion on the efficacy of sleep regulation in weight loss initiatives

As Liu and colleagues (Liu *et al.*, 2024) stated, more studies on sleep interventions aiming at weight loss are needed to come to a conclusive assessment of the potential of sleep duration and quality regulation in weight loss management. Given the current state of evidence, no conclusive statements on the efficacy on sleep regulation in weight loss interventions can be drawn. So far, no arguments exist to involve an altered sleep duration in weight loss programmes.

3.6 Weight loss interventions involving media

3.6.1 Interventions on reducing passive media consumption (screen time) in weight loss programmes

3.6.1.1 Relevance of passive media consumption for weight loss

A reduction in screen time is considered to result in weight loss for several reasons. First, prolonged screen time is associated with sedentary behaviour, which is linked to weight gain and obesity. Second, less screen time typically means more time for physical activities, helping to compensate for excess energy intake. Third, excessive screen time, especially before bed, is known from observation studies to disrupt sleep patterns and poor sleep quality is linked to weight gain due to hormonal imbalances and increased appetite. Last, screen time, especially during meals, can lead to mindless eating and increased caloric intake. Reducing screen time helps people focus on their food, potentially leading to better portion control and healthier eating habits (Maddison *et al.*, 2014).

3.6.1.2 Relevant publications on passive media consumption and weight loss

One meta-analysis of 14 RCTs including 1894 participants (Zhang *et al.*, 2022) investigated the impact of screen time interventions on BMI and BMI-z score among children and adolescents. The intervention period of included studies ranged from 1.5 to 24 months and included various kinds of monitor-equipped devices. Interventions were dichotomic by either aiming at weight reduction through apps promoting physical activity on the one hand and reducing passive, sedentary media consumption time associated with physical inactivity. Active gaming approaches, such as involvement of physically active gaming (e.g., Wii) were specifically employed to reduce weight through exercising. On the other hand, approaches aimed at reducing passive consumption of screen time involved strategies such as using electronic time control to limit access to screen devices, health education to increase awareness about the consequences of excessive screen time and providing practical strategies for reducing it.

3.6.1.3 Documented evidence on passive media consumption and weight loss

As documented by the meta-analysis mentioned above, the overall efficacy of interventions to reduce screen time yielded a significant decrease in total screen time per week for participants in the intervention groups, with a mean difference (MD) of -6.90 hours per week compared to the control group. Electronically time-controlled monitors proved particularly effective, resulting in a substantial reduction of 11.0 hours per week. Health education and home-based, parent-involved interventions also demonstrated significant effectiveness in reducing screen time.

However, regarding reduction of weight, the meta-analysis reported no significant effects on the mean difference of the BMI (MD: -0.14 kg/m^2, 95% CI: -0.29 to 0.00 kg/m^2, $p = 0.163$) and BMI-z score (MD: 0.01, 95% CI: -0.03 to 0.06, $p = 0.981$), compared to the control group. Nonetheless, a significant reduction in waistline circumference was observed (MD = -0.60 cm; 95% CI: -1.88 to +0.69 cm, $p < 0.001$), but the heterogeneity of study findings was high (I^2: 91.8%). Hence, while reducing screen time interventions were highly effective in reducing passive media consumption, they did not affect

significantly the weight status of children and adolescents. Despite this fact, a reducing effect of a reduced screen time was observed for waist circumference, though somehow inhomogeneously across studies. Zhang et al. (Zhang *et al.*, 2022) neither explicitly concluded that the reduction in waist circumference was solely attributed to increased physical activity or reduced passive screen time, nor did the authors exclude a causative effect of either factor in achieving a reduction in waist circumference.

3.6.1.4 Evaluating conclusion on screen time reduction and weight loss

Inhomogeneous results of meta-analyses suggest that initiatives on screen time reduction are effective reducing passive media consumption and that this is associated with a reduction in waist circumference, but only negligible changes in BMI. Such interventions may therefore not reduce overall weight in general, but can contribute to modest improvements in body composition, particularly in abdominal fat.

3.6.2 Technology-based interventions used in weight loss programmes

3.6.2.1 Relevance of technology-based interventions in weight loss

Technology-based interventions leverage digital tools to engage, motivate, and educate young individuals about behaviours aiming at weight loss in case of overweight or obesity, but also on achieving other health-promoting effects. Key elements of these interventions are mobile apps used either to track and monitor physical activity, eating behaviour, sleep quality or other health-related parameters and apps providing educational content on diet and other aspects of health (Kankanhalli, Saxena and Wadhwa, 2019). The application of such apps can be supported by wearable devices providing detailed data on physical activity, sleep duration and quality, or can be used, along with mobile apps, in serious gaming interventions (Villasana *et al.*, 2019). These serious gaming approaches entail active video games, also called exercise games or exergames, which can be active video games promoting physical movement or virtual reality-based fitness games. Modern technology also facilitates the implementation of intervention programs already existing online, including healthy lifestyle campaigns on social media and platforms where peer or layperson influence is offered such as Instagram, TikTok, and YouTube. Such strategies can engulf interactive content, which can partly or completely be personalized and targeted, municipality-based expert guidance can be used by modern communication technologies as well. A yet largely unexplored field with seemingly high potential is artificial intelligence-driven approaches or virtual coaches that can adapt and develop individual strategies optimizing health outcomes of the individual user (Maher *et al.*, 2020). Hence, accessibility, engagement promotion, data tracking, and social support are the unique features of technology-based interventions to achieve weight loss in overweight and obese children and adolescents, but these technologies are rather novel and need a sufficient body of scientific evidence before they can be implemented in routine municipality-based programs. Various systematic reviews and meta-analyses

have investigated the effectiveness of e-health or technology-based interventions for the treatment of children and adolescents with overweight or obesity.

3.6.2.2 E-health – interventions in weight loss initiatives

Evidence from publications

The mode of delivery of the e-health intervention varies and often involves one or more delivery channels (e.g., internet, computers, tablets, telehealth, mobile applications, phone calls, text messages, and emails). Control groups could include any comparator such as being treated according to standard or usual care, without any intervention, wait-list intervention, or another delivery mode (e.g., face-to-face). Studies included in the meta-analyses had a wide variation in duration and follow-up periods.

Results from evidence

While some studies demonstrate e-health interventions to be effective in reducing BMI and BMI-related measures among children and adolescents, with small but statistically significant weight reductions of e-health-treated groups compared to control groups by the z-score BMI (-0.31; 95% CI: -0.49 to -0.13, I^2 = 74%, p<0.001) and BMI (weighted mean difference, WMD: -0.32 kg/m^2, 95% CI: -0.50 to -0.13 kg/m^2, I^2 = 85.9%), (Azevedo *et al.*, 2022) and, comparably, a reduction in the BMI z-score in another systematic review (WMD = -0.08, 95% CI: -0.14 to -0.03, I^2 = 89.1%) (Qiu *et al.*, 2022), one systematic review did not find significant changes in obesity parameters to be significantly affected by e-health interventions delivered via mobile phones, emails, videos or mixed interventions compared to involved control groups (Flynn *et al.*, 2022). However, there seems to be consensus on an improved weight loss effect of involvement of schools or parents (WMD = −0.66 kg/m^2; 95% CI: -0.98 to -0.34 kg/m^2) (Flynn *et al.*, 2022; Qiu *et al.*, 2022).

Evaluation of the evidence on e-health interventions in weight loss

Seemingly, only minor-size reduction in BMI and associated parameters can be expected from e-health interventions in weight loss.

3.6.2.3 Electronic game-based interventions to reduce weight

Game-based interventions, including active video games (AVGs) or exergames, were suggested to be an effective tool in the treatment of overweight and obesity in children and adolescents, with varying degrees of effectiveness reported across studies (Ameryoun *et al.*, 2018; Goldthorpe *et al.*, 2020; McMullan, Millar and Woodside, 2020; Oliveira *et al.*, 2020; Suleiman-Martos *et al.*, 2021; Valeriani *et al.*, 2021; Alotaibi *et al.*, 2022; Bourke *et al.*, 2023). According to some of the meta-analyses, game-based interventions, particularly those combining active gaming with other approaches like parent education or a modified diet, show promising results with small but significant effect sizes in terms of BMI reduction (SMD: -0.234 kg/m^2; standard error (SE): 0.069) (Ameryoun *et al.*, 2018). However, the impact may vary depending on the specific game and implementation strategy (Alotaibi *et al.*, 2022;

Flynn *et al.*, 2022). Others report larger BMI z-score reduction in AVG-treated groups compared to no/minimal intervention at short-term (SMD = -0.34 kg/m^2; 95% CI: -0.62 to -0.05 kg/m^2, 6 trials) and intermediate-term follow-up (SMD = -0.36 kg/m^2; 95% CI: -0.01 to -0.71 kg/m^2, 2 trials) (Oliveira *et al.*, 2020), although statistical significance is not always reached (Suleiman-Martos *et al.*, 2021). In line with Oliveira et al. (Oliveira *et al.*, 2020), Bourke and colleagues found a larger BMI z-score reduction (mean difference, MD: -0.09 kg/m^2, CI 95%: -0.12 to -0.05 kg/m^2, I^2 = 34%, p < 0.0001) in AVG groups compared with controls (Bourke *et al.*, 2023). The impact of AVG on physical activity levels, body fat, and waist circumference is less clear, with several (systematic) reviews showing non-significant effects compared to no/minimal interventions (Oliveira *et al.*, 2020; Suleiman-Martos *et al.*, 2021; Alotaibi *et al.*, 2022; Bourke *et al.*, 2023).

3.6.2.4 Wearable devices in weight loss initiatives

The efficacy of including wearable devices in weight management in children aged 6-18 years was examined in one meta-analysis (Wang *et al.*, 2022). This review included studies that investigated both prevention and treatment, however, only the results collected on the effect of treatment are considered in the current report. Wearable devices were defined as needed to be carried fixed to the user's body and use accelerometers or sensors such as wristbands, pedometers, or smartwatches to track the wearer's physical activity or physiological data. Intervention duration ranged from 2.5 to 18 months. Interventions using wearable devices indicated significant beneficial effects on the BMI (mean difference, MD: -0.23 kg/m^2; 95% CI: -0.43 to -0.03 kg/m^2; p = 0.03; I^2 = 2%), BMI-z (MD: -0.07; 95% CI: -0.13 to -0.01; p =.01; I^2=81%), body weight (MD: -1.08 kg; 95% CI: -2.16 to -0.00 kg; p = 0.05; I^2 = 58%), and body fat (MD: -0.72%; 95% CI: -1.19 to -0.25%; p = 0.003; I^2=5%), but not on waist circumference, compared to a multifaceted intervention program based on multiple components (Wang *et al.*, 2022).

Evaluation of the evidence on wearable devices in weight loss interventions

Seemingly, significant, but not very pronounced reductions in BMI, but not waist circumference emerge from e-health interventions in weight loss.

3.6.2.5 Mobile phone app-based interventions in weight loss programmes

Newer randomized controlled trials show mixed results on technology-based interventions using mobile applications (Likhitweerawong *et al.*, 2021; Hagman *et al.*, 2022). While one meta-analysis (Hagman *et al.*, 2022) observed significant reductions in the BMI z-score across the included studies (mean ± SD: -0.30 ± 0.39 in treatment group vs −0.15 ± 0.28 in the standard care group, p = 0.0002) in children aged 4-18 years after 1 year of using a digital support system with daily weight measurements in addition to clinical treatment compared to standard care, another study (Likhitweerawong *et al.*, 2021) found no significant differences in weight-related outcomes in 10 to 15 year olds after 6 months of using a mobile/tablet application as an additional tool for standard care compared to standard care alone, measured as the average change in the intervention group vs. the change in the control group by weight

(MD: 1.55 kg; 95% CI: 0.39 to 2.73 kg vs. 2.32 kg; 95% CI: 1.06 to 3.59, p = 0.42), by BMI (-0.62 kg/m^2; 95% CI: -1.03 to -0.19 kg/m^2 vs. -0.28 kg/m^2; 95% CI: -0.75 to 0.19 kg/m^2, p = 0.33), by the BMI z-score: (-0.2; 95% CI: -0.27 to -0.12) vs. -0.15; 95% CI: -0.24 to -0.06, p = 0.48), by WC (0.17 cm; 95% CI: -1.69 to 1.82 cm vs. -0.23 cm; 95% CI: -2.33 to 1.66, p = 0.77).

Evaluation of the evidence on mobile phone apps in weight loss interventions

Inconsistent results from one systematic review and one more recent study on weight-related outcomes were observed in children and adolescents using a mobile/tablet application attempting to reduce their BMI and other indicators of obesity.

3.6.2.6 Evaluating conclusion on technology-based interventions used in weight loss programmes

Overall, technology-based interventions show promising effects in supporting a healthier lifestyle among young people, but the effectiveness can vary significantly depending on the specific technology, and further, more detailed literature reviews need to be conducted before deciding on the specific digital tool to be applied. This decision needs to be harmonized carefully with the implementation strategy and should be integrated strategically alongside other supportive measures.

3.6.3 Community-based technology interventions

3.6.3.1 Evidence from publications

Programs were heterogeneous in nature with respect to length, number and frequency of sessions, parent-involvement, and the type of technology involved. The different interventions encompassed clinic-based weight management treatments (Whitley and Yahia, 2021) or community-based programs with various delivery modes (e.g. face-to-face, online, phone, mobile applications, or mixed methods) (Moores *et al.*, 2018). Intervention duration ranged from 8 weeks to a minimum of 12 months with follow up between 10 weeks after baseline assessment, to 24 months after baseline.

3.6.3.2 Results from evidence

Both systematic reviews on community-based interventions with technology components documented an averaged reduction of the BMI between 1% and 2–4% compared to the start of the studies. They did not appear to be superior to face-to-face programs without employment of technology, which showed an averaged BMI reduction ranging between 1% to 7% of the initial value. Interventions that combined technology with face-to-face sessions, with zBMI reductions by 2% to 4% at the end of the intervention and 3–4% to 9–10% at follow-up, did not seem more effective than those without technological/digital equipment (zBMI reductions of 5% to 9% at the end of the intervention and 8–12% to 16% at follow-up) (Moores et al., 2018). Similar, evidence suggests that both clinic-based telehealth and face-to-face interventions were effective in reducing obesity, with no clear evidence of one modality being superior, although evidence on comparative effectiveness is lacking (Whitley and Yahia, 2021).

3.6.3.2 Conclusion on the efficacy of technology-based approaches in reducing weight of children and adolescents at community level

However, due cost efficacy and the potential of IT-based technology interventions to cover large operating ranges additional arguments may have to be taken into consideration when deciding upon its implementation in weight loss programs for children and adolescents, showing some benefits when applied at community level in weight-loss programs.

3.7 Board game inclusion in weight-loss programmes

3.7.1 Relevance of board gaming in weight loss interventions

Board games addressing the two most common contributing variables such as a poor diet and a sedentary lifestyle have been suggested as an education method, working both at the conscious and subconscious level, to reduce body weight in children and adolescents. The major rationale behind this approach is because children and teenagers are more likely to engage in play activities than following traditional information programmes, hoping for that this motivational advantage will lead to engaging them better in physical activity and conscious food choices. Studies have found that game-based approaches can improve health-related knowledge, behaviours, and biological indicators (Gauthier *et al.*, 2019; Noda, Shirotsuki and Nakao, 2019). To the best of the knowledge of the authors, no systematic reviews have been published yet on the efficacy of board game involvement in weight loss initiatives.

2.7.2 Available publications on board gaming in weight loss studies

One RCT with a high drop-out rate (74% of starting participants), finally including 24 completers (Sen *et al.*, 2018) examined a board game approach to children's involvement in family-based weight management compared to traditional family-based behavioural counselling in primary care for 3 months. The board game was designed to improve nutritional knowledge and to promote a healthy lifestyle.

3.7.3 Evidence on the potential of board games' involvement in weight loss initiatives

In the study mentioned above, BMI and BMI z-scores decreased significantly both in the intervention and in the control group, compared with the initial measures and these changes were statistically significant. In the behavioural group, the BMI and zBMI changed by -1.01 kg/m^2 ($p = 0.03$) and - 0.17 ($p < 0.001$), respectively, and for the game group, they altered by -0.74 kg/m^2 ($p = 0.007$) and - 0.09 ($p = 0.003$). There were no significant differences between the behavioural and game intervention group in these parameters ($p = 0.130$ and $p = 0.706$).

3.7.4 Evaluating conclusion on board games in weight loss interventions

A board game approach to family-based weight management did thus not prove more effective than traditional behavioural counselling in reducing BMI and BMI z-scores. The limitation of evidence on the role of board games in weight loss initiatives does not allow any reliable reasoning to include specifically this tool in weight loss programmes.

3.8 Parental involvement in weight loss management

3.8.1 Relevance of the involvement of parents in weight loss approaches

Parental involvement in the treatment of childhood obesity encompasses various strategies including behaviour modelling, environmental changes, rule setting, emotional support, education, and participation in structured interventions targeting their children's weight management. Parental involvement is relevant as parents serve as role models for their offspring, can create a supportive environment facilitating weight loss interventions by setting and enforcing rules, and the provision of emotional support. Naturally, parental involvement itself needs to be guided by strategies being scientifically evidenced (Tomayko *et al.*, 2021).

3.8.2 Considered publications on the role of parental involvement in weight loss initiatives

In the umbrella review by Tomayko and colleagues (Tomayko *et al.*, 2021), the involvement of parents commonly included behavioural educational sessions, behavioural counselling, dietary planning, and encouragement of physical activity. Interventions with parental involvement typically spanned over several months up to four years, with a wide variation in the length of follow-up periods.

The evidence on parental inclusion in weight loss programmes considered in this report builds on three SR addressing 25 to 32 studies or RCTs (Verjans-Janssen *et al.*, 2018; Bean *et al.*, 2020; Flynn *et al.*, 2022), three umbrella reviews comprising ten to 14 SRs and/or MAs (Chai *et al.*, 2019; Goldthorpe *et al.*, 2020; Tomayko *et al.*, 2021), two MAs including 22 and 24 RCTs (Pamungkas and Chamroonsawasdi, 2019; Bae and Lee, 2021) and one overview of Cochrane reviews including six reviews (Ells *et al.*, 2018). Three of the reviews (Goldthorpe *et al.*, 2020; Tomayko *et al.*, 2021; Flynn *et al.*, 2022) included both prevention and treatment-focused studies. However, due to the research question for this report, only the part of results from the treatment-focused intervention studies was considered in the current review.

3.8.3 Evidence on the efficacy of including parents in weight loss programmes

The systematic review by Ells and colleagues (Ells *et al.*, 2018) examined parental involvement in weight management interventions for children and adolescents of varying ages. Multicomponent

interventions for pre-schoolers up to 6 years old including parental involvement led to significant reductions in the BMI z-score over a period of 6 to 12 months (mean difference (MD): -0.3; 95% CI: -0.4 to -0.2), when maintained for up to 12 − 18 months (MD: -0.4; 95% CI: -0.6 to -0.2) and 2 years follow-up (MD -0.3; 95% CI: -0.4 to -0.1). Parent-only interventions for children under 12 did not show significant BMI z-score differences except when compared to waiting list controls (MD -0.10; 95% CI: -0.19 to -0.01). Adolescents of 12 years or older experienced significant reductions in BMI (MD: 1.18 kg/m²; 95% CI: -1.67 to -0.69 kg/m²) and BMI z-score (-0.13; 95% CI: -0.21 to -0.05) after parental involvement, with larger effects observed in studies with long-term follow-up (18-24 months) (BMI: MD -1.49 kg/m²; 95% CI: -2.56 to -0.41 kg/m²; BMI z-score, MD: -0.34; 95% CI: -0.66 to -0.02). Additionally, interventions improved parameters of health-related quality of life across all included age groups. Similarly, Tomayko et al. (Tomayko *et al.*, 2021) reported in their umbrella review covering studies from more than 30 countries that family-focussed behavioural treatments including behaviour change of both parents and children yielded a significant decrease in child BMI-z score at six-month follow-up. Parent-child (PC) interventions were, compared to parent-only (PO) interventions, including 277 participants in 3 trials with 4 treatment groups, insignificantly better (BMI z-score: -0.06; 95% CI: -0.13 to 0.02; $Z = 1.49$, $p = 0.14$; $I^2 = 37\%$). For this research question, two out of seven trials that involved parents documented a significant reduction in body weight outcomes while five did not. However, interventions that include diet, physical activity enhancement, and behavioural changes, which include parental involvement are more effective than no treatment/usual care for every outcome evaluated such as the reduction in the BMI, the BMI z-score, and body weight (e.g. zBMI: -0.07; 95% CI: -0.11 to -0.03; $Z = 3.25$, $p = 0.0006$, $I^2 = 60.4\%$; 32 trials; 2927 participants). The efficacy of studies including parents alongside of other interventions was confirmed by recent systematic reviews (Pamungkas and Chamroonsawasdi, 2019; Goldthorpe *et al.*, 2020; Flynn *et al.*, 2022) with comparable outcomes, in which home- and school-based interventions, integrating direct parental involvement and lifestyle modifications, were most effective in reducing childhood obesity. Specifically, a positive impact of modelling therapies, long-term planning, and emotional support in addition to promoting a health-promoting home environment through social support and accessibility of nutrient-dense foods over prolonged periods was reported to improve managing healthy behaviours, reducing sedentary lifestyles, foster positive parental involvement and reduce both weight and BMI (Pamungkas and Chamroonsawasdi, 2019).

Chai and colleagues (Chai *et al.*, 2019) conducted an umbrella review, which covered 14 systematic reviews published between 2004 and 2015, including 47 independent international trials (children aged six to 13 years, 1-7 years of follow-up). They concluded that both parent-child and parent-only interventions were effective in reducing zBMI, BMI percentiles, and waist circumference compared to waitlist controls, with no difference between both types of interventions. All reviews except one indicated that family-based interventions were successful in improving child weight and/or weight-

related behaviour. Five reviews highlighted that parent-only interventions had similar (n = 4) or greater (n = 1) effectiveness compared to parent-child interventions.

Similarly, Psaltopoulou and collaborators (Psaltopoulou *et al.*, 2019) reported reductions in BMI, body fat percentage, and percentage overweight in combined interventions with or without parental involvement, especially in children aged 2-8 years (ES = -0.70, 95% CI -1.00 to -0.40). A SR by Verjans-Janssen et al. (Verjans-Janssen *et al.*, 2018) indicated mixed results for BMI and BMI z-scores when school-based interventions were coupled with direct parental involvement. Most included studies included in this SR reported favourable effects on BMI or BMI z-score in case of parents' involvement. Despite effect sizes mainly being small (ES -0.04 to -0.27), the majority of authors of these studies acknowledged that school-based interventions with direct parental involvement have the potential to improve children's weight status, physical activity, and sedentary behaviour.

While parental involvement often correlates with improved obesity indices, its effect is not universally reported across all studies. Despite significant reductions in obesity indicators following dietary interventions with parental involvement and combined dietary and exercise interventions with parental involvement compared with no intervention, exercise without parental involvement alone also resulted in a significant decrease in the obesity index compared to dietary interventions with or without parental involvement and to no intervention at all (Bae and Lee, 2021). Likewise, as reported in a systematic review published by Moores et al. (Moores *et al.*, 2018), parental involvement as part of scalable community-based interventions in either separate or combined group sessions did not appear to be associated with improved weight management outcomes.

