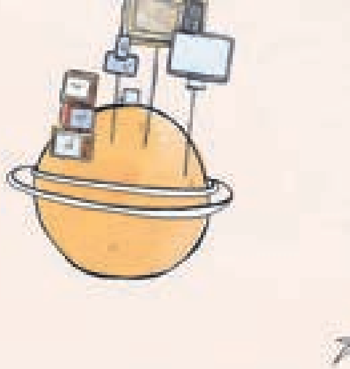
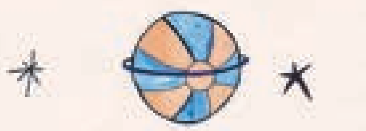


The development and evaluation of a lifestyle screening tool for young children: **FLY-Kids**



The development and evaluation of a lifestyle screening tool for young children: FLY-Kids

Anne Krijger

The Development and Evaluation of a Lifestyle Screening Tool for Young Children: FLY-Kids

J.J.A. Krijger

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The Development and Evaluation of a Lifestyle Screening Tool for Young Children: FLY-Kids

De ontwikkeling en evaluatie van een
leefstijlsignaleringsinstrument voor jonge kinderen:
FLY-Kids

Proefschrift

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Contents

Chapter 1

General introduction

A healthy lifestyle is essential for optimal growth, development, and overall health of young children (1-3 years) [1-4]. An unhealthy lifestyle in the early years, by contrast, may already have a profound negative impact on physical as well as psychological health [5-7]. Overweight and obesity are among the most common consequences. As these unfavourable outcomes are highly prevalent and may persist into adulthood, early modification of unhealthy lifestyle behaviour may have lifelong benefits [8, 9].

Lifestyle patterns of children aged 1 to 3 years can simultaneously include healthy and unhealthy lifestyle behaviours [10, 11]. Identification of unhealthy lifestyle behaviour may aid in improving children's lifestyle patterns and enable better health outcomes. Extensive lifestyle assessment to detect unhealthy lifestyle behaviour is not feasible within the time constraints of preventive youth healthcare practice. Therefore, it is desirable that a lifestyle screening tool is available to quickly identify unhealthy lifestyle behaviour in young children. Such a tool can support youth healthcare professionals providing targeted care and support parents in improving their child's lifestyle. Hence, the risk of lifestyle-related health problems in children may be reduced.

Lifestyle in Early Childhood

The first 1,000 days of life – roughly the period between conception and the second birthday – are crucial for the rest of our lives. It is during this period that the foundations are laid for long-term health, growth and (neuro)development [12]. In addition, research has indicated that later life health can be affected by the mother's lifestyle during pregnancy, as well as by the child's own early lifestyle [13, 14]. Lifestyle is a broad term that encompasses a wide range of behaviours, habits and living conditions. To survive and thrive, infants and young children first need adequate nutrition. For the first six months, and longer if possible, breastfeeding is the first choice [15]. Thereafter, a diverse diet, consisting of sufficient energy and nutrients, prevents deficiencies and is essential for optimal growth and development [16]. Numerous other lifestyle factors, including sleep, physical activity, stress, screen time, and second-hand smoke exposure, may also have a short or long-term impact on children's health [2-4, 17, 18].

Based on scientific research, national and international age-specific recommendations and guidelines have been developed to achieve the best possible lifestyle-related health outcomes. Unfortunately, a large proportion of young children does not comply with lifestyle recommendations. They eat too little fruit and vegetables, and too many packaged snacks and sugar-sweetened beverages [19]. In addition, many children lack enough physical activity and spend an increasing amount of time being sedentary and watching electronic screens [20]. Not following the guidelines, as such, has been associated with both adverse physical and psychological health consequences. Common consequences in young children include being overweight, obese or underweight, nutrient deficiencies, tooth decay, constipation, myopia, and impaired motor skills [21-27]. However, research into the consequences of lifestyle behaviour can be complex since children might exhibit multiple healthy and unhealthy behaviours simultaneously, with synergistic or opposing health effects. As a result, studies that focus on lifestyle patterns rather than individual behaviours may address a better reflection of reality. To characterize lifestyle patterns, various a priori and a posteriori methods can be used [28]. One can, for example, examine the extent to which a child complies with a certain dietary pattern, or distinguish between healthy and unhealthy patterns at population level. Lifestyle patterns, as well as the behaviours and habits that compose them, are formed from an early age and likely persist over time [11, 29]. As health outcomes associated with certain lifestyle patterns, such as overweight and obesity, can also endure and might be difficult to reverse, it is imperative to cultivate a healthy lifestyle as young as possible [30].