Similar conclusions were stated by Bean and colleagues (Bean *et al.*, 2020) in their systematic review on parent involvement in obesity treatment, analysing various formats and techniques of parent involvement applied across studies. Some interventions were delivered separately to parents and adolescents, while others utilized joint group sessions. Behavioural techniques for parents included managing the home environment, parental role modelling, positive reinforcement, and involving parents in shared decision-making and goal setting. Although interventions with parent involvement were associated with some desired outcomes in adolescent weight loss and health-related quality of life, described associations between specific parent techniques and outcomes were not always clear. Modifying the role of parents in interventions demonstrated mixed results, with most trials demonstrating parental involvement to be associated with larger effect sizes compared to no or minimal parental involvement or usual care, though the body of evidence was deemed as not being substantial enough to clarify the isolated role of parent involvement in the outcomes of the studies considered.

This conclusion on studies including parents along with other measures parallels those from other umbrella reviews, SRs, and MAs (Ells *et al.*, 2018; Chai *et al.*, 2019; Goldthorpe *et al.*, 2020; Bae and Lee, 2021; Tomayko *et al.*, 2021; Flynn *et al.*, 2022), while none of those summarizing reports claims that isolated parent involvement alone would cause significant weight reductions in children in general. Seemingly, some parts of multi-component interventions, such as parent involvement, may exert its

efficacy only when co-applied with other modifiers of children's body weight, but not as isolated interventions.

3.8.4 Evaluating conclusion on parental involvement in children's weight loss programmes

There is some, though inconsistent evidence from trials comparing parent-child or family interventions with child-only interventions or controls, that parent involvement may add benefit to studies building on other intervention types. Overall, most studies show that interventions including parents as one of several components leads to significant reductions in BMI and BMI z-scores, especially in younger children and over longer follow-up periods. However, the specific nature of this involvement, such as the intensity and type of behaviour change techniques along with their capability to promote the efficacy of intervention initiatives to reduce children's weight, needs additional studies to become fully explored (Tomayko *et al.*, 2021).

3.9 Involvement of peers in weight loss initiatives

3.9.1 Relevance of peers in weight management

Peer-led interventions in weight loss programmes for adolescents and children are considered to leverage the influence and relatability of peers to promote healthier behaviours related to diet and physical activity and hereby to support weight loss. The rationale behind these interventions is based on several key factors such as behavioural reinforcement, positive peer pressure, and accountability. Additional support of weight loss programs utilizing peer-led interventions may come from role modelling by peers, norm setting, relatability, peer support and engagement, empowerment, and self-efficacy. As children and adolescents are more likely to emulate the behaviours of peers and tend to attach to peer-set norms, peer-led interventions seem being a promising approach in weight loss programmes for children and adolescents (Lavelle *et al.*, 2023).

3.9.2 Evidence from publications

Two systematic review and meta-analyses, including 9 RCTs with 10,684 participants and 78 RCTs with 5780 participants, respectively (McGavock *et al.*, 2020; Nguyen *et al.*, 2022), investigated the effectiveness of interventions delivered by peers or laypersons in comparison with either active control groups receiving non-peer-led guidance by teachers, experts, and parents, or non-active control groups, who received standard care or a regular school curriculum. The peer-led approaches considered included people younger than 18 years either implementing or delivering a behaviour change program or both. Layperson-led interventions entailed direct involvement of non-professionals participants' schools, communities, neighbourhoods, and families. The time of follow-up of the studies considered was heterogeneous, ranging from eight weeks to three years.

3.9.3 Evidence on the efficacy of peer involvement in weight loss interventions

One meta-analysis evaluated peer-led programs that involved diet and nutrition, physical activities (sport or exercise), or lifestyle and social support from different types of settings including schools, out of school care, home, community, childcare or preschool with a minimum intervention duration of four weeks (Nguyen *et al.*, 2022). The results of their meta-analysis including 2506 children from 9 studies indicated that peer-led programs were effective for weight loss in children aged between 5 and 18 years with a significant reduction in BMI -0.15 kg/m^2 (95% CI: -0.26 to -0.03, p = 0.01, I^2 = 28%). The comparison of peer-led intervention versus control on combined BMI-related outcomes (BMI, BMI z-score and BMI percentile) using standardized mean differences with a fixed effect model confirmed the significant effect of peer involvement (MD: -0.06; 95% CI: -0.10 to -0.01, p = 0.02, I^2 = 8%, 13 studies). Subgroup analysis revealed a noteworthy difference in BMI between interventions using a physical activity approach (MD of -0.63 kg/m^2, 95% CI: -1.01 to -0.25, p = 0.001) compared with mixed education approaches (MD of -0.10 kg/m^2, 95% CI: -0.22 to 0.02, p = 0.10). Notably, this meta-analysis included a small number of studies with a possibility of reporting bias, hence, caution must be applied when interpreting the results.

Another meta-analysis (McGavock *et al.*, 2020) found that professional-led weight loss interventions were associated with reductions in weight (SMD: -1.60 kg; 95% CI: -2.30 to -0.99 kg; 68 trials; p < .001) and BMI (SMD: -0.30 kg/m^2; 95% CI: -0.39 to -0.20; 59 trials; p < .001) in children and adolescents younger than 18 years that were sustained for a short-term but not a long-term period with a follow-up of 12 to 104 weeks (weight MD, −1.02 kg; 95% CI: -2.20 to 0.34 kg; 21 trials; P = .06 and SMD: -0.12 kg/m^2; 95% CI: -0.46 to 0.21 kg/m^2; 20 trials; p < .001, respectively). Compared with this, layperson-led interventions demonstrated no significant weight loss in the short-term (MD: -1.40 kg; 95% CI: -3.00 to 0.26 kg; 5 trials; P = .05) or long-term (MD: -0.98 kg; 95% CI: -3.60 to 1.80 kg; 1 trial; p = .23) compared with standard care. Similarly, no difference was found when directly comparing professional and layperson studies (MD, −0.25 kg [95% CI −1.90 to 1.30 kg]; 5 trials; P = .38). Professional-led interventions resulted in greater reductions in percent body fat (MD, −1.70% [95% CI, −2.60% to −0.81%]; P < .001) and waist circumference (MD, −1.30 cm [95% CI, −2.06 to −0.58 cm]; p < .001) compared to standard care, while layperson-led interventions did not produce significant differences in percent body fat (MD, –0.52%; 95% CI, –3.90% to 2.80%; p = .38) or waist circumference (MD, –0.94 cm; 95% CI, –2.70 to 0.71 cm; p = .13).

3.9.4 Evaluating conclusion on the efficacy of peer involvement in weight loss programmes

Despite peer-led interventions demonstrate a small but significant reduction of the BMI in weight loss interventions, especially when focusing on physical activity, they seem to be less effective than professional-led programs in achieving sustained weight loss and improving body composition,

indicating the need for professional involvement for long-term success with only a minor benefit from the inclusion of peers.

3.10 Pharmacological interventions in weight loss approaches in children and adolescents

3.10.1 Relevance of medication in weight loss strategies

Obesity is often influenced by genetic, hormonal, and metabolic factors. Pharmacological treatments can help to address these biological components, which may not be influenced by diet, exercise, behavioural change, and other factors, alone or in combination. Hence, the latter approaches may not adequately succeed in achieving the weight loss goals necessary for an optimum health. Medications can help regulating the appetite, improve the metabolic rate, and alter the absorption of nutrients. Correspondingly, the main targets of pharmacological interventions to treat obese children and adolescents act as appetite suppressants (e.g. Orlistat), increase the metabolic rate to burn more calories, or reduce the absorption of fat, hereby reducing overall calorie intake. The American Academy of Pediatrics (AAP) recommends considering pharmacological treatment for children with severe obesity, particularly when lifestyle interventions alone do not result in adequate weight loss (Hampl *et al.*, 2023).

3.10.2 Publications on drugs in weight loss interventions

In this report, the evidence on the efficacy of drug interventions in managing overweight and obesity in children and adolescents is based on three systematic reviews, one covering 15 RCTs (O'Connor *et al.*, 2017), another including 859 studies with 8583 participants (Lentferink, Knibbe and Van Der Vorst, 2018), and one covers nine studies with 574 participants (Ryan *et al.*, 2021). Moreover, one overview of Cochrane reviews including six reviews (Ells *et al.*, 2018) and two publications on more recent RCTs are included. Metformin and Orlistat were the two most frequently used drugs but also Subtramine and the GLP-1 receptor agonists liraglutide and semaglutide were investigated. Dosage, duration of intervention, and the period of follow-up varied across studies.

3.10.3 Results from evidence

Ells and collaborators (Ells *et al.*, 2018) found a statistically significant reduction in BMI (MD: -1.3 kg/m^2, 95% CI: -1.9 to -0.8 kg/m^2) with drug interventions in children and adolescents younger than 18 years compared to controls. This effect was consistent across different drug types including Sibutramine, metformin, and orlistat. This aligns with the findings provided in another systematic review (Lentferink, Knibbe and Van Der Vorst, 2018), which highlighted a cessation of weight gain or reduction of the BMI in children aged 7 to 19 years after a 6-month application of appetite-limiting drugs (MD: -2.4 and 0.02 kg/m^2), compared to controls. The efficacy of metformin and Orlistat was further supported by the outcome of a systematic review from O'Connor and colleagues

(O'Connor *et al.*, 2017). Their findings demonstrated a reduction in BMI (SMD: -0.86 kg/m^2; 95% CI: -1.44 to -0.29 kg/m^2) and a reduced BMI z-score (SMD: -0.10, 95% CI: -0.17 to to -0.03) for 2- to 18-year-olds compared to placebo over 6 to 12 months, with small but statistically significant reductions observed. No further reductions in BMI in the metformin users was observed in intervention periods lasting longer than 6 months. Regarding insulin sensitivity, some studies found significant reductions in weight with metformin compared to placebo, while others did not observe significant differences (O'Connor *et al.*, 2017; Lentferink, Knibbe and Van Der Vorst, 2018). Quality of life outcomes did not show statistically significant variations between intervention groups and controls across the studies (O'Connor *et al.*, 2017; Ells *et al.*, 2018).

A systematic review from 2021 (Ryan *et al.*, 2021) found that liraglutide, applied subcutaneously once daily, caused a modest reduction in body weight (MD: -1.50 kg; 95% CI: -2.50 to -0.50 kg; I^2 = 64%), BMI (MD: -1.24 kg/m^2; 95% CI: -1.71 to -0.77 kg/m^2, I^2 = 0%), and BMI z score (MD: -0.14; 95% CI: -0.23,-0.06; I^2 = 43%). Glycemic control was found to be improved in children with proven insulin resistance (glycated hemoglobin A1c MD: -1.05; 95% CI: -1.93 to -0.18 %; I^2 = 76%). Adverse gastrointestinal, treatment-associated events were nausea, the risk of which increased (risk ratio 2.11; 95% CI: 1.44 to 3.09; I^2 = 0%), without significant increases in other gastrointestinal symptoms.

In a recent study from 2022 (Weghuber *et al.*, 2022), a once-weekly subcutaneous semaglutide plus lifestyle intervention for 68 weeks compared to a placebo plus lifestyle intervention resulted in significantly greater reductions in BMI (ED, -16.7%; 95% CI: -20.3 to -13.2; p<0.001), body weight (ED: = -17.7 kg; 95% CI:−21.8 to -13.7 kg) after subcutaneous application of the peptide, and a diminished waist circumference (ED: -12.1 cm; 95% CI: -15.6 to -8.7). In the semaglutide group, 73% experienced a weight loss of 5% or more, as compared with 18% in the placebo group (estimated odds ratio, 14.0; 95% CI, 6.3 to 31.0; P<0.001). Furthermore, semaglutide was associated with improvements in Weight-Related Quality of Life total score and the physical comfort domain score.

3.10.4 Evaluating conclusion on the use of medication in strategies for weight loss in children and adolescents

Evidence on the efficacy of commonly used drugs to achieve weight loss in children and adolescents have proven their efficacy in numerous trials. Overall, drug administration of different types shows promising effects on BMI reduction in paediatric populations with obesity, while the evidence regarding their impact on insulin levels and quality of life remains inconclusive. The mentioned drug types can be valuable components of paediatric obesity management, particularly when combined with lifestyle interventions, although long-term effectiveness and safety need further investigation.

3.11 Probiotic and synbiotic supplementation

3.11.1 Relevance of pro- and synbiotics in weight loss strategies

Probiotics are defined as microorganisms, which are capable to survive the gastrointestinal passage into the colon, persist for a minimum time span here, typically 3 weeks, and exert health-promoting effects of different nature during this period. The potential of probiotics in weight reduction is assumed primarily to be grounded on the bacteria's properties to regulate lipid metabolism but also to advert negative consequences of overweight and obesity such as low-grade, sub-clinical chronic systemic inflammation (Li *et al.*, 2023). Findings on other secondary health markers such as circulating transaminases, insulin resistance, hypercholesteremia, the Prader-Willi Syndrome, and non-alcoholic fatty liver disease remain inconclusive (Loy *et al.*, 2023). Moreover, single studies have found an appetite-modulating effect of probiotics (Sanchez *et al.*, 2017).

3.11.2 Publications on pro- and synbiotic interventions in weight loss management

The effect of probiotic supplementation on anthropometric and metabolic indices in children under 18 years was examined in one SR including a meta-analysis (Duan *et al.*, 2024), one systematic review (Santos *et al.*, 2023), two systematic reviews combined with meta-analyses, (Mohammadi *et al.*, 2019; Li *et al.*, 2023) and one scoping review (Loy *et al.*, 2023). A variety of probiotic strains were investigated. There were heterogeneities in dosing, species, and strain combinations as well as in the use in combination of prebiotic/probiotic treatment.

3.11.3 Evidence on pro- and synbiotics' efficacy in intervention studies on weight loss

Recent literature indicates some evidence of probiotics demonstrating beneficial effects on adiposity measures in obesity treatment. The scoping review by Loy and colleagues (Loy *et al.*, 2023) demonstrated heterogenous effects of probiotic use. Specifically, six studies highlighted a significant correlation between probiotic use and lower BMI, along with improvements in inflammatory markers, lipids, glucose metabolism, and liver health. In contrast, seven studies did not observe significant BMI reductions but did report enhancements in other health markers such as adiposity, waist circumference, insulin sensitivity, as well as behavioural and mental health. Similarly, another systematic review (Santos *et al.*, 2023) found that probiotics used for a duration between eight and 36 weeks generally had a beneficial effect on reducing anthropometric measures such as body weight, BMI ($p < 0.01$; $p = 0.001$; $p < 0.001$, 3 studies), waist circumference ($p = 0.001$; $p < 0.01$), and body fat percentage ($p = 0.021$). In contrast, two studies reported no significant effect on body composition after probiotic therapy use (2.21 ± 0.31; $p = 0.256$). No meta-analyses were performed in this SR and no overall estimation of probiotics' use in weight loss interventions. Thus, a part of the included studies suggests

that probiotics, whether as single or multiple strains, may improve BMI and other related health metrics in obese children.

Comparable results from similar studies were reported based on a meta-analysis (Duan *et al.*, 2024), which indicated that a probiotic intervention in general in adolescents resulted in a decrease in BMI with weighted mean difference (WMD) of -2.53 kg/m^2 (95% CI: -4.8 to -0.26 kg/m^2). However, a diversity of probiotics was used in the included studies impeding grouping of studies by probiotic strain. The meta-analysis by Duan and colleagues (Duan *et al.*, 2024) showed no significant effects on other anthropometric indices such as weight, waist circumference, waist-to-hip ratio, or body fat percentage. Moreover, there was no improvement in insulin levels or insulin resistance, and adverse effects were noted on total cholesterol, triglycerides, and low-density lipoprotein levels, with WMDs of 0.06 mmol/L (95% CI: 0.02 to 0.09), 0.18 mmol/L (95% CI: 0.14 to 0.21), and 0.19 mmol/L (95% CI: 0.18 to 0.20), respectively. Overall, recent studies (Mohammadi *et al.*, 2019; Li *et al.*, 2023) suggested no significant changes in BMI z-score, waist circumference, weight, body fat, fasting blood sugar and lipid profiles (triglyceride, total cholesterol, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol) following supplementation with pro-/synbiotics. However, subgroup analysis in one meta-analysis (Mohammadi *et al.*, 2019) revealed significant effects in certain subgroups (e.g., synbiotics) while, in contrast, another meta-analysis (Li *et al.*, 2023) indicated improved obesity-related outcomes in the placebo group compared to the intervention group.

Recent randomized controlled trials showed mixed results. Atazadegan and colleagues (Atazadegan *et al.*, 2023) and Khongtan with collaborators (Khongtan *et al.*, 2023) could not demonstrate any significant differences in obesity indices or body composition between probiotic supplementation and placebo groups, whereas Chen et al. (Chen *et al.*, 2022) observed a significant BMI reduction in the probiotic compared to the placebo group ($p = 0.026$) after a daily ingestion of Lactobacillus salivarius AP-32 (10^9 colony-forming units, CFU), *Lactobacillus rhamnosus* bv-77 (10^9 CFU), and *Bifidobacterium animalis* CP-9 (8×10^9 CFU) three times a day for three months. However, the observed reduction in BMI in this study may be, as the authors themselves admit, due to the fact that only the probiotic intervention group underwent a physical training and dietary advice program, but not the control group. No other significant changes were observed between the probiotic and placebo group for body composition or metabolic profile.

3.11.4 Evaluating conclusion on pro- and synbiotics in children's and adolescents' weight loss interventions

The body of evidence on the efficacy of pro- and probiotics is currently not large enough to come to a conclusive result. This may partly be due related to the heterogeneity of outcomes of the corresponding studies but also to the broad variety of both, probiotics and synbiotics. Therefore, no clear summarizing conclusion can be drawn from the results. Considerably more studies need to be conducted before pro-

and synbiotics can become a part of obesity management in children and adolescents, and whether they then should be applied in combination with other measures.

3. 12 Surgical interventions

3.12.1 Relevance of surgery in weight loss interventions

In severe cases of obesity, surgical interventions are considered as the last resort of achieving weight reduction in children and adolescents. The most common methods are gastric bypass surgery (Roux-en-Y gastric bypass, sleeve gastrectomy, adjustable gastric banding, biliopancreatic diversion with duodenal switch (BPD/DS)), and the allocation of an intragastric balloon. All methods aim at reducing calorie absorption by either preventing the ingestion of large amounts of food or by rerouting food away from much of the small intestine, reducing the absorption of calories but also other nutrients. Reduction of food allocation in the stomach can be achieved either by reducing stomach volume by surgical removal of a part of the stomach, inserting a balloon reducing intragastric space or by limiting the stomach's ability to extend by banding. The latter two methods have the advantage to be reversible (Cheng *et al.*, 2016).

3.12.2 Publications on the efficacy of surgical interventions in weight loss initiatives

One umbrella overview of Cochrane reviews (6 reviews; including 19,756 participants) (Ells *et al.*, 2018) and one Cochrane update (Torbahn *et al.*, 2022) investigated the effectiveness of surgery in reducing weight in children and adolescents. All studies examined the efficiency of gastric banding where an adjustable band is placed around the upper part of the stomach to create a small pouch with a narrow opening to the lower stomach to enhance the feeling of fullness (Penn Medicine, 2024). Both reviews based their results on only one RCT. The study in the review by Ells and colleagues included 50 predominantly female adolescent participants with severe obesity (mean age 16 years, mean BMI over 40), and had a duration of 24 months. The RCT in the Cochrane update comprised 50 participants (25 in both the intervention and comparator group) and a follow-up of two years.

3.12.3 Evidence on the efficacy of surgery in weight loss interventions

In their SR, Ells and colleagues (Ells *et al.*, 2015) reported a substantial mean reduction in weight by 34.6 kg (95% CI: 30.2 to 39.0 kg) and BMI by 12.7 kg/m^2 (95% CI: 11.3 to 14.2) in the surgery group after laparoscopic gastric banding whereas the control group, receiving placebo or no intervention, showed a considerable smaller reduction of the BMI by 1.3 kg/m^2 (95% CI: 0.4 to 2.9) over a 24-month period. In a more recent SR, Torbahn with collaborators (Torbahn *et al.*, 2022) found that laparoscopic adjustable gastric banding surgery resulted in a significant ($p< 0.001$) weight reduction (MD) by 31.6 kg (95% CI: 26.5 to 36.7) and a BMI decrease of 11.4 kg/m^2 (95% CI: 9.58 to 13.2 kg/m^2) after two

years compared to a multi-component lifestyle programme. The multicomponent lifestyle intervention included personalized calorie-reduction diet plans, increased physical activity, structured exercise schedules, advice to reduce sedentary behaviour, and support through consultations with a healthcare practitioner every six weeks.

Comparable findings were presented by a recent RCT investigating the one-year health effects of bariatric surgery in adolescents with severe obesity (BMI ≥ 40 kg/m², or ≥35 kg/m² with comorbidity). Results demonstrated that laparoscopic adjustable gastric banding combined with multidisciplinary lifestyle intervention resulted in a significant reduction in relative weight loss in terms of relative weight loss (-13.1%, 95% CI: -17.5 to -8.7; $p < .001$), BMI z-score: (-0.43; 95% CI: -0.59 to -0.26; $p < .001$) and absolute body weight (-16.9 kg; 95% CI: -22.9 to -11.0 kg; $p < .001$) compared to the control group, which received multidisciplinary lifestyle intervention such as guidance on dieting, physical activity, and behavioural changes. Additionally, participants undergoing surgery demonstrated improvements in health-related quality of life in two out of eight domains (physical functioning score and change in health score (compared to control groups, although the evidence quality varied (Torbahn *et al.*, 2022).

3.12.4 Evaluating conclusion on surgery efficacy in weight loss studies

Thus, the included studies provided evidence supporting the effectiveness of bariatric surgery as a viable intervention for severe paediatric obesity. The effect size of such intervention exceeds the efficacy of all other interventions by far. Particularly laparoscopic adjustable gastric banding, both alone and in combination with a lifestyle intervention, show promise in reducing BMI and weight in children and adolescents compared to lifestyle interventions with improvements in health-related QoL for those undergoing surgery. However, side effects and the reversibility of surgical interventions need to be taken into consideration before going for such drastic measures.

3.13 Acupuncture and acupressure

3.13.1 Relevance of acupuncture/acupressure in weight loss interventions

Previous research suggests that acupuncture can be effective in weight loss programs for children, though the underlying mechanisms seem to remain obscure. A limited number of studies have shown that acupuncture, when combined with diet therapy, can significantly reduce weight, body fat mass, and waist-hip ratio in overweight children (Quan *et al.*, 2023). Little is known on the efficacy of acupressure.