The most pronounced consequences of an unhealthy lifestyle in children are overweight and obesity. These major public health concerns accounted for a worldwide prevalence of 5.7% in children up to five years in 2020 [8]. In the Netherlands, 15.5% of children aged 2 to 9 years had overweight in 2021, of whom 4.8% were affected by obesity [31]. Moreover, being overweight or obese as a child increases the risk of having other health issues, such as type 2 diabetes mellitus, hypertension, and dyslipidaemia [21]. Although lifestyle appears to be the main determinant, the development of overweight and obesity is the result of a complex interaction between multiple child factors, including genetics, sex, and certain illnesses and medications [21]. Besides, each child has unique living conditions that can also affect each other, and might be determinants of specific lifestyle behaviour as well.

Figure 1 demonstrates an overview of various determinants of children's health [32]. This so-called "rainbow model" illustrates the relationship between one's health at the centre and layers of health determinants surrounding it. The model demonstrates that

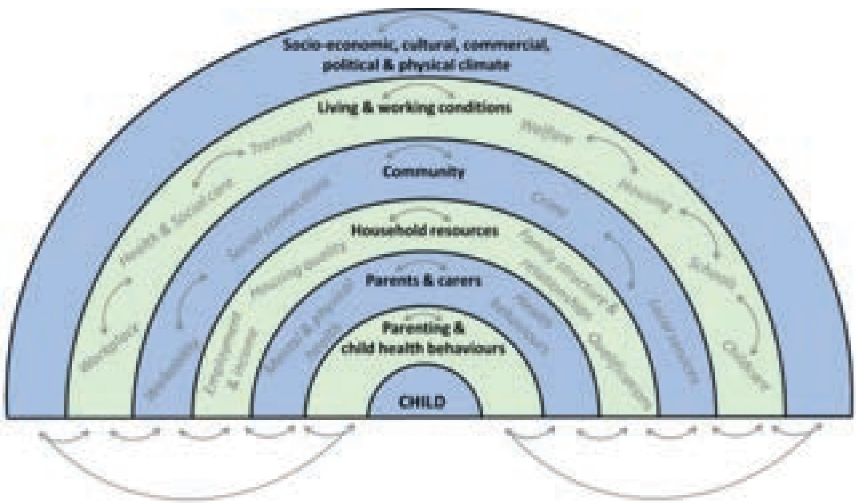

Figure 1: Social determinants of child health (Source: Pearce et al. 2019 [32])

the layer of health behaviours (e.g. lifestyle behaviours), a proximal factor in the model, may be affected by more distal factors, such as the social network, living conditions, and socio-economic, cultural and environmental circumstances. While interventions aimed at improving children's lifestyles may have a rather direct impact on health, such interventions should consider the influence of other, more distal, layers in the model in order to be effective. Interventions to tackle overweight and obesity and to improve lifestyle behaviour should consider, for example, financial resources, neighbourhood facilities and cultural habits of the family.

Promoting a Healthy Lifestyle in Young Children

To reduce the risk of overweight, obesity and other lifestyle-related health risks in young children, the different levels and domains demonstrated in Figure 1 could be exploited. In the Netherlands, there are national programmes that aim to minimise health inequalities among Dutch children to give all children a good start in life and the best changes for a good future. One example is the national action programme "Kansrijke Start" (in English: Promising Start) [33], in which municipalities and the government work together with many other parties, such as youth healthcare, to fulfil this task. While "Kansrijke Start" has a broad perspective on health in the first 1,000 days of life, local activities, such as toddler gym classes, and national initiatives, such as "Gezonde Kinderopvang" (in English: Healthy Childcare) [34] and a legal ban on child marketing of unhealthy foods, contribute specifically to promoting healthy behaviour in young children. In addition, interventions in prevention and promotion of a healthy lifestyle are deployed by the healthcare sector.