3.13.2 Publications on acupuncture in weight loss studies

Evidence on the efficacy of acupuncture on weight loss reported here is based on one systematic review and meta-analysis with all included studies conducted in South-East Asia (15 RCTs; 1288 participants) (Quan *et al.*, 2023). Interventions ranged from 30 days to 12 weeks and comprised of body acupuncture, auricular acupuncture, and different types of acupuncture combined with other interventions (e.g.,

exercise, diet, and psychology) compared to control groups undergoing diet, exercise, psychology, or other interventions. One quasi-experimental study applied acupressure to achieve weight loss in children, also considering indicators of well-being (Cha and Park, 2019).

3.13.3 Evidence on the efficacy of acupuncture and accupressure in in children's and adolescents' weight loss programmes

Quan et al. (Quan *et al.*, 2023) found acupuncture to be more effective compared to controls in improving BMI (SMD: -0.45 kg/m^2; 95% CI: -0.69 to -0.21 kg/m^2; I^2 = 71.4%, 12 studies) and body weight (MD: -0.56 kg; 95% CI: -1.01 to -0.10 kg; I^2 = 85.7%, 9 studies), but not in waist circumference (MD: 0.20 cm; 95% CI: 0.50 to 0.90; I^2 = 91.8%, 6 studies). A comparable outcome was reported for acupressure techniques, applied for eight weeks in children aged 9 to 11 years in a recent quasi-experimental study (Cha and Park, 2019). This study demonstrated significant reductions in BMI waist circumference and hip circumference after 8 weeks compared with those in the control group ($p < .001$). No statistically significant differences occurred after the acupressure treatment in body image score, depression score, or self-esteem score.

3.13.4 Evaluating conclusion on acupuncture/acupressure in weight loss interventions

These findings suggest that acupuncture can be a supplementary intervention for paediatric obesity, particularly when combined with other lifestyle modifications. However, body of evidence is very limited and the lack of the familiarity of this technique may pose an impairment of this approach in Denmark.

4 Executive summary on components of strategies applied in intervention studies on reducing overweight and obesity in children and adolescents

With respect to nutrition, interventions on changing the fruit intake have shown minimal effect on BMI or BMI z-scores. Comparably, sugar-sweetened beverages are weakly associated with BMI increases, but replacing them with noncaloric beverages only results in modest reductions in BMI. The outcomes for replacement of sugar with non-nutritive sweeteners (NNS) are mixed: while observational studies suggest a positive association between NNS consumption and increased BMI, randomized trials indicate that NNS can reduce BMI gain compared to sugar. Similarly, low glycaemic index diets have had limited effects on obesity. In contrast, hypocaloric and intermittent energy restriction diets, particularly in adolescents, have proven effective for weight loss and improving body composition.

Aerobic and resistance exercises have been shown to reduce both BMI and body fat percentage. Incorporating high-intensity exercise alongside moderate-intensity activities is particularly effective for reducing BMI and fat mass, while moderate-intensity exercise is optimal for overall weight loss. However, physical activity has been shown to be more effective in combination with other measures such as diet modification and behaviour therapy.

Behavioural therapy, particularly multi-component programs that involve parents, has proven effective for weight loss in children. Approaching weight loss from a behavioural perspective tends to be more successful than focusing exclusively on nutrition or physical exercise. Adding techniques such as motivational interviewing and cognitive-behavioural therapy can further enhance the effect of paediatric weight management strategies.

Multicomponent, lifestyle-based interventions have proven effective in reducing obesity in children and adolescents. Combining diet, physical activity, and behavioural therapy leads to more substantial weight loss compared to using individual components alone, though on average, the results stay back behind the main expectations, namely bringing the majority of children or adolescents back to normal weight.

School-based programs and those with higher contact hours show particularly promising results, although the quality of evidence varies. Follow-up studies indicate that while weight differences tend to level out over time, they remain significant for a few years after the intervention. These findings highlight the importance of implementing multifaceted strategies that have proven their long-term efficacy, to manage and prevent obesity in children and adolescents.

Current evidence on sleep interventions for weight loss is inconclusive. While some research suggests sleep regulation may impact weight management, no definitive arguments exist to include sleep alterations in weight loss programs at this time. Comparable level of evidence exists for interventions

to reduce screen time, which can modestly improve body composition, particularly abdominal fat, though effects on BMI are minimal.

The success of technology-based interventions (e.g., e-health, mobile apps) in promoting weight loss in overweight or obese youth depends on accessibility, engagement, and social support, but further research is needed before widespread implementation in community programs can generally be recommended. Some studies demonstrated that e-health interventions and wearable devices such as smart watches yield small but statistically significant reductions in BMI, though effects on waist circumference are negligible. Studies on mobile apps for weight loss in children and adolescents report inconsistent results in terms of BMI reduction and other obesity indicators. Further, detailed reviews are required to select appropriate e-tools, which then may be integrated alongside other measures. However, technology-based interventions may be cost-effective and have the potential for large-scale application in community-level weight loss programs, though more evidence is needed.

The use of board games in family-based weight management did not prove more effective than traditional behavioural counselling in reducing BMI. The limited evidence does not support incorporating board games into weight loss programs.

Inconsistent evidence exists regarding the benefit of parental involvement in child weight loss programs, though most studies suggest that including parents results in significant BMI reductions, especially in younger children and over long follow-up periods. Peer-led interventions show small but significant reductions in BMI, particularly in physical activity-focused programs. However, they are less effective than professional-led interventions in achieving sustained weight loss.

Medications have shown promising results in reducing BMI in paediatric populations with obesity, though their long-term effectiveness and impact on insulin levels and quality of life need further study. Potential short- and long-term side effects in children and adolescents need to be examined carefully if medication should be used. The current evidence on pro- and synbiotics in obesity management is insufficient to draw conclusive results. More research is needed to understand their potential role.

Bariatric surgery is highly effective for severe paediatric obesity, with considerably greater effect size than other interventions. However, potential side effects and reversibility must be carefully considered before opting for such interventions. Acupuncture may serve as a supplementary intervention for paediatric obesity, but its unfamiliarity and limited evidence restrict its applicability in certain regions, such as Denmark.

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Appendix A.

Reporting protocol for the documentation of international and Danish strategies to reduce overweight and obesity in children and adolescents: PIECOTTS Tables for systematic reviews (SRs)

Which strategies were applied at an international level to reduce body weight in overweight/obese children and adolescents?						
Population	**Intervention or Exposure**	**Comparators**	**Outcomes**	**Timing**	**Setting**	**Study design**
In: Apparently healthy children and adolescents being overweight and/or obese of both sexes aged 2-18 years inside and outside of Denmark. Out: physical or mental illnesses, children with any pre-existing health conditions (e.g., diabetes and kidney disease), eating disorders, pregnancy, actively breast feeding, etc.	In: Interventions targeting weight reduction, or any combination of these interventions, in the following areas: nutrition (including pre-, pro-, and synbiotics), physical activity, pharmacological, surgical, counselling, education (with/without parental involvement, behaviour (cognitive behaviour therapy, sedentary behaviour, meal pattern behaviour, stress management, peer-led programmes, laymen vs. professional guidance), sleep screen-time-based (media consumption), duration and pattern, or e-health (m-health, serious gaming), other technology-based (wearables), acupuncture. Out: Interventions aiming at preventing overweight or obesity	In: Intervention vs. no intervention (e.g. no treatment, wait-list control, usual care). Out: no control group	Primary: change in body mass index (BMI; absolute change, percentage of change, percentile of change, or z-score change) and change in weight (absolute change, percentage of change, or percentile of change), body composition (DEXA, BIA), other metrics of body fatness such as waist circumference and WHR. Secondary: Quality of life, insulin sensitivity	≥ 3 months	Home-based, community-based, school-based, family-based, clinical-based, healthcare.	In: Intervention studies. Out: observational studies.

Appendix B

Summary tables of relevant studies on intervention trials included in the current report considered individually or being part of systematic reviews.

Author, Year,	Country of publication Study type	Topic *Title*	Study design of primary studies	Number of primary studies	Number of studies included in meta-analysis	Year range of primary studies	Number of participants	Age range (yr)	Comparator	Outcome	Results
Duan et al., 2024	China MA	Probiotics *A meta-analysis of the therapeutic effect of probiotic intervention in obese or overweight adolescents*	RCT	8	8	?-2023	391	4-18	Control group of placebo or lifestyle modifications	Anthropometric indices (weight, BMI, WC, WHR, body fat%) fasting blood glucose and C-reactive protein, insulin, Homeostatic Model Assessment of insulin resistance, interleukin 6, tumor necrosis factor alpha, total cholesterol, triglycerides, and low-density lipoproteins	Effect of probiotic vs. control, WMD (95% CI), on: Weight: -1.59 (-7.86, 4.68) kg BMI: -0.93 (-4.26,2.41) kg/m2 HOMA-IR: 0.10 (-0.54, 0.74) Insulin: 0.09 (-0.27 to 0.45)
Liu et al., 2024	USA SR - MA	Sleep *The efficacy of sleep lifestyle interventions for the managment of overweight or obesity in children: a systematic review and metaanalysis*	Quasi-experimental studies, RCTs	8 (2 QEs, 6 RCTs)	5	-	2,231	5-7	no treatment or wait-list control, usual care, or a separate concurrent intervention (e.g., head-to-head trials)	P: body mass index (BMI) (including BMI SDS units, and BMI percentile) S: change in body composition, skinfold thickness, bioelectrical impedance, waist circumference, and dual-energy X-ray absorptiometry (DEXA); reduction in morbidity, changes in reported or quantified (i.e., accelerometers) sleep duration, changes in self- or	Effect of sleep as stand-alone vs. control intervention on Weight: $p < .04$, one study WC: $p < .000$, one study Effect of sleep in a multicomponent intervention vs. control on: BMI: Cohen's d = 0.18, 95% CI= -0.04, 0.40, Z = 1.56, p=.11, 5 studies

										parent-reported sleep quality, either qualitatively (i.e., questionnaires) or quantitatively (i.e., accelerometer-defined sleep efficiency); changes in self- or parent-reported daytime sleepiness; changes in biochemical measures of circadian phase (e.g., melatonin); cost of intervention; intervention adherence and compliance; change in health-related behavior (diet, physical activity); change in health-related quality of life; change in adverse events; and satisfaction with care outcome.	
Wang et al., 2024	China MA	Fruit interventions *The estimated effect of increasing fruit interventions on controlling body weight in children and adolescents: A meta-analysis*	RCT	22	22	2000 - 2023	12,678	3-18	Control group	weight, body mass index (BMI), body mass index-z scores (BMI-z) or waist circumference	Effect of increased fruit intake, MD (95% CI), on: BMI: −0.27 kg/m2 (−0.59 to 0.05 kg/m2), p=0.101 BMI-z: −0.15 (−0.36 to 0.07, p=0.177 WC: −0.65 cm (−1.15 to −0.05 cm), p<0.05 Prevalence of overweight/obesity: OR = 0.74, 95% CI 0.60 to 0.90, p<0.05
Baygi et al., 2023	SR-MA	Psychological interventions *The effect of psychological interventions targeting overweight and obesity in school-aged children: a systematic review and meta-analysis*	RCTs or QRCTs	54	30	Up to and including November 2022	4093	6–18	Control group or comparison between interventions	P: weight, body mass index (BMI), BMI z-score, waist circumference (WC), waist-to-height ratio (WhtR), percentage overweight S: Changes in body composition, blood pressure, biomarkers of metabolic-syndrome, behavioral measures (e.g., dietary intake, physical activity), and measures of quality of life (e.g., perceived physical and mental health)	Effect of psychological intervention vs control, SMD (95% CI), on: BMI z-score: -0.39 (-0.69, -0.09), I2 = 88.60 BMI: -0.79 (-1.48, -0.09), I2 = 97.80 Fat mass: -0.96 (-1.54, -0.38), I2 = 85.00 Body fat: -0.81 (-1.30, -0.33), I2 = 69.29

Bourke et al., 2023	UK SR-MA	Active video games *Active video games and weight management in overweight children and adolescents—systematic review and meta-analysis*	RCT, pilot studies	12 (10 RCTs, 2 pilot studies)	7 RCTs	?-2021	varied between 4 and 327	2-19	Control group, no control group, other interventions	weight, BMI, BMI Z-scores and/or body mass composition (percentage or fat and/or lean mass)	AVG vs control, MD (95% CI), on Weight: −2.66 (−5.67, +0.35) kg, I2 = 0%, p=.08 BMI (Random effect model): -2.29 (−4.81, +0.22), I2 = 49%, p.07) BMI (Fixed effect model): −1.29 (−2.20, −0.38); p=.006 BMI-z: −0.09 (−0.12, −0.05), I2 = 34%, p<.0001
Espinosa et al., 2023	USA SR-MA MEETING ABSTRACT	non-nutritive sweeteners *Effects of non-nutritive sweeteners on the BMI of children and adolescents: a systematic review and meta-analysis of randomized controlled trials and prospective cohort studies*	RCT, prospective cohort studies	13 (5 RCTs, eight prospective cohort studies)	-	-	-	2-9 10-24	-	BMI change	RCT: intake of non-nutritive sweeteners (25–2400 mg/day, from food and beverages) vs. intake of sugar from food and beverages, SMD (95% CI) on BMI: –0·42 kg/m^2 (95% CI –0.79 to –0.06), I^2=89% PCS: non-significant association between consumption of beverages containing nonnutritive sweeteners and BMI gain (0·05 kg/m^2 [95% CI –0·02 to 0·12]; I^2=67%; per daily serving of 355 mL)
Huang et al., 2023	China SR-MA	Exercise *Effects of different exercise modalities and intensities on body composition in overweight and obese children and adolescents: a systematic review and network meta-analysis*	RCT	32	32	?-2023	1,452	5-18	Participants in the control group were required to maintain their current level of physical activity or perform a different intensity and/or form of exercise.	fat mass, body fat %, BMI, fat-free mass, and weight	Effect of different exercise modalities and intensities, MD (95% CI), on: Body fat %: RT-M vs. control: -1.79 (-3.15, -0.43) kg Network, p<.05 RT-HI vs. control: -2.01 (-3.45, -0.57) kg Network, p<.05 AE-M vs. control: -2.08 (-2.88, -1.28) kg Network, p<.05 AE-HI vs. control: -1.94 (-2.77, -1.11) kg Network COM-M vs. control: -2.52 (-3.83, -1.20) kg Network, p<.05 COM-HI vs. control: -2.18 (-3.70, -0.67) kg Network, p<.05 RT vs. AE (Direct): -0.49 (-0.82, -0.16) kg Pairwise, p<.05 BMI:

											COM-HI vs. control: -1.90 (-3.22, -0.56) kg, p<.05 Pairwise AE-M vs. control: -1.53 (-2.56, -1.09) kg, p<.05 Pairwise COM-M vs. control: -1.34 (-2.27, -0.42) kg, p<.05 Pairwise AE-HI vs. control: -1.29 (-2.01, -0.58) kg, p<.05 Pairwise COM-M vs. RT-M: -0.76 (-0.46, -0.06) kg, p<.05 Pairwise COM-HI vs RT-HI: -1.20 (-2.26, -0.14) kg, p <.05 Pairwise COM-HI vs control: -1.65 (-3.27, -0.02) kg, p <.05 Network AE-M vs control: -1.49 (-2.12, -0.86) kg, p <.05 Network COM-M vs control: -1.43 (-2.35, -0.51) kg, p <.05 Network AE-HI vs control: -1.18 (-1.93, -0.44) kg, p <.05 Network RT-M vs control: -0.91 (-1.78, -0.05) kg, p <.05 Network RT-HI vs control: -0.43 (-1.76, -0.90) kg, p <.05 Network Fat mass: COM-HI vs. control: -2.40 (-3.87, -0.92) kg Pairwise, p<.05 AE-HI vs. control: -2.55 (-3.77, -1.34) kg Pairwise, p<.05 AE-M vs. control: -2.38 (-4.33, -0.42) kg Pairwise, p<.05 RT-HI vs. control: -1.47 (-2.40, -0.90) kg Pairwise, p<.05 AE-M vs. control: -2.31 (-3.83, -0.79) kg Network, p< 05 AE-HI vs. control: -2.25 (-3.51, -1.00) kg Network, p<.05 COM-M vs. control: -2.87 (-4.97, -0.76) kg Network, p<.05 COM-HI vs. control: -2.87 (-4.84, -0.91) kg Network, p<.05 RT-HI vs. control: -1.56 (-3.40, 0.28) kg Network, p<.05 Fat free mass: RT-M vs. Control: 0.70 (0.46, 0.94) kg Pairwise

											RT-HI vs. AE-HI: 0.69 (0.47, 0.91) kg Pairwise RT-M vs. AE-M: 0.88 (0.65, 1.11) kg Pairwise RT-HI vs. Control: 1.10 (0.22, 1.99) kg, p<.05 Network Weight: COM-M vs. Control: -4.49 (-6.24, -2.73) kg, p<0.05 Pairwise AE-HI vs. Control: -2.33 (-3.01, -1.46) kg, p<0.05 Pairwise AE-M vs. Control: -2.03 (-2.58, -1.47) kg p<.05 Pairwise COM-M vs. RT-M: -1.82 (-5.09, -1.45) kg Pairwise AE-HI vs. AE-M: -0.68 (-1.74, -0.37) kg Pairwise AE-M vs. Control: -2.03 (-2.76, -1.31) kg p<.05 Network AE-HI vs. Control: -2.29 (-3.19, -1.39) kg p<.05 Network RT-M vs. Control: -1.41 (-2.38, -0.44) kg p<.05 Network COM-M vs. Control: -4.58 (-5.94, -3.22) kg p<.05 Network COMHI vs. Control: -3.11 (-6.11, -0.12) kg p<.05 Network COM-HI vs. Control: -0.36 (-2.15, 1.43) kg p>.05 Network
Jakobsen et al., 2023	Denmark SR-MA	Nutrition *Effects of foods, beverages and macronutrients on BMI z-score and body composition in children and adolescents: a systematic review and meta-analysis of randomized controlled trials*	RCT	16	13	Up to July 2021	1773	4-18	lower consumption of a food, beverages or macronutrient	P: BMI, body fat mass or lean body mass	SSB vs. non-caloric beverages or flavored milk, MD (95% CI) on BMI-z: − 0.05 (− 0.20, 0.09), p=0.48, 2 studies, I2 = 90% BF%: -0.70 (− 0.78, − 0.62), p<0.001, three studies, I2 = 0%

Kalaitzopoulou et al., 2023	Greece SR-MA	Low Glycemic Index/Load Diet *The Effectiveness of a Low Glycemic Index/Load Diet on Cardiometabolic, Glucometabolic, and Anthropometric Indices in Children with Overweight or Obesity: A Systematic Review and Meta-Analysis*	RCT	11	11	Inception-2023	634	7-18	Any dietary intervention	P: Body weight, BMI, BMI z-score, waist circumference S: FM, F%, fasting blood glucose, fasting insulin, HOMA-IR, LDL-c, HDL-c, total cholesterol, triglycerides, SBP, DBP	Effect of low glycemic index/load diet vs. control diets, MD (95% CI), on: BW: −0.14 (−1.93 to 1.64), PI −3.04 to 2.76) BMI: −0.31 (−0.85 to 0.23), PI −1.07 to 0.45 BMI z-score: −0.03 (−0.09 to 0.02), PI −0.12 to 0.06 WC: −0.52 (−2.35 to 1.31), PI −3.49 to 2.45 FM: −0.23 (−2.61 to 2.16) Fat%: −0.19 (−1.07 to 1.26), PI −2.46 to 2.65 Fasting insulin (Fins): −0.61 (−4.16 to 2.94), PI −10.03 to 8.81 HOMA-IR: -0.40 (−1.08 to 0.28), PI −2.19 to 1.39
Li et al., 2023	China SR-MA	Probiotics *Effects of probiotic administration on overweight or obese children: a meta-analysis and systematic review*	RCT	5	4	inception to 2023	206	6-18	Placebo group	P: BMI, TG, and TC	Probiotic vs. placebo group, WMD (95% CI) on BMI: 0.85 (0.04 to 1.66), p=0.04, four studies, I2 = 83%, p=0.0005
Loy et al., 2023	USA Scoping R	Probiotics *Probiotic Use in Children and Adolescents with Overweight or Obesity: A Scoping Review*	RCT	19	-	Inception-2021	945	4 mo-19	Placebo	BMI, waist circumference; TNF alpha, tumor necrosis factor alpha; IL-6, interleukin 6; lipopolysaccharide; CRP, triglyceride; LDL, total cholesterol; HDL, glucose; HOMA, homeostatic model assessment for insulin resistance; GLP1, blood pressure, insulin	Probiotics demonstrated heterogeneous effects across 19 studies: 16 showed positive outcomes such as reduced BMI and improved metabolic markers, while one showed negative effects, and two showed no significant impact. Seven studies showed improvements in inflammatory markers, adiposity, WC, fasting insulin, HOMA-IR, ultrasound results, liver function tests, cholesterol, triglycerides, behavioral

											and mental health, and social withdrawal.
Park & Kim 2023	Korea SR	Nutrition *Systematic review of macronutrients modified dietary intervention in the management of 1 overweight/obese children and adolescents*	RCT	9	-	2000 - 2016	647	7-18	Any comparison among macronutrient modification intervention groups	Obesity-related trait, lipid, and glycemic parameters	A macronutrient-modified dietary intervention across nine studies consistently demonstrated improvements in body composition, lipid profiles, and glycemic parameters. In seven studies, significant enhancements in BMI z-scores, body fat mass, lipid profiles, and glycemic parameters were observed without notable differences among diet groups. However, two studies comparing low-carbohydrate (LC) and low-fat (LF) diets showed varying results, with greater weight loss in the LC group, improved non-HDL cholesterol levels, and decreased triglyceride levels compared to the LF group.
Quan et al., 2023	China SR-MA	Accupuncture *Does acupuncture improve the metabolic outcomes of obese/overweight children and adolescents? A systematic review and meta-analysis*	RCT	15	15	Inception-2023	1288	8-16	Subjects undergoing diet, exercise, psychology, and other interventions were included as control groups	BMI, waist circumference, and body fat. Metabolic outcomes included lipid metabolism indicators of obesity/overweight such as serum leptin, triglyceride (TG), total cholesterol (TC), low-density lipoprotein (LDL), and high-density lipoprotein (HDL).	Acupuncture vs. control, SMD (95% CI): BMI: -0.45 (-0.69 to -0.21), I2 = 71.4%, 12 studies BW: -0.56 (-1.01 to -0.10), I2 = 85.7%, 9 studies WC: 0.20 (.0,50 to 0.90), I2 = 91.8%, 6 studies
Santos et al., 2023	Brazil SR	Probiotic *Effect of oral probiotic supplementation in obese children: A systematic review*	RCT	8	-	2010 - 2022	554	0-18	Oral placebo supplementation	reduction in body weight, waist circumference, and body fat percentage	• Long-term Effects (Birth to 12 Years) showed mixed results. One study observed a moderated weight gain from birth to four years, especially in overweight children at ten years (p=0.063). Another study found no significant effect on BMI (p=0.67) or BF% (p=0.82).

											• Probiotic intervention significantly decreased BMI in overweight, obese, and severely obese children. • WC reduction observed in obese and severely obese children • BF% decreased significantly (p=0.021) in one study. • Two studies did not observe changes in body composition after probiotic intervention (p = 0.256)
Alotaibi et al., 2022	Saudi Arabia R	Technological interventions (AI, robots, or ML techniques) *Efficacy of Emerging Technologies to Manage Childhood Obesity*	RCT and interventions	26	-	2010 – 2021	ranged from 17 to 18,818	≤18	Control group	BMI) BMI z-score, or BMI percentile, or other anthropometrical, diet-based, and physical activity measurements.	Positive effects on BMI or BMI-related measures: • Active video game and exergame interventions such as Xbox 360, or music and video games demonstrated effectiveness in reducing BMI or BMI z-scores. • Engagement in moderate intensity exergaming showed reductions in BMI and improvements in fundamental movement skills. • Group sessions combining healthy eating habits with active video games led to increased nutritional knowledge and adherence to dietary recommendations. Mixed effects on BMI or BMI-related measures: • While some studies reported decreases in BMI or BMI z-score among participants engaged in dance-based exergaming others found no effect. No effect on BMI or BMI-related measures: • Stationary biking with "GameBike" intervention vs. stationary cycling with music showed no difference respect to BMI.
Flynn et al., 2022	UK SR	Intervention settings	RCT	28	-	2010 - 2020	ranged from 18 to 1211	0-5	Control group	BMI (z-scores and percentiles), skinfold measures, weight, and height	Home-based interventions, integrating family involvement and lifestyle modifications, were most effective in

		Preventing and treating childhood overweight and obesity in children up to 5 years old: A systematic review by intervention setting									reducing childhood obesity; 4 out of 5 studies showed significant weight improvements, with all studies reporting dietary and physical activity enhancements. School-based interventions showed some effectiveness (5/11 studies), while community-based interventions had minimal impact and hospital/clinic-based interventions had mixed results. E-health interventions did not significantly affect obesity measures overall, but one study noted dietary and behavioral improvements.
Kouvari et al., 2022	Greece SR-MA	Digital Health Interventions *Digital Health Interventions for Weight Management in Children and Adolescents: Systematic Review and Meta-analysis*	RCT	8	8	2000 - 2021	582	≤18	Control group	BMI, BMI z-score, and other BMI-related metrics (eg, BMI-SD score)	Technology-based vs control, SMD (95% CI), on BMI-related metrics: –0.61 (–1.10 to –0.13); p=.01 After 6 mo: –0.37 (–0.72 to –0.03); p=.03 After 24 mo: –0.31 (–0.63 to 0.02); p=.07 The effect of parental involvement in technology-based vs control, SMD (95% CI), on BMI-related metrics: Yes: –0.39 (–0.59 to –0.18); p<.001 No: –0.36 (–0.83 to 0.11); p=.14
Lassale et al., 2022	Spain SR	Mediterranean diet *Mediterranean diet and adiposity in children and adolescents: A systematic review*	Interventions and observational studies	55 (8 interventions, 47 observational studies)	-	2010 - 2021	441,740	2-18	Control group (three did not compare to a control group)	weight, BMI, waist circumference, and body fat	When compared to a control group, three interventional studies found significant differences in obesity or BMI, while two did not, and three did not compare with a control. More than half of observational studies found no evidence of an effect on markers of abdominal obesity, while three out of five longitudinal studies found a negative association.
Li et al., 2022	China SR-MA	Lifestyle interventions	RCT	8	8	January 1980	495	<18	Control group	P: changes in BMI S: fasting blood glucose (FBG), blood pressure, total	Lifestyle intervention vs. control MD (95% CI):

		Effectiveness of lifestyle interventions for treatment of overweight/obesity among children in China: A systematic review and meta-analysis				- April 2022				cholesterol, low-density lipoprotein, high-density lipoprotein, and triglyceride.	BMI change: -1.49 (−2.20 to -0.77; p<.001) BMI change including multi-component interventions: MD (95% CI) = -2.03 kg/m2 (−3.62 to -0.43), p< .001, 5 studies) vs. PA alone (pooled BMI (95% CI) = -0.90 (-1.53, -0.27) kg/ m2, 3 studies) or health education alone (pooled BMI (95% CI) =-0.85 (-1.28, -0.43) kg/m2, 2 studies).
Méndez-Hernández et al., 2022	Mexico SR-MA	Strength training *Effects of Strength Training on Body Fat in Children and Adolescents with Overweight and Obesity: A Systematic Review with Meta-Analysis*	RCT	28	10	2000 - 2021	1834	5-19 (av. 12.5 ± 2.6)	Not stated	% body fat, fat free mass, BMI, waist circumference	The effect of strength training on Body fat%: OR (95% CI) = -3.63 (2.60-4.66)
Nguyen et al., 2022	SR-MA	Peer-led programs *Effectiveness of peer-led programs for overweight and obesity in children: systematic review and meta-analysis*	RCT	14 (RCTs, 10 cluster-randomized, 4 individual randomizations)	9	Inception-2018	10,684	<18	Control group	BMI, BMI z-score and BMI percentile	The effect of peer-led programs, MD (95% CI), on (random or fixed effect model) BMI: -0.15 kg/m^2 (−0.26, −0.03), p=.01; I2 = 28%, p=0.19, 9 studies BMI z-score: -0.06 (−0.17, 0.04), p=.25; I2 = 82%, p<-0001, 7 studies BMI percentile: -0.89 (-2.60, 0.82), p=0.31; I2 = 0%, p=0.88, 3 studies Overall effect on BMI, BMI z-score and BMI percentile (combined effect model): MD (95% CI) = -0.06 (-0.10, -0.01), p=.03; I2 = 8%, p=0.36, 13 studies Intervention effect on BMI using PA MD (95% CI) = -0.63 (-1.01, -0.25), p=.001 vs. mixed education approach MD

											(95% CI) = -0.10 (-0.22, 0.02), p=0.10, I2 = 0%, p=0.58
Qiu et al., 2022	China SR-MA	E-health *Effectiveness of multiple eHealth-delivered lifestyle strategies for preventing or intervening overweight/obesity among children and adolescents: A systematic review and meta-analysis*	RCT	40	32 [BMI], 25 [BMI z-score], 11 [WC], 11 [BW], 6 [body fat%]	Inception-2022	6,403	6-18	Control group treated according to standard or usual care, without any intervention, wait-list intervention, or another delivery mode (e.g., face-to-face)	BMI, BMI Z-score, waist circumference, body weight, and body fat%	e-health vs. control, WMD (95% CI), on BMI: WMD (95% CI) = −0.32 (-0.50 to -0.13), I2 = 85.9% BMI z-score: −0.08 (−0.14 to −0.03), I2 = 89.1%, 25 studies WC: −0.87 (−1.70 to −0.04), I2 = 43.3%, 11 studies BW: −0.96 (−1.55 to −0.37), I2 = 0.0%, 11 studies Body fat%: −0.59 (−1.08 to −0.10), I2 = 0.0%, 6 studies e-health effect, WMD (95% CI), on BMI using parental or school involvement: −0.66 (−0.98 to −0.34) vs no parental or school involvement: −0.00 (−0.22 to 0.22)
Soares et al., 2022	Brazil SR	Physical activity *Effects of physical activity on body mass and composition of school-age children and adolescents with overweight or obesity: Systematic review focusing on intervention characteristics*	cohort, case-control, cross-sectional, cluster-randomized, pharmacological, reviews	27	-	?-2021	1,216	5-17	Non-exercise control group	BMI, total body mas, BMI percentile, BMI z-score, % fat, waist circumference, hip circumference, WHR, etc.	Improved body mass and body composition was observed when PA was • Performed for 6- to 35 weeks (mostly 12–14 weeks) • 2- to 5 d/wk (mostly 3 d/wk) • during 8- to 60 min (mainly 60 min) • with moderate to high intensity (60–90% maximal heart rate or 40–70% heart rate reserve) • recreational or systematized
Torbahn et al., 2022	UK Cochrane update	Surgery *Surgery for the treatment of obesity in*	RCT	1	-	Inception-2015	50	<18	(a) Surgery. (b) Surgery + other therapy.	P: BMI, weight loss S: Health-related quality of life and self-esteem, All-cause mortality. Morbidity (changes in disease status).	The effect of surgery intervention on Weight (at two years): -34.6 kg (95% CI 30.2 to 39.0), p<.001 BMI: -12.7 (95% CI 11.3 to 14.2), p<.001

		children and adolescents							Placebo compared with (a), usual care (non-surgical treatment) compared with (a), placebo + other therapy compared with (b), usual care (non-surgical treatment) + other therapy compared with (b).	Measures of body fat distribution. Behaviour change. Participants' views of the intervention. Socioeconomic effects.	The effect of lifestyle intervention on Weight: -3.0 kg (95% CI 2.1 to 8.1), p<.001 BMI: -1.3 (95% CI 0.4 to 2.9), p<.001 At two years, the gastric banding group performed better than the lifestyle group in two of eight health-related quality of life concepts.
Wang et al., 2022	China SR-MA	Wearable devices The *Effectiveness of Wearable Devices as Physical Activity Interventions for Preventing and Treating Obesity in Children and Adolescents: Systematic Review and Meta-analysis*	RCT	12	10 [BMI], 6 [BMI-z], 5 [BW], 5 [WC], 6 [BF%]	Incep tion-2021	3227	6-18	Control group	BMI, BMI z-score (BMI-Z), body weight, or body fat.	Wearable devices vs. control MD (95% CI): BMI: –0.23 (–0.43 to –0.03); p=.03; I2=2%, 10 studies BMI z-score: –0.07 (–0.13 to –0.01), p=.01; I2=81%, 6 studies Body weight: –1.08 (–2.16 to –0.00), p=.05; I2=58%, 5 studies Body fat %: –0.72 (–1.19 to –0.25), p=.003; I2=5%, 6 studies WC: 0.55 (–0.21 to 1.32), p=.16; I2=0%, 5 studies
Zhang et al., 2022	China MA	Screen time *Effect of screen time intervention on obesity among children and adolescent: A meta-analysis of randomized controlled studies*	RCT	14	14	1990 - 2020	1894	≤18	Control group	Screen time, BMI, BMI-z	The effect of screen time intervention, MD (95% CI), on BMI: -0.14 (−0.29 to 0.00), p=0.163 BMI-z: 0.01 (−0.03 to 0.06), p=0.981 Waistline: −0.60 cm (−1.88 to 0.69), p<0.001

Aceves-Martins et al., 2021	Mexico SR-MA	Intervention evaluation *Interventions to Treat Obesity in Mexican Children and Adolescents: Systematic Review and Meta-Analysis*	RCT, controlled clinical trials, cohort studies	29 (10 RCTs, 3 controlled clinical trials, 16 cohort analytic studies)	4	1995 - 2021	2302	≤18	Studies with or without a control group were considered.	body mass index, body mass index z-score	The effect of various interventions vs control to treat obesity on: BMI (≤6 mo): -1.52 (95%CI -2.15 to -0.89), I2 = 66% BMI (12 mo): -1.31 (95%CI, -1.73 to -0.89), I2 = 50%
Albornoz-Guerrero et al., 2021	Chile SR	Multicomponent interventions *Characteristics of Multicomponent Interventions to Treat Childhood Overweight and Obesity in Extremely Cold Climates: A Systematic Review of a Randomized Controlled Trial*	RCT	29	-	2010 - 2020	4434	6-12 (av. 9.3)	Not specified	P: BMI, BMI Z-score BMI-SDS S: nutritional status and physical and mental health (depression, mood, self-esteem, health-related quality of life, anxiety, or others.)	Positive effects on the reduction of BMI, included: ≤ 6 mo: • recreational activities • education • nutritional programs • participation of both child and parents 2 mo: • physical activity recommendations • nutritional and physical exercise programs • cooking classes • participation of both child and parents
Azevedo et al., 2021	Narrative SR-MA	E-health *The effectiveness of e-health interventions for the treatment of overweight or obesity in children and adolescents: A systematic review and meta-analysis*	RCT	19	16	?- 2020	2,352	≤17	no intervention, wait-list control, standard or usual care, or concomitant intervention (another behavior-change intervention, which was also delivered in the	BMI, BMI-z	E-health vs. control, SMD (95% CI), on BMI or BMI-z: -0.31 (-0.49 to -0.13), I2 = 74%, p<0.001

									intervention group)		
Bae & Lee 2021	South Korea MA	Diet, exercise, and lifestyle interventions *The effect of diet, exercise, and lifestyle intervention on childhood obesity: A network meta-analysis*	RCT	24	24	?-2019	2145	6-12	Comparison of two or more interventions (i.e., diet, exercise, lifestyle, a combination of two out of the three interventions, or all three, each with or without parental aid) or comparison of the research intervention group to a comparative control group	Changes in BMI, BMI z-score, percent body fat, or percent overweight	E w/o P was the most effective treatment at reducing obesity index measurements, followed by the D w/P and D+E+L w/P treatments. Efficacy of treatment options on intervention effect vs. no intervention, SMD (95% CI): E w/oP: -1.59 (-2.23 to -0.96) D w/P: -1.02 (-1.79 to -0.25) D w/oP: -0.79 (-1.68 to 0.10) D+E+L w/P: -0.65 (-1.14 to -0.15) D+E w/oP: -0.66 (-1.78 to 0.46) D+E+L w/oP: -0.40 (-1.13 to 0.33) D+E w/P: -0.18 (-0.93 to 0.58)
Bondyra-Wiśniewska et al., 2021	Poland SR	Lifestyle interventions *Impact of Lifestyle Intervention Programs for Children and Adolescents with Overweight or Obesity on Body Weight and Selected Cardiometabolic Factors—A Systematic Review*	Any nutritional intervention	18	-	2010 - 2019	1587	6-18	Majority of interventions had no control group, but control groups were reduced calorie diet (low fat, high fiber) or standard care groups	P. BMI, BMI-z, at least one lipid profile component (such as total cholesterol, low density lipoprotein cholesterol, high density lipoprotein cholesterol and triglycerides) S: body composition assessment (lean mass, body fat, free-fat mass), waist circumference, waist to hip ratio and blood pressure	Decrease in BMI and/or BMI z-score associated with diet, PA, involvement of dietician/nutrition specialist and physician, longer duration of intervention. Decrease in BMI associated with improvements in total cholesterol, triglycerides, low density lipoprotein cholesterol, and blood pressure.
Cao et al., 2021	China MA	Exercise	RCT	12	12	Until 2021	325	6-18	moderate-intensity	body mass (BM), body mass index (BMI), total body fat	HIIT vs MICT, SMD (95% CI), on VO2 max: 0.87 (0.39 to 1.35), p=.000

		Effects of High-Intensity Interval Training and Moderate-Intensity Continuous Training on Cardiometabolic Risk Factors in Overweight and Obesity Children and Adolescents: A Meta-Analysis of Randomized Controlled Trials							continuous training group (MICT)	percentage (%BF), visceral adipose tissue (VAT), fat-free mass (FFM), maximal oxygen uptake (VO2max), systolic blood pressure (SBP), diastolic blood pressure (DBP), triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), blood glucose (BG), blood insulin (BI) and homeostasis model assessment (HOMA-IR).	systolic blood pressure: −0.64 (−1.05 to −0.22), p=.003, I2 = 78.4%; p = 0.000 BMI: 0.03 (−0.75 to 0.80), p=0.949, I2 = 89.8%; p = 0.000, 12 studies BM: −0.10 (−0.61 to 0.41), p=0.705, 11 studies Body fat %: -0.23 (−0.73 to 0.28), p=0.380, I2 = 74.5%; p = 0.000, 10 studies FFM: 0.15 (−0.16 to 0.45), p=0.338, I2 = 3.6%; p = 0.394, six studies Abdominal fat: -0.21 (−1.19 to 0.76), p=0.670, six studies Blood insulin: −0.21 (−0.99 to 0.57), p=0.596, I2 = 74.5%; p=0.008, four studies HOMA-IR: 0.08 (−0.54 to 0.70), p=0.803, I2 = 70.1%; p=0.008, four studies
Chen et al., 2021	China SR-MA	Exercise *Effects of aerobic exercise and resistance exercise on physical indexes and cardiovascular risk factors in obese and overweight school-age children: A systematic review and meta-analysis*	RCT	13	13 [BMI], 8 [BF%], 6 [TG, TC], 7 [LDL; HDL], 5 [insulin, HOMA-IR]	2000 - 2021	504	6-12	Other types of intervention or a placebo condition or healthy control	body mass index (BMI) and body fat percentage, and cardiovascular risk factors such as VO2peak, triglycerides (TG) and low-density lipoprotein (LDL), high-density lipoprotein (HDL), total cholesterol (TC), insulin and insulin resistance	Aerobic exercise and resistance exercise vs. control, MD (95% CI), on BMI: -0.66 (0.9 to -0.43), p<.00001; heterogeneity: I2 =85%; x2 =94.01; p < 0.00001, 13 studies BF%: -1.29 (2.39 to -0.18), p=.02; heterogeneity: I2 =86%; x2 = 62.72; p<.00001, eight studies Insulin and insulin resistance: N/A due to limited number of trials
Jacob et al., 2021	UK SR-MA	School-based interventions with health education *A systematic review and meta-analysis of school-based*	RCT, QE, non- RCT	39	14	2006 - 2020	-	10-19	Control group	BMI, BMI z-score	Interventions with after-school components, parental involvement, digital media usage, measures to improve the environment, and involvement of key stakeholders like teachers and parents were associated with significant reductions in BMI and/or BMI z-score.

		interventions with health education to reduce body mass index in adolescents aged 10 to 19 years									The overall pooled estimate of change in BMI z-score in the intervention group compared with the control group was -0.06 (95% CI -0.10 to -0.03; p < 0.001).
Lee 2021	MA	Exercise *Influences of exercise interventions on overweight and obesity in children and adolescents*	RCT	27	27	January 1990 - August 2020	-	7-18	Control group	BMI, % body fat, fat free mass, fat mass, waist circumference, fasting glucose, fasting insulin, insulin resistance, CRP, TNF-alpha, triglycerides, total cholesterol, HDL, LDL, SBP, DBP, and VO2_peak	The effect of exercise, d (95% CI), on BMI: −0.28 (−0.75 t0 0.20), p=.25, k = 11 BF%: −0.54 (−0.95 to −0.14), p=.01, k = 12 FFM: −0.68 (−1.30 to −0.05), p=.03, k = 7 WC: −0.02 (−0.82 to 0.77), p=.95, k = 6 Fasting insulin: −0.51 (−0.77 to −0.26), p=.00, k = 3
Mado et al., 2021	Indonesia SR	Family involvement *Intervention empowerment of families in preventing and controlling overweight and obesity in children: A systematic review*	RCT	20	-	2014 - 2019	-	2-18	Control group	BMI	Effective components in intervention empowerment in families: • Health education and training activities • Various approaches, such as courses, teaching practices, and utilizing media like flipcharts and posters, are effective in delivering health education. • Socioeconomic backgrounds greatly influence the effectiveness of interventions. • Family empowerment allows for the optimization of health education programs by modifying intervention methods and media used. • The Participative Health Education method is recommended for all families, offering advantages such as scalability, flexibility, diverse media usage, and longer intervention duration (~6 months) to ensure sustained health behavior change.

Suleiman-Martos et al., 2021	Spain SR-MA	Gamification *Gamification for the Improvement of Diet, Nutritional Habits, and Body Composition in Children and Adolescents: A Systematic Review and Meta-Analysis*	RCT	23	6 [Nutritional knowledge], 2 [BMI-z]	Inception-2021	11,280	5-19	comparison was made between the pre- and post-intervention groups, or the intervention and control groups	diet and body composition improvement	Gamification vs. control, SMD (95% CI), on BMI z-score: -0.05 (-0.21 to 0.11), I2 = 100%, 2 studies
Valeriani et al., 2021	Italy SR	Exergames *Exergames in Childhood Obesity Treatment: A Systematic Review*	RCT	10	-	Until 2021	1251	0-18	age- and condition-matched control group	weight and/or body mass index/z-scores and circumferences reduction	Seven out of ten studies reported better outcomes in children/adolescents involved in the exergame interventions, with significant differences between groups in four, while three studies found better outcomes in control groups.
Tomayko et al., 2021	USA UR	Parental involvement *Parent Involvement in Diet or Physical Activity Interventions to Treat or Prevent Childhood Obesity: An Umbrella Review*	SR, MA	14	-	Inception-2020	130,260; 119,299 from prevention, 10,961 from treatment-focused	3-12	control group, comparison group, and/or alternative treatment group	BMI, BMI z-score, BMI percentile, weight	Family behavioral treatments show a significant decrease in child BMI-z score at six-month follow-up but not consistently later. Family treatments result in a significant decrease in child percent overweight. Educational interventions with parent involvement led to a significant decrease in child BMI but not in BMI-z. Parent-only interventions, while effective compared to usual care or waitlist controls, show no superiority over minimal control interventions. School-based prevention interventions involving parents demonstrate significant reductions in child BMI.
Whitley & Yahia 2021	USA & Canada SR	Clinic-based telehealth vs. face-to-face interventions *Efficacy of Clinic-Based*	RCT, case series. Cohort studies, cross-	10	-	2011-2021	747	6-18	Comparison interventions included face-to-face in-person visits vs.	BMI, BMI z-score	Both clinic-based telehealth and face-to-face weight management interventions are effective in reducing obesity in children and adolescents, with a lack of evidence on which modality is more effective. Combining

		Telehealth vs. Face-to-Face Interventions for Obesity Treatment in Children and Adolescents in the United States and Canada: A Systematic Review	sectional studies						telehealth visits		both modalities as adjunct therapies showed outcome improvements in 5 out of 10 studies.
Bean et al., 2020	USA SR	Parental involvement *Parent Involvement in Adolescent Obesity Treatment: A Systematic Review*	Prospective RCT, RCT	32	-	Inception-2019	-	12-18	Control group	BMI, BMI z-score	Joint Sessions with Parent-Adolescent Dyads: • Joint lifestyle management sessions involving both parents and adolescents show effectiveness in weight loss interventions. • Involvement of both parents and adolescents leads to greater adolescent weight loss compared to individual involvement. • Joint sessions can foster communication and support between parents and adolescents, enhancing treatment outcomes. Separate but Concurrent Group Sessions for Mother-Adolescent Dyads: • In some cases, separate but concurrent group sessions for mothers and adolescents may be more effective than joint sessions. • Superior weight loss outcomes were observed when interventions were delivered to mother-adolescent dyads separately, suggesting the importance of the nature of parental involvement. • Mother's attendance is a significant factor, indicating that consistent parental involvement is crucial for success. Parent-Only Treatment vs. Combined Treatment: • Involvement of both parents and adolescents results in greater

											adolescent weight loss compared to treatment involving only one group individually. • Parent-only treatment is superior for younger children (<11 years), while combined treatment yields greater weight loss for adolescents (≥11 years). Enhanced Parenting Component in Behavioral Treatment: • Enhanced parenting components focused on increasing parental modeling and communication skills may not necessarily lead to better weight loss outcomes for adolescents. • Adolescents who received standard behavioral treatment without enhanced parenting showed a trend for greater BMI reduction
Goldthorpe et al., 2020	UK SR	School-based interventions *Are primary/elementary school-based interventions effective in preventing/ameliorating excess weight gain? A systematic review of systematic reviews*	SR of RCT, non-RCT, no control, RCT	10		2007 - 2019 (trials in included SRs between 1973 - 2017)		4-12	no intervention or comparison between different interventions	BMI, BMIz, diet, exercise, weight management, lifestyle, physical activity, sedentary behavior, fruit and vegetable consumption, sugar consumption, food	Multifaceted interventions promoting PA and reducing sedentary behavior were most effective for weight loss, while dietary strategies improved behavioral and cognitive outcomes. Other effective components for weight-management included parental involvement and longer duration. However, the optimal duration for interventions remains unclear.
McGavock et al., 2020	SR-MA	Layperson-led vs professional-led behavioral interventions *Layperson-Led vs Professional-*	RCT	78	Immediate postintervention weight change: 5 [layperson vs standard,	1996 - 2019	5780	5-18	professional-led vs standard, (2) layperson-led vs standard, and (3) professional-	BMI, BMI z-score	Professional-led weight loss interventions were associated with reductions in weight (MD (95% CI) = −1.60 kg (−2.30 to −0.99 kg); 68 trials; p<.001) and BMI (SMD (95% CI) = −0.30 (−0.39 to −0.20); 59 trials; p<.001) that were not sustained long term (weight MD (95% CI) = −1.02 kg (−2.20 to 0.34