An example of such an intervention is lifestyle screening. Lifestyle screening methods are commonly used to detect the consequences of an unhealthy lifestyle at an early, asymptomatic stage. Nevertheless, lifestyle screening can also be applied to identify lifestyle behaviours and factors that may have negative health consequences later in life and, therefore, require modification. Tools with the latter purpose go beyond measuring and could aid healthcare professionals to provide targeted lifestyle support and behavioural counselling. To this end, the tool should be accompanied by specific courses of action. Since young children often do not yet suffer from adverse consequences of their lifestyle, the application of such screening tools might be of great value in this population. Moreover, if the tool provides a quick and easy overview of the child's lifestyle, it would be ideal for use within the busy practice of preventive youth healthcare.

Dutch Youth Healthcare

In the Netherlands, youth healthcare is preventive healthcare aimed at promoting and preserving physical, psychosocial and emotional health of all children aged 0-18 years. Dutch youth healthcare is organised separately from curative care for children, as it is provided by municipalities through 38 regional organisations and public health services

[35]. Core activities of youth healthcare include monitoring growth and development, screening, immunization, and counselling. Youth healthcare works multidisciplinary, for example in collaboration with dieticians or physiotherapists, and children can be referred to specialist care if necessary. Children are automatically registered with youth healthcare and invited for regular consultations. Dutch youth healthcare is free of charge and reaches up to 95% of all young children [36].

Youth healthcare professionals in the Netherlands provide care in accordance with 35 evidence-based guidelines and have access to a range of interventions and screening tools. They are trained in integral assessment of children's needs in the context of family and environment. In addition, the modus operandi of youth healthcare professionals is characterized by a demand-driven approach. This approach is founded on the premise that parents are reinforced in their parenting when care providers offer help that matches the needs indicated by the parents themselves [37]. Furthermore, it may increase parental engagement and support joint decision-making.

Promoting a healthy lifestyle and prevention of lifestyle-related health complaints are among the responsibilities of Dutch youth healthcare. The "Gezamenlijk Inschatten van Zorgbehoeften" (in English: Joint Assessment of Care Needs) methodology, a discussion method for deciding about appropriate care, can be utilized to address care needs related to lifestyle [38]. However, there is no instrument available that provides a quick and easy overview of young children's lifestyle that supports youth healthcare professionals and parents in discussing the topic of lifestyle. Given the magnitude of the lifestyle-related problems, there is a demand for such an instrument, on the condition that it aligns with current youth healthcare working practices.

The FLY-Kids Project 2020-2023

The FLY-Kids (Features of Lifestyle in Young Kids) project 2020-2023 aimed to develop and evaluate a lifestyle screening tool for young children as a first step towards prevention of overweight and underweight. The project was subject to the National Prevention Agreement, a covenant of the Dutch Ministry of Health, Welfare and Sport that addresses the reduction of overweight, smoking, and problematic alcohol consumption among the Dutch population [39]. A partnership between the Erasmus Medical Centre, Dutch Knowledge Centre for Youth Health, Netherlands Nutrition Centre, National Institute for Public Health and the Environment, Netherlands Organisation for Applied Scientific Research, Diagnostic Centre for Nutritional Problems, and Association of Dutch Infant and Dietetic Foods Industries was formed to conduct the project. It was predetermined that the screening tool would be completed by parents prior to a youth healthcare consultation. In addition, the data generated by the screening tool had to support healthcare professionals in discussing lifestyle with parents, and lead to advice to improve children's lifestyle. Other features of FLY-Kids were designed and evaluated in a process of four successive work packages and in co-creation with parents and youth healthcare professionals. The project has yielded a digital version of FLY-Kids and its accompanying implementation strategy.

Aims and Outline Thesis

The aim of this thesis is to improve preventive youth healthcare for young children by developing and evaluating a lifestyle screening tool.

Therefore, the main objectives are:

Part I – Current lifestyle behaviour of children

1. To explore current lifestyle behaviour in children
2. To identify patterns in lifestyle behaviour of young children

Part II – Existing tools and requirements from youth healthcare practice

3. To summarize characteristics of existing lifestyle screening tools for children
4. To determine requirements for the lifestyle screening tool according to parents and youth healthcare professionals

Part III – Development and evaluation of FLY-Kids

5. To design and evaluate the lifestyle screening tool 'FLY-Kids'

Part I and II of this thesis describe the formative research conducted to inform the development of the lifestyle screening tool. Part I illustrates current lifestyle behaviour in children. Nutrient intake and food consumption among Dutch toddlers are described in **Chapter 2**. **Chapter 3** depicts clusters of lifestyle behaviours and their associations with socio-demographic characteristics in the same toddlers. In **Chapter 4**, a study on the longitudinal association between diet quality and cardiovascular outcomes in children is presented.