		Led Behavioral Interventions for Weight Loss in Pediatric Obesity			layperson vs professional], 68 [professional vs standard] Immediate postintervention BMI change: 8 [layperson vs standard], 5 [layperson vs professional] 59 [professional vs standard] Long-term weight change: 1 [layperson vs standard], 4 [layperson vs professional] 21 [professional vs standard] Long-term BMI change: 2 [layperson vs standard], 3 [layperson vs profession				led vs layperson-led weight loss interventions.		kg); 21 trials; p=.06; BMI SMD (95% CI) = −0.12 (−0.46 to 0.21); 20 trials; p<.001). No association between layperson-led interventions and weight loss in the short-term (MD (95% CI) = −1.40 kg (−3.00 to 0.26 kg); 5 trials; p=.05) or long-term (MD (95% CI) = −0.98 kg (−3.60 to 1.80 kg); 1 trial; p=.23) compared with standard care. No difference in head-to-head trials (professional vs layperson MD (95% CI) = −0.25 kg (−1.90 to 1.30 kg); 5 trials; p=.38).

					al] 20 [professional vs standard]						
McMullan et al., 2020	UK SR	Technology-based intervnetions *A systematic review to assess the effectiveness of technology-based interventions to address obesity in children*	RCT	11	-	Up and until 2018	varied from 26 to742	8-18	non-technology-based interventions or the stated technology-based interventions compared with each other	P: BMI S: weight, BMI percentile, BMI z-score, percentage body fat (% BF), waist circumference (WC) and waist to hip ratio (WHR)	Two out of five studies on active video games demonstrated a statistically significant mean difference for the intervention compared to the control for all or some of their weight-related outcomes. One out of five internet-based studies had a statistically mean difference for the intervention compared to the control for one of its weight-related outcomes. One technology-based intervention using mobile phone communication had no statistically significant impact on body weight, BMI, BMI z-score, WC and WHR compared to the control group.
Salam et al., 2020	Pakistan UR	Lifestyle interventions *Effects of Lifestyle Modification Interventions to Prevent and Manage Child and Adolescent Obesity: A Systematic Review and Meta-Analysis*	RCT, QE	654	-	1990 - 2020	-	0-19	no intervention or standard of care	P: MI z-scores, BMI, change in body weight, and adverse events S: prevalence of overweight and obesity, percentage body fat change, skin fold thickness, waist circumference, health-related quality of life, self-esteem, and cost effectiveness of the intervention	Diet and exercise interventions vs. control, MD (95% CI), on BMI z-score: -0.12 (-0.18 to -0.06), 32 studies; 33,039 participants; I2 93% BMI: -0.41 kg/m2 (-0.60 to -0.21), 35 studies; 47,499 participants; I2 98% BW: = -2.07 (-2.90 to −1.24), 24 studies; 4415 participants; I2 86% WC: -2.03 (−3.50 to −0.56), 8 studies; 2234 participants; I2 87% Behavioral therapy alone vs control, MD (95% CI), on BMI-z: −0.07 (−0.14 to −0.00), 19 studies; 8569 participants; I2 76% Combination of exercise and behavioral therapy vs control, MD (95% CI), on BMI z-score: −0.08 (−0.16 to −0.00), 9 studies; 7334 participants; I2 74%

											Combination of diet, exercise and behavioral therapy vs. control, MD (95% CI), on BMI z-score: −0.13 (−0.25 to −0.0), 5 studies; 1806 participants; I2 62% Exercise only vs. control, MD (95% CI), on BMI-z: −0.13 (−0.20 to −0.06), 12 studies; 1084 participants; I2 0% BMI: −0.88 (−1.265 to −0.50), 34 studies; 3846 participants; I2 72% BW: −3.01 (−5.56 to −0.4), 16 studies; 1701 participants; I2 78% BF%: -1.36 (2.32 to −0.39), 25 studies; 1635 participants; I2 78% Exercise and behavioral therapy vs. control, MD (95% CI), on BMI-z: −0.08 (−0.16 to −0.00), 8 studies; 466 participants; I2 49% Diet and behavioral therapy vs. control, MD (95% CI), on BMI z-score: −0.16 (−0.26 to −0.07), 4 studies; 329 participants; I2 0% Combination of diet, exercise, and behavioral therapy vs control, MD (95% CI), on BMI-z: −0.09 (−0.14 to −0.0), 13 studies; 2995 participants; I2 12% WC: -1.54 (−2.56 to −0.52), 11 studies; 3018 participants; I2 63%
Adom et al., 2019	South Africa SR	School-based lifestyle interventions *School-Based Interventions Targeting Nutrition and Physical Activity, and Body Weight*	RCT, QE	10 (4 RCTs, 5 QE)	-	2000 - 2018	9957	6-15	controlled or no control study design, with or without randomization	changes in nutrition and PA knowledge, attitude, intention and self-efficacy, and behaviors, changes in body weight, percent body fat, BMI, or BMI z-score	Three of five studies that evaluated weight status (body mass index (BMI), BMI z-score, overweight/obesity prevalence), three of six studies that reported PA outcomes (number of sports activities, and physical activity duration ≥ 30 min for at least six days/week), and four of six reporting on nutrition-related outcomes

		Status of African Children: A Systematic Review									(number meeting fruit and vegetable intake ≥ 5 times/day) found beneficial effects of the interventions.
Andela et al., 2019	Australia SR-MA	Very low-energy diet *Efficacy of very low-energy diet programs for weight loss: A systematic review with meta-analysis of intervention studies in children and adolescents with obesity*	RCT	24 (16 pre-post, 4 non-RCTs, 2 RCTs, 2 chart reviews)	20 [weight], 10 [BMI]	1980 - 2018	674	5-18		weight (kg), BMI (kg/m2), percentage weight change, percentage ideal body weight, fat mass, fat-free mass, percentage body fat, waist circumference, or skinfold thickness, insulin	VLED vs control, MD (95% CI), on Weight: -10.1 kg (-11.4 to -8.7 kg), p<.001; I2 = 92.3% BMI: −4.9 kg/m2 (−5.6 to −4.2 kg/m2), p<.001 I2 = 68.8% fasting insulin concentration: −7.9 uIU/ml (−11.6 to −4.1 uIU/ml), p<.001; I2 = 66.3%, four studies Adolescent-only studies showed significantly greater weight loss (p=.01) vs adolescent + child studies: MD (95% CI) = −17.7 kg (−25.1 to −10.4 kg), p<.001; I2 = 94.3%, four studies vs −7.9 kg (−8.8 to −7.1 kg), p<.001; I2 = 78.3%, 16 studies. BMI was most pronounced yet non-significant (p=0.057) in the three adolescent-only studies (MD (95% CI) = −5.8 kg/m2 (−6.9 to −4.6 kg/m2), p<.001; I2 = 70.5%) compared with the seven child and adolescent studies (−4.6 kg/m2 (−5.0 to −4.1 kg/m2), p<.001; I2 = 0%). Moderator analysis indicated that trials including an inpatient phase of 3 to 8 weeks in duration achieved significantly greater (p=.026) weight loss compared with outpatient trials (MD (95% CI) = −12.8 kg (−16.2 to −9.4 kg), p<.001; I2 = 95.8%, six studies versus −8.6 kg (−10.0 to −7.3 kg), p<.001; I2 = 84.1%, 14 studies
Chai et al., 2019	Australia UR	Family-based interventions *Effectiveness of family-*	SR	14	-	1990 - 2016 (trial	-	≤18	a waitlist or no intervention control,	BMI, body fat percentage and waist circumferences.	Family-based interventions targeting parents, alone or with their child, are effective for child weight management. Effective interventions employed

		based weight management interventions for children with overweight and obesity: an umbrella review				s in included SRs between 1967 - 2015)			usual care, or other interventions.		parent-targeted strategies, including nutrition and PA education sessions, positive parenting skills, role modelling and child behavior management to encourage positive healthy eating/exercise behaviors in children and/or whole family.
Hamid & Sazlina 2019	Malaysia SR-MA	Weight-reduction interventions *Interventions for obesity among school children: A systematic review and meta-analyses*	RCT, QE	14 (13 RCTs, 1 QE)	8	2000 - 2017	1616; 969	6-12	usual care or minimal advice	eight, standard body mass index (BMI) in kg/m2, BMI percentile, BMI z-scores and standard deviation scores, percent of overweight, weight for height percentage, waist circumference) and body composition (including lean body mass, body fat and fat mass)	The effect of current interventions for the management of obesity vs. control, SMD (95% CI), on BMI z-score: -0.14 (-0.87 to 0.60); p=0.72 WC: -0.25 (-0.51 to 0.01), p=0.06) BF%: 0.30 (-0.17 to 0.76), p=0.21)
Kelley et al., 2019	USA SR-MA	Exercise *Exercise and adiposity in overweight and obese children and adolescents: a systematic review with network meta-analysis of randomized trials*	RCT	57 (54 RCTs, 3 randomized trials)	50 [BMI], 45 [BF%], 31 [FM],	1973 - 2018	2792	2-18	Control group	P: Changes in BMI in kg/m2, fat mass and % body fat. S: body weight, lean body mass, waist circumference, waist-to-hip ratio, energy intake, energy expenditure, physical activity level, maximum oxygen consumption (VO2max in mL/kg/min), muscular strength, resting systolic and diastolic blood pressure, total cholesterol, high-density lipoprotein cholesterol, ratio of total cholesterol to high-density lipoprotein cholesterol, non-high density lipoprotein cholesterol, low density lipoprotein cholesterol, triglycerides, glycosylated hemoglobin, fasting and non-fasting glucose and insulin.	The effect of exercise intervention, ES (95% CI), on BMI, 50 studies: • Aerobic vs control: –1.04 (-1.42 to −0.65) • Strength vs control: -0.14 (-0.88 to 0.60) • Aerobic & strength vs. control: -0.75 (-1.39 to -0.12) • Strength vs. aerobic: 0.90 (0.14 to 1.65) • Aerobic & strength vs. aerobic: 0.28 (-0.42 to 0.98) • Aerobic & strength vs. strength: -0.62 (-1.54 to 0.31) FM, 31 studies: • Aerobic vs control: –2.15 (-3.33 to −0.98) • Strength vs control: -1.41 (-3.43 to 0.62) • Aerobic & strength vs. control: -2.55 (-4.06 to -1.04) • Strength vs. aerobic: 0.75 (-1.40 to 2.89)

											• Aerobic & strength vs. aerobic: -0.40 (-2.14 to 1.34) • Aerobic & strength vs. strength: -1.14 (-3.50 to 1.21) BF%, 45 studies: • Aerobic vs control: -1.54 (-2.18 to -0.90) • Strength vs control: -1.31 (-2.53 to -0.09) • Aerobic & strength vs. control: -2.18 (-3.17 to -1.19) • Strength vs. aerobic: 0.23 (-1.03 to 1.49) • Aerobic & strength vs. aerobic: -0.64 (-1.75 to 0.46) • Aerobic & strength vs. strength: -0.87 (-2.36 to 0.61) Statistically significant decreases in fasting insulin were observed for aerobic exercise, strength exercise and combined aerobic and strength exercise as a result of combined aerobic and strength exercise
Mohammadi et al., 2019	Iran SR-MA	Pro-/synbiotic supplementation *Effects of pro-/synbiotic supplementation on anthropometric and metabolic indices in overweight or obese children and adolescents: A systematic review and meta-analysis*	RCT	9	6 [BMI z-score, WC, weight, body fat]	Up to 2018	410	2-18	Placebo or lifestyle modifications	BMI z-score, waist circumference, weight, body fat, fasting blood sugar and lipid profiles (triglyceride, total cholesterol, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol)	pro-/synbiotics vs control, WMD (95% CI), on BMI z-score: -0.09 z-score (-0.23 to 0.05), 6 studies, p=0.19, I2 = 85.0%, p<.001 BMI-z after sensitivity analysis: -0.06 z-score (-0.09 to -0.04) WC: -0.62 cm (-1.73 to 0.48), p= 0.26, 7 studies, I2 = 10.7%, p=0.34 WC after sensitivity analysis: -0.92 cm (-1.76 to -0.08) Weight: 0.70 kg (-1.07 to 2.47), p=0.43, four studies, I2 = 0.0%, p=0.97 Body fat: 0.41% (-1.70 to 2.51), p=0.70, 4 clinical studies, I2 = 78.1%, p=.003

Oliveira et al., 2019	Brazil SR-MA	Active Video Games *Effects of active video games on children and adolescents: A systematic review with meta-analysis*	RCT	12	11	incep tion to 2018	1016	2-19	no/minimal intervention	BMI and BMI z-score, body weight, body fat, and waist circumference	AVG vs. no/minimal intervention, SMD (95% CI), on BMI/zBMI short-term: −0.34 (−0.62 to −0.05), 6 studies BMI/zBMI intermediate-term follow-up: −0.36 (−0.71 to −0.01), 2 studies BW short-term: −0.12 (−0.30 to 0.06), 5 studies BW intermediate-term follow-up: −0.25 (−0.46 to −0.04), 2 studies BF short-term: −0.31 (−0.72 to 0.10), 3 studies WC short-term: −0.64 (−1.46 to 0.17), 2 studies
Pamungkas & Chamroonsawasdi 2019	Indonesia SR-MA	Home-based interventions *Home-Based Interventions to Treat and Prevent Childhood Obesity: A Systematic Review and Meta-Analysis*	RCT	22	22 [BMI-z]	2009 - 2018	-	School age	Control group	Physical activity, sedentary lifestyle and healthy diets BMI z-scores, changes in obesity and overweight status summarized as proxy indicators	Home-based interventions (incl. parental involvement, nutrition, increased PA, reduced sedentary behavior) vs. control on BMI z-score: -36.99% (z = 36.99, p = 0.00), I2 = 98%
Psaltopoulou et al., 2019	Greece SR	Nutritional, behavioral, and physical activity interventions *Prevention and treatment of childhood and adolescent obesity: a systematic review of meta-analyses*	MA	66	-	?-2015	-	0-19	Various comparison groups	weight change, body mass index (BMI), Z scores, overweight/obesity status, fat mass reduction, central obesity	*Dietary Factors:* Non-interventional • Marginal positive correlation between dietary energy density and children's fat mass index (change in FMI = 0.064, 95% confidence interval (CI) 0.01–0.11, p=.013, six cross-sectional studies, 6800 children). • Correlation became statistically non-significant when adjusted for biases. Meal Frequency: Non-interventional • Three or more family-shared meals per week reduced the possibility of childhood obesity by 12% compared to < three family meals

											pr week (1 MA, 8 studies, 44,016 children). • Increased eating frequency associated with 22% lower likelihood of being overweight/obese (log(odds ratio) = − 0.24, 95% CI − 0.41 to − 0.06, 1 MA, 18,849 children and adolescents). *Dietary Factors:* Interventional • Diet alone could produce significant weight loss and reduce many obesity-related outcomes [standardized mean difference (SMD) = − 1.82, 95% CI −2.40 to − 1.23, P < 0.001], that were also maintained during the follow-up, to a lesser extent (SMD = − 0.64, 95% CI −0.89 to − 0.39, P < 0.001) (2 MA). *Nutritional Education:* Interventional • Nutritional education alone yielded a mean BMI reduction of 0.33 kg/m2 (95% CI − 0.55 to − 0.11) (1 MA, 8 RCTs, 8451 participants). • However, majority of dietary behavioral modification studies did not show significant effects. Sugar-Sweetened Beverages (SSB): Non-interventional & interventional • Weak association between SSB consumption and BMI (ES = 0.017 kg/ m2 change in BMI (95% CI − 0.009 to 0.044), 1 MA). • SSB consumption could lead to weight gain (0.06 unit increase in BMI (95% CI 0.02–0.10)), while replacing SSBs with noncaloric beverages may induce BMI reduction (0.34 kg/m2 (95% CI − 0.50 to − 0.18) (1 MA). • No correlation between dietary sugars and children's BMI/BMI-Z score (1 MA). Cereal Consumption: Non-interventional & interventional

											• High frequency of cereal consumption associated with lower BMI and BMI-Z scores (ES = − 1.13 units; 95% CI − 0.81 to − 1.46, p<.0001, 1 MA). School-Based Programs: Non-interventional & interventional • Implementation of School Breakfast Program associated with BMI reduction (WMD (95% CI) = − 0.08 (−0.14 to − 0.02), 1 MA). • No significant association found between dairy product consumption and adiposity-related outcomes in children, but inverse relation found in adolescents (ES = − 0.26, 95% CI − 0.38 to − 0.14, p<.0001, 1 MA). *Physical Activity Interventions:* Actual Interventions: • Various exercise modalities positively affect body composition by reducing body fat while increasing fat-free mass. • Combination of aerobic and resistance exercise yields better body fat percentage reduction (ES = 1.20± 0.35, 95% CI 0.34–2.10) vs. aerobic activity alone (ES = 0.58± 0.31, 95% CI 0.18–0.90). • Mixed results on BMI and absolute body weight changes. Behavioral and/or Educational Interventions: • Diversity in effects of behavioral interventions targeting increased physical activity. • Exercise-promoting educational interventions significantly reduce BMI (WMD = − 0.15, 95% CI − 0.34 to 0.04) and body fat percentage (WMD = − 0.7, 95% CI − 1.05 to − 0.31) for participants up to 18 years (1 MA). *Combined Interventions:* Diet and Exercise:

											• Interventions combining diet and exercise yield better outcomes compared to exercise-only or no intervention group (2 MA). • Resistance training alone or combined with diet vs. diet only increased lean body mass only (pooled difference = 0.44 kg, 95% CI 0.04–0.84) and reduced body fat percentage more (pooled difference = − 2.73%; 95% CI −4.38 to − 1.09) • School-based combined interventions effective in reducing obesity-related indices (r = 0.128, 95% CI 0.126–0.171, p<.001). • School-based combined interventions reduced absolute body weight in kilograms (SMD = − 0.29 kg, 95% CI − 0.45 to − 0.14, p=.0002). • School-based behavioral interventions which improved dietary habits and increased PA led to weight loss (BMI/BMIZ score reduction = − 1.09 units, 95% CI −1.84 to − 0.34, p<.001, 1 MA). • Combined interventions with or without family participation might reduce multiple obesity-related outcomes such as BMI, percentage of overweight or body fat percentage. Physical Activity or Diet Plus Another Intervention: • Parental and family behavioral interventions combined with exercise boost body fat percentage reduction. • Combining sedentary behavior reduction with diet PA produces overall BMI reduction (-0.073 kg/m2 (95% CI − 0.135 to − 0.011, p=.021)). Sedentary Behavior Reduction Interventions: • Mixed results on BMI reduction with screen time and sitting time reduction.

											• Reduction in screen time did not significantly affect BMI. Multidimensional Interventions: • Combination of PA, education, and nutrition resulted in a small reduction in BMI mean difference = − 0.10, 95% CI −0.16 to − 0.04, six studies) • School and after-school intervention programs combining physical activity, lifestyle modification, and nutrition had a small positive effect on weight-related outcomes (r = 0.047, 95% CI 0.023–0.070, P < 0.001). • Physical exercise combined with diet and behavioral therapy reduced BMI-Z score but had high heterogeneity (-0.25 BMI-Z score units (95% CI − 0.36 to − 0.14), eleven studies, I2 = 100%). School-Based Interventions: • School-based interventions with dietary and/or physical activity components reduce obesity incidence by 26%, while classroom activities and physical education by 27% (nineteen RCTs). • Mixed programs during and after school hours resulted in small reductions in weight-related outcomes. • School-based obesity prevention and treatment programs lowered BMI and BMI-Z scores. • Educational programs reduced waist circumference (-3.21 cm (95% CI − 6.34 to − 0.07)) and BMI (-0.86 kg/m2 (95% CI − 1.59 to − 0.14)). • School nutritional education plus PA did not reach statistical significance (47 studies). Behavioral or Educational Interventions: • Behavioral modification strategies resulted in a small-scale reduction

											in BMI z-score (ES = − 0.07, 95% CI − 0.10 to − 0.03), in BMI alone (ES = − 0.09 kg/m2, 95% CI − 0.16 to − 0.03) and in the prevalence of overweight and obesity (relative risk = 0.94, 95% CI 0.89–0.99) (2 MA). • Lifestyle modification reduced obesity-related outcomes in older children and adolescents. • Active behavioral interventions yielded positive effects. • Combinations of behavioral modification with additional components were more effective than behavioral interventions alone. • Mixed behavioral interventions were effective against obesity, especially when parents were included (WMD = 0.30, SE = 0.11, p=.027). • Family behavioral treatment indicated mild reductions in weight-related outcomes among children. • Solely educational interventions induced BMI reduction (ES = − 0.18 kg/ m2, 95% CI − 0.30 to − 0.05) but did not affect body fat percentage (ES = 0.13, 95% CI − 0.04 to + 0.3). Lifestyle Interventions without Further Specification: • Various lifestyle interventions resulted in greater reductions in BMI/BMI-Z score in children (seventeen RCTs). • Lifestyle programs effectively caused weight loss (ES = − 0.95 kg, 95% CI −0.79 to − 1.11) in middle-school/pre-teen children and reduced BMI (− 0.08 kg/m2 (95% CI − 0.16 to − 0.01, p=0.02) (1 MA). • Effectiveness was not observed in older children and teenagers.

											• Lifestyle interventions did not reveal effectiveness in US minority children (1 MA).
Ameryoun et al., 2018	Iran SR-MA	Game-based interventions *Impact of Game-Based Health Promotion Programs on Body Mass Index in Overweight/Obese Children and Adolescents: A Systematic Review and Meta-Analysis of Randomized Controlled Trials*	RCT	10		2005 - 2017	1402	5-18	Control group	BMI (metric BMI (kg/m2), BMI z-score, and BMI percentile)	Game-Based Health Promotion Programs vs. control, SMD (SE), on BMI: -0.234 (0.069) BMI z-score: -0.181 (0.071) A combined approach (active gaming along with other interventions), had a greater effect on BMI reduction (Hedges' g =-402, SE = 0.182, compared to g =-189, SE = 0.070, for intervention involving active gaming alone
Ells et al., 2018	UK overview of Cochrane reviews	Weight-reduction interventions *Interventions for treating children and adolescents with overweight and obesity: an overview of Cochrane reviews*	Reviews	6	-	2015 - 2017 (included studies between 1968 and 2016)	19,756	≤18	true control (placebo or no intervention), usual care (defined by either the study author or reviewer) or an alternative concomitant therapy providing it was delivered in both the intervention and comparator arms	P: BMI / BMI z-score, body weight and adverse events S: health-related quality of life; self-esteem; all-cause mortality; morbidity; body fat distribution; behaviour change; participants' views of the intervention; socioeconomic effects	*Interventions for pre-school children up to the age of 6 years, MD (95% CI)* Multicomponent interventions vs control (6-12 mo): −0.3 units (−0.4 to −0.2), four trials Multicomponent interventions vs control (12-18 mo): −0.4 units (−0.6 to −0.2), four trials Multicomponent interventions vs control (2 yr): -0.3 units (−0.4 to −0.1), one trial Parental weight change: −4.69 kg (−7.27 to −2.11), three trials Mixed results on reported health-related quality of life *Interventions for school aged children under 12 years* Lifestyle interventions targeting parents as the sole agents for change, MD (95%CI) on BMI z-score:

											Parent-only vs parent child intervention: −0.04 units (−0.15 to 0.08), three studies Parent-only vs minimal contact control interventions: −0.01 units (−0.07 to 0.09), one study Parent-only vs waiting list control: −0.10 units (−0.19 to −0.01), two studies *Lifestyle interventions targeting the child-only, or child and parent* MD (95% CI) BMI z-score: −0.06 units, (−0.10 to −0.02), 37 studies No difference in health-related QoL between intervention vs control. *Interventions for children 12 years and older* MD (95% CI) BMI: −1.18 kg/m2 (−1.67 to −0.69), 28 studies BMI (18-24 mo): −1.49 kg/m2 (−2.56 to −0.41), six trials BMI z-score: −0.13 units (−0.21 to −0.05), 20 trials BMI z-score (18-24 mo): −0.34 units (−0.66 to −0.02), five trials Health-related QoL (6-24 mo): SMD (95% CI): 0.44 (0.09 to 0.79), 7 studies Parental involvement did not significantly alter the effect estimates. *Drug interventions for the treatment of obesity in children and adolescents* Drug intervention vs. control, MD (95% CI), on BMI: −1.3 kg/m2 (−1.9 to −0.8), 16 studies No statistical significance in health-related QoL between groups (2 studies) *Surgery for the treatment of obesity in children and adolescents*

											Laparoscopic adjustable band vs multicomponent lifestyle intervention (usual care), MD (95% CI), on BMI: -12.7 kg/m2 (11.3 to 14.2) in intervention group compared to - 1.3 kg/m2 (0.4 to 2.9) in the control arm. Surgery participants also experienced improvements in two of eight quality of life concepts, when compared to the control
Karalexi et al., 2018	Greece SR-MA	Non-nutritive sweeteners *Non-Nutritive Sweeteners and Metabolic Health Outcomes in Children: A Systematic Review and Meta-Analysis*	Observational studies (case-control or cohort)	13	9 [BMI], 3 [FM]	Up to 2017	-	2-17	Any" compared with "no" consumption of NNS	P: obesity	"Any" vs "no" consumption of NNS, OR (95% CI) on BMI: 1.15 (1.06 to 1.25), 9 studies Association between NNS consumption and fat mass accumulation, OR (95% CI): 1.29 (0.90 to 2.13), 3 studies
Lentferink et al., 2018	Netherlands SR	Drugs *Efficacy of metformin treatment with respect to weight reduction in children and adults with obesity, a systematic review*	RCT, open label study	15 (14 RCTs, 1 open-label study (+ 14 adult studies))	-	?-2018	-	7-19	placebo or untreated control group	P: weight, BMI S: Homeostatic Model Assessment for Insulin Resistance (HOMA-IR)	The effect of metformin treatment on BMI at 6 mo: • Intervention group: range of -2.4 to +0.02 kg/m², with all studies demonstrating either stabilization (n=1) or a decrease (n=11) in BMI • Control group: In six of the 12 studies, the control group showed an increase in BMI, ranging between +0.11 to +0.9 kg/m², and in the remaining six studies a decrease ranging from -0.05 to -1.1 kg/m² • Placebo: significant reduction in BMI in the metformin group was observed in eight studies. The remaining four studies observed no differences between the groups. HOMA-IR: • Metformin vs placebo: • Three studies showed a significant reduction in the metformin versus placebo group.

											• One study showed a significant smaller increase in HOMA-IR in the metformin versus the placebo group. The remaining studies did not observe significant differences between the groups for HOMA-IR
Moores et al., 2018	Australia SR	Community-based interventions *A systematic review of community-based interventions for the treatment of adolescents with overweight and obesity*	RCT	31	-	2011 - 2017	Ranged from 16 40 to 208	13-17	Studies of all designs (i.e. randomized controlled-trials, case–control studies and pre–post uncontrolled studies with no comparison group)	P: body Mass Index (BMI); BMI z-score (BMIz); weight; and % overweight S: iet-related behaviours; activity-related behaviours; sedentary-related behaviours; self-esteem; and quality of life.	Effective characteristics in community-based interventions: • Inclusion of a psychological component, in addition to a healthy lifestyle component, appears to enhance effectiveness of interventions long-term. The four programs which were deemed most effective, as determined by BMI-z decrease ≥10% at follow-up, also reported significant improvements in adolescent self-esteem/self-perception or QoL at follow-up. • No consistent pattern was observed between total or frequency of contact and weight outcome measures. • Including 1:1 support or a psychological component did not consistently improve effectiveness of the intervention. • Four studies reported BMI-z decreases of ≥10% at follow-up, and all included a psychological component. • Programs targeting adolescents or the whole family showed similar reductions in BMI-z. • Online-only programs had somewhat smaller reductions in BMI compared to face-to-face programs. • Technology combined with face-to-face sessions did not appear to be more effective in reducing BMI-z compared to interventions without technology.

Verjans-Janssen et al., 2018	Netherlands SR	School-based physical activity and nutrition interventions with direct parental involvement	RCT, QE, cross-sectional studies	25 (10 RCTs, 11 QE, 3 pretest-posttest, 1 cross-sectional)	-	2016 - 2018	Ranged from 97 to 9867	4-12	Control group	Body Mass Index (BMI), the BMI z-score (BMI adjusted for age and gender) and/or PA, SB, and NB	Mixed results for BMI and BMI z-score. 61.1% of studies on BMI or BMI z-score found favorable results. The effect sizes were mainly small (ES -0.04 to -0.27)
Elvsaas et al., 2017	Norway SR-MA	Multicomponent lifestyle interventions *Multicomponent Lifestyle Interventions for Treating Overweight and Obesity in Children and Adolescents: A Systematic Review and Meta-Analyses*	RCT	39	BMI: 14 [6 mo], 19 [12 mo], 8 [24] BMI-z: 8 [6 mo], 22 [12 mo], 11 [24 mo]	2008 - 2015	5,397	2-18	waiting list or no intervention, standard care, and minimal intervention or self-help	BMI and/or BMI Z score	BMI 6 mo, MD (95% CI, (14 studies): -0.99 (-1.36 to -0.61), p=.00001, I2 = 72% < 12 y: -0.74 (-0.26 to -0.22), p=.0006, I2 = 77% ≥ 12 y: -1.26 (-1.85 to -0.68), p=.001, I2 = 70% BMI 12 mo (19 studies): -0.67 (-1.01 to -0.32), p<.00001, I2 = 80% < 12 y: -0.31 (-0.45 to -0.17), p=0.47, I2 = 0% ≥ 12 y: -1.02 (-1.95 to -0.10), p<.00001, I2 = 87% BMI 24 mo (8 studies): -0.96 (-1.63 to -0.29), p=.005, I2 = 65% < 12 y: -0.28 (-0.85 to 0.30), p=0.26, I2 = 25% ≥ 12 y: -1.58 (-2.33 to -0.83), p=0.18, I2 = 36% BMI-z 6 mo (18 studies): -0.12 (-0.17 to -0.06), p<.00001, I2 = 77% < 12 y: -0.16 (-0.27 to -0.05), p<.00001, I2 = 79% ≥ 12 y: -0.10 (-0.16 to -0.03), p<.0001, I2 = 77% BMI-z 12 mo (22 studies): -0.16 (-0.21 to -0.10), p<.00001, I2 = 69% < 12 y: -0.17 (-0.26 to -0.07), p=.0006, I2 = 68% ≥ 12 y: -0.16 (-0.23 to -0.09), p=.0002, I2 = 71% BMI-z 24 mo (11 studies): -0.16 (-0.21 to -0.10), p=0.17, I2 = 33% < 12 y: -0.13 (-0.26 to 0.00), p=0.09, I2 = 58% ≥ 12 y: -0.17 (-0.23 to -0.11), p=0.28, I2 = 21%

Mead et al., 2017	UK Review	Diet, physical activity and behavioural interventions	RCT	70	-	1984 - 2016	8461	6-11	A variety of control groups	P: Changes in measured (not self-reported) body mass index (BMI), BMI z score and weight, Adverse events S: Health-related quality of life • Self-esteem • All-cause mortality • Morbidity • Anthropometric measures other than change in BMI, BMI z score and weight • Behavior change • Participants' views of the intervention • Socioeconomic effects	Behaviour-changing interventions vs. no treatment/usual care control, MD (95% CI), on BMI: -0.53 kg/m2 (-0.82 to -0.24), p<.00001; 24 trials BMI z-score: -0.06 units (-0.10 to -0.02), p=.001; 37 trials Weight: -1.45 kg (-1.88 to -1.02), p<.00001; 17 trials Child-reported health-related QoL: SMD (95% CI): 0.15 units (-0.34 to 0.64); p=0.55; 3 trials WC: -2.41 cm (-3.59 to -1.23), p<.0001; 11 trials Percentage overweight: 3.27% (-7.47 to 0.92), p=0.13; 3 trials BF% (BIA): -1.25% (-2.62 to 0.12), p=0.07; 5 trials BF% (DXA): -1.04% (95% CI -2.88 to 0.80), p=0.27; 5 trials Behaviour-changing intervention plus additional component vs behaviour-changing intervention alone, MD (95% CI), on BMI: -0.75 kg/m2 (-1.42 to -0.09), p=.03; 4 trials BMI z-score: -0.03 units (-0.10 to 0.04), p=0.37; 5 trials BW: 1.59 kg (-4.58 to 7.77), p=0.61; 4 trials Cluster RCTs with usual care or no treatment control group (1 study added a coping skills training element to a family behavioral therapy intervention), MD (95% CI), on BMI: -0.49 kg/m2 (-1.24 to 0.27), p=0.20; 2 trials Children in clinical decision support vs. usual care, MD (95% CI), on BMI z-score: -0.06 (-0.11 to -0.02), 1 study Children in clinical decision support + individual family counselling vs. usual care, MD (95% CI) on

											BMI z-score: -0.05 (-0.09 to 0.00), 1 study No subgroup differences for change in BMI, BMI z-score, or weight depending on setting. No subgroup differences for change in BMI, BMI z-score, or weight depending on the intervention involved the parent and child, whether only the child was treated without any parental involvement and whether the parent was specifically targeted (but the child was included in the intervention)
O'Connor et al., 2017	USA Evidence Report and SR	Weight-reduction interventions *Screening for Obesity and Intervention for Weight Management in Children and Adolescents*	RCT, non-RCT	59 (RCTs, non-RCTs)	-	2005 - 2016	8583	2-18	usual care, other control groups, placebo	Weight or excess weight (eg, body mass index [BMI]; BMI z score, measuring the number of standard deviations from the median BMI for age and sex), cardiometabolic outcomes, quality of life, other health outcomes, harms.	BMI z-score: • Lifestyle-Based Weight Loss Intervention vs. control, SMD (95% CI): −1.10 (−1.30 to −0.89), 6 trials; I2 = 43.4%) • Metformin vs. placebo, SMD (95% CI): −0.10 (−0.17 to −0.03), 6 trials; I2 = 13.1%) BMI • Lifestyle-Based Weight Loss Intervention vs. control, SMD (95% CI): -0.86 (-1.44 to -0.29) • Metformin vs. placebo, SMD (95% CI): −0.86 (−1.44 to −0.29), 6 trials; I2 = 0% • Orlistat vs placebo. small between-group differences ranging from −0.94 (95% CI, −1.58 to −0.30) to −0.50 (95% CI, −7.62 to 6.62) QoL: • Lifestyle-Based Weight Loss Intervention vs. control: Most did not find greater improvement • Orlistat vs. placebo: No differences at 6 months Insulin:

											• Metformin vs. placebo: non-significant • Orlistat vs. placebo: non-significant

Author, Year,	Country of publication	Design	Subject characteristics at baseline N, gender, age	Intervention	Outcome	Results
Atazadegan et al., 2023	Iran	RCT Inclusion: 8-18 years; BMI ≥ the age- and sex-specific 85th percentile according to the World Health Organization percentiles Exclusion: Use of antibiotics during the previous three months; having any chronic disease, including diabetes, thyroid disorders, cardiovascular diseases, digestive problems, pancreatic and liver diseases.	N = 60 Synbiotic group, mean (SD): 11.23 (2.37) yr, 13F, 17M Placebo: 11.07 (2.00) yr, 19F, 11M Males: 30 Females: 30	Synbiotic group: two daily capsules containing 12 × 109 colony forming units (CFU) of probiotics (6 × 109 CFU: Lactobacillus coagulans SC-208, 6 × 109 CFU Lactobacillus indicus HU36). The prebiotic was short-chain fructooligosaccharide (FOS), and each capsule included 38.5 g FOS (7.7% of each capsule). Placebo: 0.5 g capsules containing maltodextrin 2x/d before lunch and dinner. Duration: eight weeks	Anthropometric indices and body composition	Change between groups, means (± SD) Weight, kg: Synbiotic: −0.12 ± 1.87 Placebo: 0.12 ± 2.15 p=0.644 BMI, kg/m2: Synbiotic: −0.12 ± 0.75 Placebo: −0.05 ± 0.78 p=0.747 WC, m: Synbiotic: −0.0022 ± 0.01 Placebo: −0.0003 ± 0.02 p=0.599 WHR: Synbiotic: −0.02 ± 0.13 Placebo: 0.0002 ± 0.02 p=0.315 FM: Synbiotic: 0.01 ± 1.43 Placebo: 0.27 ± 1.30 p=0.469
Khongtan et al., 2023	Thailand	Inclusion: BMI ≥ 25 kg/m2, 7-12 yr Exclusion: Neurological conditions intake of antibiotic or probiotic	N = 10 Male: 6 (60%) Female: 4 (40%) 9 yr (median)	Probiotics: 8 × 109 CFU of L. paracasei HII01 (2 × 109 CFU) and B. animalis subsp. lactis (6 × 109 CFU) Dose: once daily Duration 12 weeks	obesity indexes (body weight, BMI, body, and visceral fats), inflammatory and oxidative stress markers, gut	No statistically significant differences were observed in the studied obesity indexes. BW: p=0.116 BMI: p=0.256 BF %: p=0.115 Visceral fat: p=0.180

		products in the previous 14 days			microbiota, and working memory	
Roebroek et al., 2023	The Netherlands	RCT Inclusion: 14-16 years; BMI > 40 kg/m2 or > 35 kg/m2 with obesity associated co-morbidity; participation in weight reduction program without accomplishing the intended effect of ≥ 5% weight loss Exclusion: eating disorders; unrealistic expectations of weight loss; inadequate social support of the family or caregivers, skeletal or developmental immaturity, severe cardiorespiratory impairment, syndromic disorders causing obesity; physical disorders with highly possible influence on weight	N = 59 Surgery group: n = 29 Control group: n = 30 Male: 12 Female: 47 15.8±1.0 yr (mean±SD)	Surgery and lifestyle group (intervention): laparoscopic placement of an adjustable gastric band while participating in a family-based multidisciplinary lifestyle intervention at their referring pediatric obesity clinic. Extensive dietary instructions were given both before and after the surgical procedure. Lifestyle control group: participation in a family-based multidisciplinary lifestyle intervention at their referring pediatric obesity clinic.	P: total weight change (in percentage) S: changes in BMI z-score, glucose metabolism (asting glucose, fasting insulin, and insulin resistance score (HOMA-IR index)), blood pressure, lipid profile, and any adverse events or complications	Gastric band surgery vs control group (12 mo), treatment effect (95% CI) on Weight los %: -13.10 (-17.49 to -8.72, p<.001 BMI z-score: -0.43 (-0.59 to -0.26), p<.001 Absolute weight: -16.9 (-22.9, -11.0), p<.001 Fasting insulin, μU/L: treatment effect not given, p=.003 HOMA-IR: treatment effect not given, p=.002
Chen et al., 2022	Taiwan	RCT Inclusion: 6-18 years; BMI ≥ the age- and sex-specific 85th percentile Exclusion: underlying conditions and other severe chronic diseases; use of anti-obesity medication; ongoing use of probiotic products; use of antibiotics	N = 53 Probiotics: 13F, 14M, 11.6 ± 0.6 yr (mean±SD) Placebo: 10F, 16M, 11.2 ± 0.7 Males: 30 Females: 23	Probiotics: three packages of supplementary probiotics pr. day containing a total number of 10^{10} colony-forming units (CFU) including Lactobacillus salivarius AP-32 (10^9 CFU), Lactobacillus rhamnosus bv-77 (10^9 CFU), and Bifidobacterium animalis CP-9 (8×10^9 CFU). Every package of supplement contained functional ingredients (i.e., white kidney bean extract: 300 mg, Psyllium husk: 100 mg, and Garcinia cambogia extract: 100 mg) and probiotics. Plus diet and exercise guidance. Placebo: three packages of the supplement containing the same ingredients without any of the probiotics. Duration: 3 months	gut microbiota and weight control	Change rate (%), mean±SD BMI, kg/m2: Probiotics: 95.9±0.8 Placebo: 98.1±0.9 p=0.026 Weight, kg: Probiotics: 98.0±0.7 Placebo: 99.6±0.8 p=0.062 WC, cm: Probiotics: 99.3±0.7 Placebo: 99.3±0.5 p=0.742 HbA1c (%): Probiotics: 99.0±1.2

						Placebo: 101.1±0.5 p=0.378 Insulin, μ IU/ml: Probiotics: 114.4±9.3 Placebo: 112.2±13.9 p=0.423 HOMA-IR: Probiotics: 115.8±11.0 Placebo: 116.0±16.0 p=0.374
Hagman et al., 2022	Sweden	Inclusion: children and adolescents with obesity between 4.0 and 17.9 years of age Exclusion: no restrictions for referral were set in terms of other diseases, neuropsychiatric disorders, or previous obesity treatment	N = 428 Intervention: n = 107 Control: n = 321 67 % males 4.1–17.4 years	Intervention: The treatment with the digital support system was integrated with clinical treatment and based on four cornerstones: (1) a custom-made body scale for daily home measurements of weight; (2) a personalized weight development target curve in a mobile application; (3) close monitoring by clinical staff of treatment progress; (4) and frequent communication between the clinical staff and families. The patients accessed the digital support system through a mobile application and the health care professionals accessed the system through a web page. Additionally, participants and parents received information about healthy eating and recommendations regarding PA. Control: received standard pediatric obesity treatment. Duration: 1 year	change in BMI Z-score	change in BMI Z-score, mean ± SD, Intervention: −0.30 ± 0.39 Control: −0.15 ± 0.28 p = 0.0002. GLM analyses, estimate (SE) Intervention vs. control: -0.162 (0.035), p<.0001 Female vs male: 0.018 (0.032), p=0.572
Meng et al., 2022	China	RCT Inclusion: 11-13 years; BMI ≥ the 95th percentile for their age and sex; be between Tanner stage 1 to 3; be free of any medication that could interact with the	N = 45 HIIT: n = 15 MICT: n = 15 CON: n = 15 Male: 45 (100%) 11.2±0.7 years	HIIT: Three days a week of high-intensity interval training (HIIT) were conducted. Each session began with a 5-minute warm-up comprising 3 minutes of moderate-intensity jogging, 1 minute of dynamic stretching, and 1 minute of acceleration running. Over 12 weeks, running intensity increased from 90% to 100% of Maximum	VO2 peak	Pairwise significance: BMI (kg/m2): HIIT vs. CON: p<.05 HIIT vs. MICT: NS MICT vs. CON: NS %BF: HIIT vs. CON: p<.05

		protocol (e.g., cardiac abnormalities, hypertension, diabetes, orthopedic, neuromuscular, or neurological disorders); present no contraindication to physical activity; self-report less than 2 h of physical activity per week Exclusion: if participants were not able to make up a missed training session within the same week.		Aerobic Speed (MAS). During the sessions, participants completed two sets of eight 15-second bouts of high-intensity running (90-100% MAS, approximately 80-90% of maximum heart rate), alternating with eight 15-second recovery bouts at low intensity (50% MAS, approximately 40-60% of maximum heart rate). There was a 3-minute rest between sets, resulting in a total duration of 11 minutes per session. MICT: Three days per week, participants engaged in moderate-intensity continuous training. Each session began with a 5-minute warm-up, consisting of 3 minutes of moderate-intensity jogging, 1 minute of dynamic stretching, and 1 minute of acceleration running. Over the 12-week period, running intensity gradually increased from 60% of maximum aerobic speed (MAS) in the first 4 weeks to 65% for weeks 5–8, and finally to 70% for weeks 9–12. CON: non-exercising control Duration: 12 weeks		HIIT vs. MICT: NS MICT vs. CON: p<.05 FM (kg): HIIT vs. CON: p<.05 HIIT vs. MICT: NS MICT vs. CON: p<.05 FFM (kg): HIIT vs. CON: NS HIIT vs. MICT: NS MICT vs. CON: NS WC (cm): HIIT vs. CON: NS HIIT vs. MICT: NS MICT vs. CON: NS Insulin (μIU/mL): HIIT vs. CON: p<.05 HIIT vs. MICT: NS MICT vs. CON: p<.05 HOMA-IR: HIIT vs. CON: p<.05 HIIT vs. MICT: NS MICT vs. CON: p<.05
Mohamed et al., 2022	Egypt	Quasi-experimental research design Inclusion: 12 to ≤ 18 years old adolescents with obesity Exclusion: diagnosed with acute or chronic illness, cognitive disorder; use of prescription drug for weight reduction within the last three months; use of other alternative therapies within the last month prior to the experiment; having skin lesions at the intervention site	N = 60 Intervention: n = 30 M/F: 10 (33.3%)/20 (66.7%) 15.80±1.32 years (mean±SD) Control: n = 30 M/F: 13 (43.3%)/17 (56.7%) 15.77±1.28 years (mean±SD)	Intervention: received routine hospital care in addition to application of acupressure technique at specific point of children's body Control: receiving only routine hospital care Duration: 8 weeks	BMI	Intervention vs. control, MD (T), on BMI: -3.647 (-5.822), p<.001