Part II is geared more towards the new lifestyle screening tool. The systematic review in **Chapter 5** gives an overview of existing lifestyle screening tools for children. **Chapter 6** focuses on the COVID-19 child check questionnaire, a screening tool to measure factors of stress, and physical and social daily life activities in children during the COVID-19 pandemic. In **Chapter 7**, the needs and wishes of parents and youth healthcare professionals regarding the lifestyle screening tool under development are addressed.

Part III is devoted to the actual development and evaluation of FLY-Kids. An overview of the development process and first evaluation of FLY-Kids within youth healthcare practice is described in **Chapter 8**.

Chapter 9 provides an overall discussion in which the main findings of this thesis and future perspectives are addressed.

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Part I

Current lifestyle behaviour of children

Chapter 2

Evaluation of nutrient intake and food consumption among Dutch toddlers

Elly Steenbergen, Anne Krijger, Janneke Verkaik-Kloosterman, Liset Elstgeest, Sovianne ter Borg, Koen Joosten, Caroline van Rossum

Nutrients. 2021 May 1;13(5):1531

Abstract

Improving dietary habits at a young age could prevent adverse health outcomes. The aim was to gain insight into the adequacy of the dietary intake of Dutch toddlers, which may provide valuable information for preventive measures. Data obtained from the Dutch National Food Consumption Survey 2012–2016 were used, which included 672 children aged one to three years. Habitual intakes of nutrients were evaluated according to recommendations set by the Dutch Health Council. Specific food groups were evaluated according to the Dutch food-based dietary guidelines. For most nutrients, intakes were estimated to be adequate. High intakes were found for saturated fatty acids, retinol, iodine, copper, zinc, and sodium. No statement could be provided on the adequacy of intakes of alpha-linoleic acids, N-3 fish fatty acids, fiber, and iron. 74% of the toddlers used dietary supplements, and 59% used vitamin D supplements specifically. Total median intakes of vegetables, bread, and milk products were sufficient. Consumption of bread, potatoes and cereals, milk products, fats, and drinks consisted largely of unhealthy products. Consumption of unfavorable products may have been the cause of the observed high and low intakes of several nutrients. Shifting towards a healthier diet that is more in line with the guidelines may positively affect the dietary intake of Dutch toddlers and prevent negative health impacts, also later in life.

Introduction

A healthy diet, characterized by an adequate, safe, and balanced nutritional intake, is pivotal in preserving and promoting overall health throughout the life course [1]. Early childhood is a period of rapid growth and development, and therefore, a time of great opportunity, yet also vulnerability. Hence, nutrition during early life is of special importance and increasingly recognized for its long-term implications [2]. Undernutrition during childhood, defined as insufficient intakes of energy or nutrients, has been linked to short-term consequences, such as impaired growth and development as well as higher infection and mortality risk [3]. In addition, undernutrition is also related to later life health consequences, such as the increased risk of diabetes and hypertension. In addition, an inadequate diet might also have sociodemographic consequences in the long-term, such as lower education level and lower income, due to poorly developed cognitive function [4]. Overnutrition comprises the excess and insufficiency of dietary intake along with overweight and obesity. Childhood obesity is associated with various comorbidities, including childhood manifestations of cardiovascular disease, obstructive sleep apnea, non-alcoholic fatty liver disease, and psychosocial problems [5]. Moreover, childhood obesity has been shown to track into adulthood and increases the risk of type 2 diabetes, hypertension, dyslipidemia, and carotid-artery atherosclerosis in those children with persisting obesity [6,7]. Diet-related health consequences are a major threat in public health in Europe as well as worldwide [8].

Although dietary habits established during childhood likely persist into adulthood [9], diet is considered an important modifiable factor [10]. Hence, improving dietary habits at a young age could sustainably prevent adverse health outcomes. In many countries, food-based dietary guidelines are developed to help consumers eat healthily. A healthy diet provides a sufficient intake of nutrients to maintain or improve people's health. A review on the dietary intake of young children from several European countries has shown potential deficiencies or excess in the intake of nutrients and food groups [11]. However, some of the included studies were conducted more than a decade ago. National food consumption surveys, carried out in several countries, are periodically conducted to provide insight into dietary habits at the population level so that, for example, policymakers and health professionals can implement this in practice by facilitating the shift to more sustainable and safe food for the consumers.