Weghuber et al., 2022	Austria	RCT Inclusion: 12 to <18 years of age) with a BMI in the 95th percentile or higher (according to sexand age-specific growth charts); those with a BMI in the 85th percentile or higher who had at least one weight-**related coexisting condition** were also eligible; at least one unsuccessful dietary weight loss effort Exclusion: weight change of more than 5 kg or use of a medication for obesity within 90 days before screening; previous bariatric surgery; uncontrolled thyroid disease; presence of secondary causes of obesity; major depressive disorder within 2 years before screening; diagnosis of severe psychiatric disorders or bulimia nervosa; and history of suicide attempt	N = 201 Male/female: 76/125 (38%/62%) 15.4±1.6 years Semaglutide: n = 134 Male/female: 50/84 (37%/63%) 15.5±1.5 years Placebo: n = 67 Male/female: 26/41 (39%/61%) 15.3±1.6 years	Semaglutide: once-weekly subcutaneous semaglutide (at a dose of 2.4 mg) plus lifestyle intervention. The dose of semaglutide was escalated over a period of 16 weeks from 0.25 mg to 2.4 mg or to the maximum dose that did not cause unacceptable adverse events. Placebo: placebo plus lifestyle intervention. Duration: 68 weeks	percentage change in BMI	Semaglutide vs. placebo, EM (95% CI) on Change in BMI, %: −16.7 (−20.3 to −13.2), p<.001. ≥5% reduction in body weight, %: 14.0 (6.3 to 31.0), p<.001. Change in BMI: −6.0 (−7.3 to −4.6) Change in BMI standard-deviation score: −1.0 (−1.3 to −0.8) Change in body weight: Absolute change, kg: −17.7 (−21.8 to −13.7) Relative change, %: −17.4 (−21.1 to −13.7) Change in waist circumference, cm: −12.1 (−15.6 to −8.7) Change in IWQOL-Kids questionnaire scores, points: Physical comfort domain: 6.6 (2.0 to 11.2) Body esteem domain: 3.9 (−1.9 to 9.8) Social life domain: 3.1 (−1.8 to 7.9) Family relations domain: 3.4 (−0.3 to 7.1) Total score: 4.3 (0.2 to 8.3)
Robinson et al., 2021	USA	RCT Inclusion: 7-12 years; BMI ≥ 85th percentile Exclusion: diagnosed with a medical condition or taking a medication affecting growth; had a condition limiting participation in interventions or assessments; unable to speak English	N = 241 MMM: n = 120 HE: n = 121 Male: 107 (44%) Female: 134 (56%) 9.5±1.4 yr (mean±SD)	MMM: targeted multiple levels, including children, parents, peer groups, clinics, and community environments. It focused on various aspects such as eating habits, physical activity, screen time, and parenting, employing behavioral and environmental strategies. Developed over three years for each family, it integrated Bandura's social cognitive model and Latinx cultural values, incorporating recent social psychological science to enhance intrinsic motivation and values affirmation. The intervention aimed for holistic behavior change, employing stealth intervention principles. GOALS@home involved home-based interventions with five modules	P: child BMI trajectory over three years. S: one- and two-year changes in BMI.	MAD (95% CI) BMI (1 yr): −0.73 kg/m2 (−1.07, −0.39) kg/m2, d= −.55 BMI (2 yr): −0.63 kg/m2 (−1.13, −0.14) kg/m2, d= −.33 BMI (3 yr): −0.25 kg/m2 (−0.90, 0.40) kg/m2, d= −.10, p=0.45 BF% (1 yr): –1.29 (–1.91 to –0.67), d= 0.53 BF% (2 yr): -1.06 (-1.99 to -0.13), d= 0.29 BF% (3 yr): -0.50 (-1.63 to 0.63), d= 0.11 WC (1 yr): –1·68 (–2.65 to –0.70), d= 0.44, WC (2 yr): –1.56 (–2.96 to –0.15), d=0.28 WC (3 yr): -0.93 (-2.79 to 0.93), d= 0.13

				spanning three years, addressing environment alteration and behavior change. Team GOALS provided after-school sports programs, while Primary Care GOALS facilitated medical providers' involvement in counseling and reinforcing participation. HE (active control; community-based nutrition and health education intervention): involved continuous intervention over three years for each family. It comprised two annual home counseling visits, monthly health education newsletters sent to both parents and children, quarterly neighborhood health education events, and 1–2 annual social trips to the Stanford campus or athletic events. Content emphasized nutrition, physical activity, screen time, chronic disease prevention, and general health topics. Duration: 3 years		
Diao et al., 2020	China	RCT Inlusion: Exclusion:	N = 948 Intervention: n = 518 Control: n = 430 11.39 ± 1.81 years (average)	Intervention: included family-, individual-, and school-based interventions involving health education, diet, and PA in the form of informing participants of the risk factors and health consequences of being overweight or obese, while also introducing actionable prevention strategies. Additionally, participants were provided with a healthy diet plan based on current Chinese dietary guidelines and a formulated exercise plan. Duration: 1 year	QoL	Intervention vs. control (B, SE, t, p), on Physical QoL: −0.072, 0.377, −0.192, 0.848 Psychological QoL: 1.883, 0.646, 2.917, 0.004 Social QoL: 0.221, 0.702, 0.314, 0.754 Pubertal QoL: 0.853, 0.296, 2.881, 0.004 Total QoL: 3.024, 1.214, 2.491, 0.013 Significant differences in psychological (B = 2.605, SE = 0.752, P = 0.001) and pubertal (B = 0.864, SE = 0.417, P = 0.039) dimension scores and in overall QoL (B = 4.904, SE = 1.714, P = 0.004) among boys, with no significant differences in physical or social dimensions (P > 0.05). In contrast, no significant differences were detected for any dimension among girls (P > 0.05).

Kelly et al., 2020	USA	RCT Inclusion: 12 to <18 years; obesity defined as BMI ≥ 30 or ≥ 95th percentile for age/sex; stable weight change < 5 kg in 90 days before screening; poor response to lifestyle therapy as per site investigator's judgment documented in medical records; type 2-diabetes. Exclusion: Type 1-diabetes	N = 251 Liraglutide: n = 125 female = 71 (56.8 %) 14.6±1.6 yr Placebo: n = 126 female: 78 (61.9 %) 14.5±1.6 yr	Liraglutide: Treatment was initiated at a dose of 0.6 mg daily for 1 week, and then the dose was increased weekly until the maximum tolerated dose or the 3.0-mg dose (highest dose allowed) was reached Placebo: volume-matched placebo administered subcutaneously once daily Duration: 56 weeks plus 26 weeks of follow-up without treatment	Change in BMI	Liraglutide vs. placebo, EMC (95% CI), on BMI standard-deviation score, absolut change: −0.22 (−0.37 to −0.08) BMI standard-deviation score, relative change - %: −7.64 (−12.41 to −2.87) BMI as percentage of the 95th percentile — percentage points: −6.24 (−9.70 to −2.79) BMI, absolut change: −1.58 (−2.47 to −0.69) BMI, relative change %: −4.64 (−7.14 to −2.14) Weight, absolut change – kg: −4.50 (−7.17 to −1.84) Weight, relative change – %: −5.01 (−7.63 to −2.39) WC – cm: −2.93 (−5.24 to −0.63) Liraglutide vs. placebo, geometric mean ratios ±CV (coefficient of variation), on Fasting insulin: 0.91 (0.77 to 1.06) β-cell function on HOMA: 0.97 (0.85 to 1.12) Insulin resistance on HOMA: 0.91 (0.77 to 1.08) Total score on weight-related QoL–Kids questionnaire: 1.31 (−1.57 to 4.20)
Likhitweerawong et al., 2020	Thailand	RCT Inclusion: 10-15 years; BMI ≥ the 95th percentile for children and adolescents of the same age and sex Exclusion: non-android device users; having a chronic medical illness; not living in Chiang Mai; having an intellectual disability or requiring special educational needs; not	N = 70 Intervention: n = 35 Male: 24 (69 %) 13.11±1.99 (mean±SD) Control: n = 35 Male: 24 (69 %) 12.81±1.79 (mean±SD)	Intervention: standard care + OBEST mobile application. The application included four features: 1) Goal and Rewards, 2) Daily Dietary Record, 3) Tips and News, and 4) Messaging. Control: standard care Duration: 6 months	changes in weight, healthy eating behaviors, and quality of life	Intervention vs control, mean (95% CI), on Weight, kg: 1.55 (0.39 to 2.73) vs. 2.32 (1.06 to 3.59), p=0.42 BMI, kg/m2: − 0.62 (− 1.03 to − 0.19) vs. -0.28 (− 0.75 to 0.19), p=0.33 BMI z-score: −0.2 (− 0.27 to − 0.12) vs. −0.15 (− 0.24 to − 0.06), p=0.48 WC, cm: 0.17 (− 1.69 to 1.82) vs. −0.23 (− 2.33 to 1.66), p=0.77 Intervention vs control, mean (95% CI), on QoL scores

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<td>being ethnically Thai; being morbidly obese</td>
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<td>Physical functioning: 4.91 (− 2.55 to 11.96) vs. 1.91 (− 4.22 to 7.43), p=0.53
Emotional functioning: 2.14 (−3.78 to 7.94) vs. 4.6 (−2.02 to 10.03), p=0.57
Social functioning: 1.0 (−5.83 to 7.56) vs. 5.42 (0.51 to 10.57), p=0.29
School functioning: 1.0 (−3.71 to 5.14) vs. 2.15 (−3.57 to 8.09), p=0.76
Psychosocial health summary score: 1.38 (−3.2 to 5.45) vs. 4.06 (0.2 to 8.06), p=0.37
Total summary score: 2.61 (−2.44 to 6.81) vs. 3.31 (−1.04 to 7.28), p=0.82</td>
</tr>
<tr>
<td>Yoshinaga et al., 2020</td>
<td>Japan</td>
<td>RCT

Inclusion: 6-12 years, percentage overweight (%OW) ≥20%</td>
<td>N = 190
Walking:
n = 65
9.7 ± 1.3 years
Male/female: 38/21
Limiting screen time:
n = 60
10.0 ± 1.5 years
Male/female: 28/18
Control:
n = 65
9.9 ± 1.5 years
Male/female: 31/20</td>
<td>Walking: promoting PA through walking (≥10 000 steps on school holidays).
Limiting screen time: avoiding sedentary lifestyle (<90 min on weekdays and <150 min on school holidays).
Control: no intervention

Duration: 3 months</td>
<td>decrease in percentage overweight</td>
<td>Walking vs. control, adjusted mean difference (95% CI), on
Weight, kg: −0.67 (−1.2 to −0.14), p=.01
%OW: −2.18 (−3.85 to −0.52), p=.01
BMI, kg/m2: −0.37 (−0.65 to −0.09), p=.009
BMI z-score:
Japanese reference: –0.06 (−0.11 to −0.01), p=.01
IOTF: −0.08 (−0.14 to −0.02), p=.01
CDC reference: −0.06 (−0.10 to −0.01), p=.01

<table>
<tr><th>Groups</th><th colspan="3">Mean difference (95% CI)</th></tr>
<tr><th></th><th>Walking</th><th>Limiting ST</th><th>Control</th></tr>
<tr><td>Number of subjects</td><td>59</td><td>46</td><td>51</td></tr>
<tr><td>Weight (kg)</td><td>0.26 (–0.11/0.62)</td><td>0.80 (0.33/1.28)</td><td>0.88 (0.51/1.24)</td></tr>
<tr><td>Percent overweight (%)</td><td>−4.06 (–5.32/−2.80)</td><td>−1.97 (−3.34/−0.60)</td><td>−1.81 (−2.84/−0.79)</td></tr>
<tr><td>Body mass index (BMI) (kg/m^2)</td><td>−0.46 (–0.67/–0.26)</td><td>−0.16 (–0.39/0.08)</td><td>−0.10 (−0.27/−0.08)</td></tr>
<tr><td>BMI Z-score</td><td></td><td></td><td></td></tr>
<tr><td>Japanese reference</td><td>−0.12 (−0.15/-0.08)</td><td>−0.06 (−0.10/−0.03)</td><td>−0.06 (−0.09/-0.03)</td></tr>
<tr><td>IOTF reference</td><td>−−0.16 (−0.21/−0.11)</td><td>−0.09 (−0.13/−0.04)</td><td>−0.08 (−0.12/−0.04)</td></tr>
<tr><td>CDC reference</td><td>−0.12 (−0.15/−0.08)</td><td>−0.07 (−0.10/−0.03)</td><td>-0.07 (−0.09/−0.04)</td></tr>
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Arlinghaus et al., 2019	USA	RCT Inclusion: Mexican-Americans; 10-17 years; BMI percentile ≥ 85th percentile Exclusion: pregnancy; cognitive impairment as identified by the school; use of weight loss medication; type 1or 2 diabetes	N = 243 Males: 100 (49.3) Females: 103 (50.7%) 12.02 ± 0.57 years (mean ± SD)	Intervention: Consisted of nutrition lessons 1, 3, or 5 d a week based on the traffic light diet, circuit-based PA, behaviour modification techniques (token economy system, goal setting, and self-monitoring), and parental involvement (materials sent home and monthly parent meetings). 80% of time was spent on PA, and 20% was spent on nutrition. All activities were led by research staff trained in behaviour modification by a clinical child psychologist. Control: Treatment as usual (PE class with sports-based skill development and practice led by PE teachers. Duration: 24 weeks	zBMI	zBMI units (95% CI), 3 d/wk vs control: −0.19 (−0.28 to −0.11), p< .001 5 d/wk vs control: −0.18 (−0.27 to −0.10), p< .001 3 vs 5 d/wk: 95% CI (0.09 to 0.08), p=.87
Jebeile et al., 2019	Australia	Noncontrolled trial Inclusion: 12-17 years; BMI ≥ 30 kg/m2 Exclusion: type 1 diabetes or type 2 diabetes; secondary causes of obesity; psychiatric disturbance, weight-altering medication; not speaking English	N = 30 Females: 25 12-17 (mean ± SD age: 14.5 ± 1.4)	Phase 1 (0-12 wk): IER diet comprised of a VLED 3 d/wk and 4 d/wk of healthy eating. Participants were supported by a study dietitian during 20- to 40-min individual face-to-face consultations and via their choice of electronic mail, short message service, or telephone calls between visits. Phase 2 (13-26 wk): Either continuation of the VLED 3 d/wk, or reduce to 2, 1, or 0 VLED d/wk in the context of a healthy eating plan for the next 14 wk. Regular face-to-face consultations and support between visits by the study dietitian continued. Duration: 26 weeks	P: feasibility of intermittent energy restriction and change in BMI S: diet acceptability, body composition, cardiometabolic risk, insulin, vascular structure and function, quality of life (Pediatric Quality of Life Inventory), and eating behaviors [Dutch Eating Behavior Questionnaire (DEBQ-C)]	difference in EMM ± SEMs BMI %95th percentile (12 wk): −5.6 ± 1.1, p<.001 BMI z-score (12 wk): −0.10 ± 0.02, p<.001 BMI %95th percentile (26 wk): −5.1 ± 1.9 percentage points, p=.013 BMI z-score (26 wk): −0.12 ± 0.04, p=.007 Waist-to-height ratio (12 wk): −0.02 ± 0.008, p=.018 BF% (12-26 wk): −1.57% ± 0.76%, p=0.05 Overall mean fasting plasma insulin concentrations did not change during the intervention. Several domains of quality of life increased, including emotional (7.71 ± 3.0, p=0.02) and social (4.58 ± 2.08, p=0.041, between 12 and 26 wk) subscales, and general wellbeing (7.93 ± 3.73, p=0.049). Study completers who maintained a reduced BMI %95th percentile at 26 wk had greater improvements in psychosocial (p=0.039) and total HRQOL (p=0.028) than those who did not reduce their weight.

Recasens et al., 2019	Spain	Follow-up on a two-year cluster-randomised prospective study Inclusion: children who had participated in the Avall study (2006)	N = 278 Intervention: n = 156 Control: n = 122	Intervention: Promoting healthy eating habits and PA in the school setting over a two-year period. Every classroom used three hours a week for activities related to healthy food habits and/or physical activity. In addition, an extracurricular intervention that relied on collaboration between schools and participating families was designed.	BMI changes over time (eight years)	Intervention vs. control, mean difference (95% CI), on BMI: 0.68 (0.02 to 1.34), p=.045
SoJung et al., 2019	USA	RCT Inclusion: 2–17 years; BMI≥85th percentile and <40 kg/m2; pubertal (Tanner stages II-V); non-smokers; physically inactive (no participation in structured physical activity for past three months before study entry except school physical education classes) Exclusion: participation in structured exercise; significant weight change (Δ BMI >2–3 kg/m2) in the past three months before study entry; endocrine disorders (eg, polycystic ovary syndrome, diabetes); syndromic obesity; psychiatric disorders or the use of chronic medications which influence glucose metabolism (ie, insulin sensitizers) or body composition	N = 118 AE: n = 38 male/female: 13/25 14.4 ± 1.6 yr RE: n = 40 male/female: 15/25 14.4 ± 1.6 yr Combined: n = 40 male/female: 14/26 14.5 ± 1.7 yr	All participants were asked to attend either aerobic exercise (AE), resistance exercise (RE), or combined AE+RE 3 times/week, 60 minutes/session. Duration: 6 months	P: insulin sensitivity S: liver fat and intermuscular adipose tissue	Pairwise significance: *AE vs RE* Weight, kg: NS BMI, kg/m2: NS BMI percentile: NS WC: NS Fat%: NS Total fat, kg: NS FFM: NS Peripheral insulin-stimulated glucose disposal, Rd (mg/kg/min): p<.05 Peripheral insulin-stimulated glucose disposal, Rd (mg/kg*FMM/min): p<.05 *AE vs. combined* Weight, kg: p<.05 BMI, kg/m2: NS BMI percentile: NS WC: NS Fat%: NS Total fat, kg: NS FFM: NS Peripheral insulin-stimulated glucose disposal, Rd (mg/kg/min): NS Peripheral insulin-stimulated glucose disposal, Rd (mg/kg*FMM/min): NS *RE vs. combined* Weight, kg: NS BMI, kg/m2: NS BMI percentile: NS WC: NS Fat%: NS Total fat, kg: NS FFM: NS Rd (mg/kg/min): NS

						Rd (mg/kg*FMM/min): NS
Sen et al., 2018		Randomized trial Inclusion: 9–12-year-old children with obesity Exclusion: unable to understand and to follow the instructions given by the physician; illiterate children	N = 108 (24 completed) Game group: n = 12 Female: 5 (41.7%) 10.75±1.14 years Behavioral group: n = 12 Female: 4 (33.3%) 9.91±1.08 years	Game group: parents participated in six group sessions lasting 40–60 min at 2-week intervals. Children participated in game sessions where they played the board game Kaledo which is designed to improve nutritional knowledge and to promote a healthy lifestyle. Behavioral group: parents and children participated in ix group sessions lasting 40–60 min at 2-week intervals. Duration: 3 months	BMI z-score	Changes in BMI z-score, mean ± SD Behavioral group: 1.90 ± 0.30 Game group: 1.98 ± 0.31 p = 0.706 Changes in BMI, kg/m2, mean ± SD Behavioral group: 24.43 ± 2.33 Game group: 26.24 ± 2.67 p = 0.130



Report II

Lifestyle interventions for children and adolescents with overweight or obesity in the Danish municipalities: An overview

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Authored by

Pernille Andreassen, PhD
E-mail: pernilleandreassen@ncfo.dk
Phone: +45 2033 1982

Jane Nautrup Østergaard, PhD
E-mail: janeos@rm.dk
Phone: +45 2388 2456

Jens Meldgaard Bruun, MD, professor
E-mail: jensbru@rm.dk
Phone: +45 3533 2516

Steno Diabetes Center Aarhus and the Danish National Center for Obesity
Aarhus University Hospital
Palle Juul-Jensens Boulevard 11, Entrance A
8200 Aarhus N
Denmark
CVR: 29190925

Contents

1 Background 3
2 Aim and purpose of Report II 3
3 Methods 4
3.1 Delimitations 4
4 Results 5
4.1 Number of interventions, target groups and propagation 5
4.2 Referrals 8
4.3 Intervention content, set up, professionals, and duration 8
4.4 Evaluations 11
5 Description of new trends 11
6 Summary 13
References: 14

1 Background

Poor progress in supporting healthy behaviours in childhood is part of the ethology for the reduced wellbeing, poorer mental health and increased risk of long-term chronic disease among children. Since 2000, the childhood overweight rates have been stable in Denmark, though a deeper look into the prevalence of childhood obesity reveals a significant inequity as this is due to a reduced prevalence among children from more affluent families and a rise among children from less affluent families. During the recent years the prevalence of children with low mental health and wellbeing has been rising internationally and as well as in Denmark.

According to the Danish Health Act, § 119, the 98 Danish municipalities are responsible for the citizen oriented disease prevention and health promotion and have a joint responsibility with the five regions in Denmark for the patient oriented prevention of disease progression (Sundhedsloven, 2016). The municipalities are obligated to create frameworks for a healthy lifestyle and to offer accessible health interventions ('sundhedstilbud') to promote health and prevent disease among citizens. They are also obligated to approach citizens with interventions and cooperate with local clubs, associations, and volunteers to promote health (Sundhedsstyrelsen, 2018).

However, there are few directives regarding which specific health promoting and disease preventing interventions the municipalities should offer. In other words, "*there is no specific description of how the work should be done, and which services should be prioritised*" (Sundhedsstyrelsen, 2018). Subsequently, the focus, approach, content, number, and scope of interventions in the municipalities vary greatly.

This is also the case regarding health interventions for children and adolescents with overweight and obesity, which is not an obligatory area of focus for the municipalities. Nonetheless, the municipalities have a number of reports and recommendations from different government agencies, councils and institutes to guide them in their work with overweight and obesity. These include a health promotion package (Sundhedsstyrelsen, 2018). and comprehensive reviews of evidence for lifestyle interventions (Sundhedsstyrelsen and University of Copenhagen, 2018) and for prevention of overweight and obesity among children and adolescents (Bruun *et al.*, 2021).

2 Aim and purpose of Report II

The aim of this study is to map and provide insight into the lifestyle interventions available for children and adolescents with overweight or obesity (0-18 years) in the Danish municipalities. The purpose is to shed light

on the aims, content, scope and outcome of the interventions as well as provide insights into how the municipalities manage different factors in connection with the interventions, such as evaluation, cooperation and follow-up. The purpose is to generate knowledge that can serve to inspire and is relevant for designing future implementation strategies of preventive measures.

3 Methods

The results presented in this report are primarily based on data collected for the 'municipality map', developed by the Danish National Center for Obesity (NCFO) to provide a dynamic and up to date overview of all municipal and regional interventions for children, adolescents and adults with overweight and obesity in Denmark. The map is accessible at www.ncfo.dk/kommuner.