In 2020, a Dutch governmental project was launched on developing a screening tool to assess the nutrition and lifestyle of young children living in the Netherlands, after which measures can be implemented to prevent negative health outcomes. The present study is part of this project and aimed to identify potential nutritional challenges of Dutch children aged one up until three years, which could be considered to be considered in the screening tool. To identify nutritional challenges, the habitual dietary intake, in terms of macronutrients and micronutrients and specific food groups, are described and examined on adequacy by using the most recent food consumption data of the Dutch National Food Consumption Survey (DNFCS 2012–2016) conducted in the general population of the Netherlands [12].

Materials and methods

To assess the dietary intake of Dutch toddlers, data of the DNFCS 2012–2016 were used. A detailed methodological description of the DNFCS has been described elsewhere [12].

Data Collection and Study Population

In short, the DNFCS 2012–2016 was a cross-sectional survey carried out among the general Dutch population (1–79 years; n = 4313). Data were collected from November 2012 to January 2017. Participants were recruited from representative consumer panels of Kantar Public, for which the sampling was adjusted for characteristics, such as region of residence, degree of urbanization, educational level, and stratified for age and gender.

General data on background and lifestyle factors of participants were collected from questionnaires. Data on food consumption (intake of foods, drinks, and dietary supplements) were obtained during two nonconsecutive multiple-pass 24 h dietary recalls [13], with an interval of about four weeks, carried out by trained dieticians. The dietary recalls were evenly distributed over the days of the week and seasons.

For the present study, data of 672 children aged one to three years were used. The dietary recalls in this age group were completed by their parent(s) or caregiver(s); the first interview was performed during a home visit (including height and weight measurements by the dietician), and the second one was by telephone. To cover any consumptions at the daycare or elsewhere, the parent(s) or caregiver(s) completed a food diary for their child the day before the interviews took place.

To calculate macronutrient and micronutrient intake, food consumption data were combined with an extended version of the Dutch Food Composition Database (NEVO-online 2016) [14] and the Dutch Supplement Database (NES) dated 1 January 2018 [15]. In addition, the foods were classified into food groups according to the "wheel of five", which is substantiated by the Dutch food-based dietary guidelines [16]. Within this classification, products were distinguished into products that meet the Dutch food-based dietary guidelines (within the wheel of five) and products for which it is advised not to consume or to limit the consumption (outside the wheel of five). In addition, the wheel of five provides general recommendations on food consumption [17].

Data Analyses

Descriptive statistical analyses of participants' general characteristics were performed for the study population, unweighted and weighted for sociodemographic properties for which a weighting factor was applied to the participants in the analyses for results to be representative for children aged one to three years in the Netherlands. These general characteristics included characteristics of the participants' household, supplement use, and fruit and vegetable consumption. Unless otherwise stated, statistical analyses were performed in SAS, version 9.4 [18].

The habitual intake (also referred to as usual intake) distribution of macronutrients, micronutrients, and food groups was estimated from the observed daily intake by correction for the intra-individual (day-to-day) variance, using the Statistical Program to Assess Dietary Exposure (SPADE version 3.2.52 in R, [19]). SPADE analyses were performed age-dependently by gender, using data from all subjects in DNFCS 2012–2016 to predict the model parameters. Results were combined for specific age groups, e.g., children aged one to three years. For most nutrients, the SPADE one-part model was used. Different models were used for folic acid (two-part model) and micronutrients, fiber, and N-3 fish fatty acids (three-part model). If relevant, usual nutrient intakes from food, dietary supplements, and discretionary salt used at the table or during preparation were modelled separately and subsequently combined to total the usual intake (first shrink then add) [20,21]. For iodine and sodium, salt added during preparation or at the table was considered. To estimate the intake from different sources, a multipart model was used. To estimate habitual food consumption, different SPADE models were used for food groups consumed episodically (two-part model) and daily (one-part model). For more details, see the report on the DNFCS 2012–2016 [12].

Results for children aged one to three years are shown in terms of the mean and the distribution of the habitual nutrient intake and food consumption per day (percentiles 5, 25, 50, 75, and 95). 95% confidence intervals were estimated for the mean and the median (50th percentile) using bootstrap analyses.