The data collection for the map started in 2021 and was originally based on information from the municipalities' own homepages and from the joint public healthcare portal *Sundhed.dk*, where the interventions were described. Since 2023, the map has been updated by contacting all municipalities directly by mail and/or phone to confirm or correct the interventions described on the 'municipality map'. The map is updated annually.

Previous relevant research done in this area will be included in the report in order to show temporal development and provide a more nuanced understanding of the subject matter. E.g. this report includes a study made in 2017, by the National Institute of Public Health ('Statens Institut for Folkesundhed/SIF'). This study showed that at that time 95 municipalities had interventions for children and adolescents with overweight, and 55 municipalities had more than one intervention for this target group: 40 municipalities had one intervention, 23 had two interventions, 16 had three interventions and 16 municipalities had four or more interventions (Kierkegaard *et al.*, 2017). However, the SIF study included e.g. referrals to lifestyle camps ('Julemærkehjem') and hospitals as well as conversations with a community health nurse ('sundhedsplejerske') as types of interventions, which is not the case with NCFO's 'municipality map'. This should be taken into consideration when comparing the numbers of SIF's study to NCFO's findings, where these possibilities have not been included, and where focus is solely on the interventions that the municipalities themselves offer.

3.1 Delimitations

The NCFO data collection includes only interventions that are solely for citizens with overweight or obesity. As such, interventions that may be considered adjacent, such as interventions for citizens with type 2

diabetes, are left out in order to focus exclusively on the interventions developed for and offered to children and adolescents with overweight or obesity by the municipalities in Denmark.

It is worth mentioning that online descriptions of the interventions, which are used in this report, are typically sparse, and therefore the interventions may be more comprehensive than indicated here.

In the report, there will not be distinguished between the terms 'overweight' and 'obesity'. Rather the terms and admission requirements used in specific municipal interventions will be used and highlighted.

4 Results

The data from NCFO's 'municipality map' used in this report was extracted on July 19th 2024 - unless otherwise stated.

4.1 Number of interventions, target groups and propagation

As shown in table 1, 69 out of the 98 Danish municipalities offer a lifestyle intervention for children or adolescents with overweight. Thus 29 municipalities do not have municipality-driven interventions.

Table 1. Lifestyle interventions for children or adolescents with overweight in the municipalities of in the five Danish regions.

Region	**Number of municipalities with a lifestyle intervention for children or adolescents with overweight**	**Number of municipalities in total in the region**
The North Denmark Region	9	11
Central Denmark Region	16	19
The Region of Southern Denmark	17	22
Region Zealand	9	17
The Capital Region of Denmark	18	29
In total	69	98

However, based on readily accessible knowledge, it is not possible to assess the capacity of the interventions, i.e. how many participants they can contain and if they are filled to capacity, if there are waiting lists, and how many drop out and why.

The vast majority of the municipalities that had an intervention in 2024 offered *one* type of intervention (n=64) for children or adolescents with overweight. Three municipalities in The Region of Southern Denmark and two municipalities in The Capital Region of Denmark offered *two* different interventions.

None of the municipalities had more than two interventions. Thus there was a total of 74 different interventions for children and adolescents spread over 69 municipalities, as shown in table 2.

Table 2. Number of interventions in the municipalities that offered intervention/s

Number of interventions	Municipalities
One intervention	64
Two interventions	5
Total number of interventions	74

The number of municipalities with interventions for children and adolescents with overweight and obesity seems to have been decreasing over the past years (table 3). In NCFO's study from 2022, 76 municipalities had interventions for children and adolescents with overweight with a total of 86 different interventions. In 2023, 75 municipalities had interventions for children and adolescents with overweight with a total of 84 different interventions, and, as just recounted, in 2024 the number was 69 municipalities with a total of 74 different interventions (see table 3). Overall, both the number of municipalities with interventions and the total number of interventions across the municipalities has been declining over the past few years.

Table 3. Number of interventions in the municipalities 2022-2024

Year	Number of municipalities with interventions	Total number of interventions across the municipalities
2022	76	86
2023	75	84
2024	69	74

In terms of target groups, most interventions (67 out of 74) involve the whole family. These interventions will be described in more detail later. The few interventions that do not involve the whole family, but children or adolescents only (n=3) typically consist of a number of conversations between the child and a school health nurse. This is the case in Faxe municipality, where schoolchildren living with overweight are offered 6-7 consultations with the school health nurse or a nutritional advisor regarding issues such as diet, exercise and lifestyle. The interventions are typically not elaborately described online and might in practice involve the parents as well.

In three municipalities, the intervention is directed at the parents alone. For instance, this is the case in the intervention "Sund familie" in Guldborgsund municipality, where parents of children with overweight are offered a group-based intervention with guidance about e.g. food, meals, exercise, screen time and sleep. However, if the child is above the age of 14, the child can also participate in the intervention. In a similar vein, some of the other municipalities that offer interventions for the whole family indicate that it depends on the age of the child, whether or not they participate in the intervention, for example in Skive municipality.

An overview of the target groups for the interventions can be seen in table 4.

Table 4. Age and target groups for the interventions*

Target groups	**Number of interventions**
Municipal interventions involving **families**	69
Municipal interventions involving **children or adolescents** only	1
Municipal interventions involving **parents** only	3
Municipal interventions involving parents and children over a certain age	1

Regarding age groups, most interventions span both children (defined as 0-12 years old) and adolescents (defined as 13-17 years old), as can be seen in table 5. Furthermore, a few municipalities offer interventions that go beyond the age of 17 and continue into adulthood (n=2). For example, Nyborg municipality offers an intervention aimed at children and young people between the ages of 3 and 25.

Table 5. Age groups for the interventions*

Age groups	**Number of interventions**
Municipal interventions involving **children** (0-12 years old)	5
Municipal interventions involving **adolescents** (13-17 years old)	2
Municipal interventions involving **children and adolescents** (0-17 years old)	64
Age not indicated	3

* The age group division (0-12 years old and 13-17 years old) and target group division is made by NCFO and not the municipalities, and therefore there is an overlap between the categories.

As to the aim or focus of the lifestyle interventions, they often have more than one focus, as can be seen in table 6. Of the 74 municipality interventions, 26 focus primarily on weight, weight maintenance or weight loss, while 22 indicate that their focus is both weight (maintenance/loss) and well-being, which denotes a weight related focus in the majority of the interventions. Ten interventions specify that their main focus is healthy habits or a healthy lifestyle, while health or health in combination with well-being is central in 12 interventions. Finally, overall well-being is the focus of four interventions.

Table 6 Primary focus*

Focus	**Number of interventions**
Weight, weight maintenance or weight loss	26
Weight (loss) and well-being	22
Lifestyle / healthy habits	10
Health and well-being	6
Health	6
Well-being	4

* as described on the municipalities' home pages

4.2 Referrals

15 interventions require a referral from a doctor, a health nurse or a hospital, while 57 interventions have open access, although it is also possible to be referred by a doctor or a health nurse. Two municipalities have not indicated whether referral is necessary.

4.3 Intervention content, set up, professionals, and duration

Table 7 shows an overview of the different kinds of content and activities encompassed by the interventions. Most interventions have more than one type of activity.

Table 7 Types of activities

Type of activity	**Number of interventions**
Dietary guidance	66
Exercise guidance	66
Sleep habits guidance	16
Mental health guidance	13
Screen time guidance	10
Healthy habits guidance	9
Exercise activities	5
Dietary activities	2
Disordered eating	1 (above the age of 16)
Online-course	1
Activities not described on home page	8

Most of the interventions feature some form of dietary guidance and exercise guidance (n=66). The dietary guidance is rarely described in detail online on Sundhed.dk and the municipalities' home pages, but may consist of e.g. guidance in terms of choice of food, meal and eating habits, the development of individual meal plans and habits regarding sugar. Guidance in connection with exercise is even less elaborately described online, often it is simply described as exercise, movement, activity or sports guidance.

Some municipalities describe online that guidance regarding sleep habits (n=16) and screen time (n=10) is also included in the intervention, while mental health guidance is emphasized in 16 descriptions of interventions.

In terms of dietary activities, families in the intervention cooking and eating together or food workshops ('Madværksted') are mentioned. Exercise activities are also not described thoroughly, but the possibility of participating in a childrens' exercise or swimming team – sometimes with payment - is mentioned (for instance in Solrød and Ballerup municipalities). Ballerup municipality mentions the possibility of being

referred to Jump4Fun, which is an exercise team "with room for diversity" in the sports association DGI (Jump4Fun).

Although weight is the focus of many interventions, only very few interventions indicate that weighing is part of the intervention (for example Faaborg-Midtfyn). While online interventions are a little more widespread in interventions aimed at adults with obesity (n=8), there is only one online intervention aimed at young people (in Aabenraa municipality).

One intervention approach is particularly prominent, which is the "*Holbæk-model"*, which was developed at the children's ward at Holbæk hospital around 2007 and is a family- and conversation-based program focusing on behavior change by way of individually tailored family plans. Typically focus in Holbæk-based interventions will be on weight loss or reducing the degree of overweight by having the children maintain their weight while they grow (Holbæk Sygehus, 2023). In their own recounts, many municipalities describe their approach as "inspired by" or "using a modified version" of the Holbæk-model.

The Holbæk model or a version of it is used in 40 out of the 69 municipalities that have interventions, as shown in table 8. It is particularly prominent in Central Denmark Region (11 out of 16 municipalities with interventions), and Region Zealand (7 out of 9).

Table 8. Use of specific approaches: "The Holbæk model"

Region	The Holbæk-model or an intervention inspired by or using elements of this approach
The North Denmark Region	4 (out of 9 municipalities with interventions in the region)
Central Denmark Region	11 (out of 16 municipalities with interventions in the region)
The Region of Southern Denmark	7 (out of 17 municipalities with interventions in the region)
Region Zealand	7 (out of 9 municipalities with interventions in the region)
The Capital Region of Denmark	11 (out of 18 municipalities with interventions in the region)
In total	40 (out of 69 municipalities with interventions in all five regions)

The number of municipalities making use of a the Holbæk-model or a version inspired by the model seems to have decreased a little between 2017 and 2024 (from 47 to 40), but the overall number of municipalities with an intervention has also decreased during the same period (table 9).

Table 9. The Holbæk-model (or inspired by the Holbæk-model)

Year	**Municipalities using or inspired by the Holbæk-model**
2017 (SIF)	47 municipalities
2022 (NCFO)	52 municipalities (out of 76 municipalities with interventions)
2023 (NCFO)	50 municipalities (out of 75 municipalities with interventions)
2024 (NCFO)	40 municipalities (out of 69 municipalities with interventions)

As shown in table 10, the majority of the interventions involve the whole family (n=66), while seven interventions are a mix of individual family activities, such as diet and exercise guidance, as already described, and common group activities, such as lectures or cooking activities. No interventions are purely group based, and only one intervention targets adolescents.

Table 10. Type of intervention

Type of intervention	**Number of interventions**
Individual family intervention	66
Group interventions	0
Mix of individual family and group intervention	7
Individual intervention for adolescents	1

Table 11 shows an overview of the duration of the interventions. In 25 cases, the duration of the intervention is not indicated online, but in many of these cases some version of the Holbæk-model is utilized, meaning that the duration of the intervention is probably adapted to the individual family and may potentially last several years. In 23 interventions, the length of the intervention is individually adapted to the needs of the participating families, and in 19 cases the intervention lasts longer than one year. Only in seven cases in total, interventions last less than one year.

Table 11. Duration

Duration	**Number of municipalities**
One meeting	0
0-3 months	0
4-6 months	1
7-12 months	6
More than 12 months	19
Individually adapted	23
Not indicated	25

Very few interventions mention any kind of follow-up after the intervention. Only in one case a three month follow up after the intervention is mentioned (in Aarhus municipalty) and a few interventions emphasize involving introduction to local sports associations ('foreningsliv') (for instance Esbjerg and Greve municipalities).

The professionals carrying out the interventions are often not mentioned or described online. However, (school) health nurses seem central to many interventions, sometimes in cooperation with a clinical dietitian. A few municipalities mention interdisciplinary cooperation, for example in Copenhagen municipality where (school) health nurses, nurses, diet- and exercise guides and psychologists cooperate with a doctor and

volunteers, and in Hjørring municipality where a (school) health nurse runs the intervention along with a clinical dietitian and a physical therapist.

Six municipalities mention that they cooperate with a Julemærkehjem, and a few interventions mention cooperation with local institutions and local community, for example:

- in Aalborg municipality where the health nurse clinic cooperates with Aalborg Universitety Hospital ('Videncenter for børn og unge med overvægt').
- in Mariagerfjord municipality where a healthcare professional team cooperates with health nurses, school, kindergarten, after school programs, the church's family support and more.
- in Viborg where the intervention team cooperates with among others the 'ROS-team' at 'Hospitalsenhed Midt'.

Nine interventions in eight different municipalities offer interpretation assistance ('tolkebistand').

It is not possible based on the online information to determine how many interventions are permanent and how many are time limited projects.

4.4 Evaluations

As has previously been described in the report 'Kortlægning af livsstilsinterventioner' (Kierkegaard *et al.*, 2017), only very few of the municipalities that offer interventions for children or adolescents with overweight have publicly available evaluations of the current interventions. This seems to still be the case, because only two interventions have evaluations readily available online, some of which are more than ten years old (Aarhus municipality and København municipality).

5 Description of new trends

Healthy weight development in childhood is modified by multiple lifestyle behaviours, among others physical activity, screen use, diet and sleep. Optimal healthy behaviours are essential in childhood as patterns established early persist to some degree into adolescence and adulthood (Melby *et al.*, 2021; Kristensen *et al.*, 2008). Research document that (un)healthy behaviours can be improved, but the effect almost never persists or lasts beyond the trial period and is as such of little usage in changing the health of populations (Olsen *et al.*, 2024). New strategies are under development and tested to implement effective interventions to improve the health and wellbeing of younger generations. An answer to this call is applying participatory systems-oriented approaches as these has been proven to engage and motivate local communities to take a

comprehensive and system-oriented responsibility to target complex childhood health behaviours and ultimately to change these behaviours (Allender *et al.*, 2019; Allender *et al.*, 2024; Allender *et al.*, 2021).

In a Danish context, a three-year participatory systems-oriented trial Children's Cooperation Denmark (Child-COOP DK) is currently being applied in local communities located in five municipalities (Ryom *et al.*, 2023). Child-COOP DK have trained approximately 30 municipal staff in working with a participatory systems approach, supported the recruitment of participants to - and the running of – participatory workshops, supported the municipality staff in their work with the formation of Action Groups to support the development and implementation of actions. Collection of Baseline data in 2023 and follow-up data in 2026 will enable the Child-COOP trial to track how these efforts have resulted in changes at systems and/or child level in the intervention communities compared with selected comparison communities.

Another large Danish study 'Generation Healthy Kids' investigates whether a truly multilevel intervention targeting physical activity, screen use, diet and sleep can promote healthy weight development (Thomsen *et al.*, 2024).

Finally, in municipal interventions aimed at adults with overweight and obesity, there has been some interest and inspiration from the concept of "Health at every size" (“ligevægt”/ ”Vægtneutral sundhed”), where focus is moved away from weight and weight loss and instead placed on mental, social and physical health. This approach is seen for instance in Kolding municipality, that had a "ligevægt" intervention aimed at families, which was shut down however. The principles of "ligevægt" seems to influence interventions for adults with overweight in the Danish municipalities. It is not, however, possible to conclude from the descriptions available online, whether this is also the case in the interventions for children and adolescents.

6 Summary

Out of all 98 municipalities, 69 municipalities offered an intervention for children and/or adolescents with overweight or obesity. Five municipalities have two interventions, making a total of 74 different interventions. The number of municipalities offering interventions for this target group seems to be declining (from 76 municipalities in 2022 to 69 in 2024).

The vast majority of the interventions (n:69 out of N:74) target the whole family, rather than parents or children only. Most municipalities (n:64) include a wide age group. The aims of the interventions vary: In the short descriptions of the interventions on the municipalities' home pages, some (n:26) highlight weight, while others (n:22) focus on both weight and well-being ("trivsel"). Some (n:12) emphasize health and well-being, and others (n:10) healthy habits. Most of the interventions where the length of the intervention is indicated, the duration is more than 12 months (n:19) or is adapted individually (n:23).

In terms of methods, most of the interventions (n:69) offer guidance; especially dietary and exercise guidance. Some also address sleep habits (n:16), mental health (n:13) and screen time (n:10). Only very few interventions offer activities, such as cooking or exercise classes. In terms of specific approaches, the "Holbæk model" or variations inspired by this approach are prominent.

There are very few publicly available evaluations of this kind of intervention.

Data was accessed on July 19th, 2024.

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Conclusion

This report provides a comprehensive evaluation of lifestyle interventions aimed at reducing overweight and obesity in children and adolescents. It can be used as a starting point to build a policy basis for novel and impactful interventions that can help counter overweight and help advance physical, mental and social health and wellbeing in children and adolescents. The report consists of two diverse but supplementary parts that in combination give an overview of different types of existing knowledge on this subject that can support the development of such study designs.

Report 1 focuses on large scale, international intervention studies using different strategies to reduce overweight and obesity in children and adolescents. This report builds on a previous synthesis (Sundhedsstyrelsen, 2018), focusing on evidence published between 2017 and 2024 and applies strict inclusion criteria, considering only systematic reviews, meta-analyses, umbrella reviews, and recent RCTs with at least three months of intervention. It covers a wide range of intervention types, focusing mainly on their effectiveness for weight loss and improving body composition. Particularly multi-component programs that involve parents have proven effective for weight loss in children, also improving cardiometabolic markers and psychosocial outcomes. Approaching weight loss from a behavioural perspective tends to be more successful than focusing exclusively on nutrition or physical exercise. As such the combination of diet, physical activity, and behavioural therapy leads to more substantial weight loss compared to using individual components alone. In terms of nutrition alone, particularly hypocaloric and intermittent energy restriction diets have proved effective for weight loss and improving body composition. Similarly, in terms of exercise and physical activity alone, aerobic and resistance exercises as well as high-intensity exercise alongside moderate-intensity activities are seen modestly to reduce both BMI and body fat percentage. In other areas, the evidence is inconclusive or lacking; i.e. in terms of technology-based and sleep interventions.

The findings in report 1 largely confirm what has previously been reported in the report from Danish Health Authority from 2018 (Lind *et al.*, 2018). Report 1 also includes studies on weight loss medications and bariatric surgery, showing that while these are effective for weight loss in children with (severe) obesity, more studies need to be done on short-term side effects and long-term effects on body weight and well-being.

Based on information available online, Report 2 aims to provide an overview of the lifestyle interventions available for children and adolescents with overweight or obesity in the Danish municipalities. The report shows that in 2024, 69 out of the 98 municipalities offered an intervention for children and/or adolescents with overweight or obesity, and that the number of municipalities offering interventions for this target group

seems to be declining slightly. The vast majority of the municipal interventions target the whole family, and the duration of the interventions are often more than 12 months or are adapted individually. The aims of the interventions vary: Some focus primarily on weight, while others focus on health, overall well-being, and healthy habits. However, the methods used for most interventions are guidance; especially on diet and physical activity. Finally, the report shows that there are very few (publicly available) evaluations of the municipal interventions.

Thus the interventions in the Danish municipalities seem to carry out some of the strategies that were found to be effective in Report 1; e.g. interventions focusing on multiple components and involving the whole family. However, the lack of systematic evaluation of different types of results (whether it be in terms of weight or well-being – or both) and insight into how the interventions are actually carried out make it difficult to assess the effect or quality of the interventions. As such, there are still a number of issues, possibilities and challenges that need to be addressed to uncover both what is ideal (from a healthcare perspective) and what is possible (in the real world).

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Perspectives

The aim of this report has been to combine different types of existing literature and empirical knowledge to support the design of future, novel and impactful interventions that can efficiently counter the development of overweight and help advance the physical, mental and social health in children and adolescents.

The conclusions of Report I are that multicomponent, family-based lifestyle interventions represent the most effective and evidence-based approach to children living with overweight and obesity. Of importance, it seems evident that single-strategy interventions are insufficient to alleviate overweight and obesity. However, despite promotion of well-being related to some interventions no directly, transferable, and effective ways or concepts to prevent development of overweight and obesity was identified. It is therefore of the utmost importance to carefully consider every intervention initiated in order to attenuate or prevent adverse effects such as stigma

The conclusions from Report I are reflected in Report II, which shows that Danish municipalities in local real-life practice use different methods to alleviate overweight and obesity and to prevent further inordinate weight development. However, the lack of systematic evaluation of the different types of outcomes from the interventions (whether it be in terms of body weight or well-being – or both) and insight into how the interventions are actually carried out make it difficult to assess the effect or quality of the interventions. Again, no single municipality-driven method or concept has been developed, which is why the advice of Report II is to engage in studies investigating the development of interventions across municipalities building on best-practice. These interventions need to be multidisciplinary and multicomponent, as emphasized in Report I. Furthermore, partnerships should be developed, preferably involving academic institutions, to facilitate an evaluation of these municipality-driven interventions to, in collaboration with the municipalities, optimize daily clinical practice to improve well-being of the children and reduce stigma (Ryom *et al.*, 2023).

There are, however, also other challenges to consider apart from implementation. For instance, there is often only very little information on possible 'adverse events' or harm caused by different strategies or interventions. This may for example be in terms of weight stigma which is pervasive and may affect children and adolescents, potentially leading to low self-esteem and negatively influence on school performance (Puhl *et al.*, 2020). A qualitative study from Denmark has shown how participation in health education interventions may lead to intra-familial stigmatization (Høeg *et al*., 2018), and it has been suggested that researchers, professionals, and families may work together to co-design a family-based interventions to prevent childhood overweight and obesity (Høeg *et al.*, 2019). Another pressing and challenging issue,

although still not well-researched, is the long-term effects of interventions targeting childhood obesity. Results from a Danish follow-up study show that an intervention associated with improvements in children's BMIz score were not sustained at six years of follow-up (Fogh *et al.*, 2026). Other recent Danish studies emphasize the importance of including children early in lifestyle interventions to reduce the risk of children/families leaving the intervention prematurely (Jørgensen *et al*, 2023) and indicate that longer lasting, flexible and customized efforts may be helpful for a long-term beneficial development in BMI in children with obesity (Jørgensen *et al*., 2024).

Additionally, as is apparent from Report II, the importance of gaining more insight into what actually happens in the municipal interventions as well as advancing local evaluations that can show the different outcomes of specific real-life interventions seems pertinent. Such insights would make evident what health promoting possibilities are available in the municipalities as well as "what works" in terms of well-being and healthy weight development in children and adolescents in a municipal setting.

Finally, neither report I or II have (directly) address social inequality in obesity and health or focus on structural approaches, legislations, and policies. State and local governments make numerous decisions that directly and indirectly affect health and weight development in children, including access to healthy food and physical activity, which is important to have in mind so as to grasp the complexity of overweight and obesity rather than address these issues as "individual lifestyle problems".

Overweight and obesity remain difficult to prevent, partly because no clear and consistent understanding exists of the root causes. Therefore, there is a continued need for research on how to promote healthy weight among all children and young people, how to prevent the development of overweight in individuals, and which interventions are most effective in reducing existing overweight among children and young people.

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