Evaluation of Intake and Consumption

The habitual intake distributions of macronutrients and micronutrients from food only and from food and dietary supplements, if relevant, were evaluated by comparison with the ad-interim Dutch dietary reference intakes set by the Health Council in 2014 [22]. The evaluation method differed depending on the type of dietary reference value that was available. The estimated average requirement (EAR) of nutrients was used to estimate the proportion of Dutch toddlers with inadequate intake, using the EAR cut-point method [23]. If the proportion was less than 10%, the nutrient intake was considered adequate by a rule of thumb. When the EAR was not available, the adequate intake (AI) was used, which qualitatively evaluates whether a low prevalence of inadequate nutrient intake could be assumed [24]. If the median intake was at or above the AI, the intake seemed adequate. If the median intake were below the AI, no statement could be provided on the risk of inadequacy and further research on the intake is required. The evaluation with an EAR or AI does not indicate whether the intake is adequate or tolerable but only indicates the probability of adequacy.

For vitamin D, the intake evaluation was performed by comparing the intake with the AI, which was set assuming sufficient exposure to sunlight (i.e., 3 μg). It was assumed that two-thirds of the requirement was covered by vitamin D production in the skin by sunlight exposure with light skin types [25]. The AI for vitamin D intake when sunlight exposure is insufficient is 10 μg. For energy, the intake could not be evaluated by the EAR cut-point method, as one of the underlying assumptions (i.e., intake and requirement are not correlated) was not met. For vitamin K1, no estimations were made for the intake from food and supplements as no data were available on vitamin K1 in the NES database.

The tolerable upper intake levels (UL) for nutrients set by European Food Safety Authority (EFSA) [26] were used to estimate the proportion of Dutch toddlers that may be potentially at risk of adverse effects due to excessive intake of a nutrient. If this proportion (whose intake exceeded the UL) was larger than 2.5%, the nutrient intake was considered high at a population level. Otherwise, the intake was considered tolerable by a rule of thumb.

The habitual consumption distribution of food groups was evaluated by the wheel of five and the Dutch food-based dietary guidelines [17]. Recommendations of intakes of vegetables, fruit, and bread were set in terms of a range. For the intake evaluation, it was assessed per food group whether the median intake was equal to or larger than the recommended intake (or higher than the lower bound of the range) for products within the wheel of five ("in") and for all products within and outside the wheel of five ("total"). For the food groups, cheese and meat, the guideline was a maximum consumption, and it was assessed whether the median intake was below that recommendation.

Results

Population Characteristics

The population characteristics of the study population are shown in Table 1. Within the study population, there was an even distribution of boys and girls, of which the majority had a normal BMI. Eight percent of the study population was overweight or obese, and eight percent was (seriously) underweight. The migration background of the children's parents was mostly Dutch, and most of the parents had finished at least a middle education. Household sizes varied (between two to five persons), of which mostly consisted of four persons. Relatively more households were located in the west, corresponding with the most densely populated area of the Netherlands. From the questionnaires, it was observed that 77% of the toddlers had a daily consumption of fruits and 50% a daily consumption

2

Table 1. Population characteristics of children aged one to three years in the Netherlands un-weighted and weighted for demographic properties (DNFCS 2012–2016; n = 672).

Variable	Categories	Frequency		
		n	% Unweighted	% Weighted
Gender	Male	332	49.4	50.0
	Female	340	50.6	49.9
BMI[1]	Seriously underweight	18	2.7	3.0
	Underweight	37	5.5	5.4
	Normal weight	563	83.8	83.0
	Overweight	38	5.7	6.4
	Obesity	14	2.1	2.0
	Unknown	2	0.3	0.2
Native country of the parents[2]	Dutch	622	92.6	92.0
	Western immigrant	17	2.5	2.3
	Non-Western immigrant	33	4.9	5.7
Size of household	Two or three persons	195	29.0	30.0
	Four persons	294	43.8	43.2
	Five or more persons	183	27.2	26.8
Highest education of the parents[3]	Low	29	4.3	8.0
	Middle	199	29.6	38.0
	High	444	66.1	54.0
Region of household location[4]	West	303	45.1	47.1
	North	78	11.6	9.8
	East	152	22.6	21.8
	South	139	20.7	21.2
Fruit consumption	Zero to four days per week	59	8.8	9.1
	Five to six days per week	97	14.4	14.4
	Every day	516	76.8	76.5
Vegetable consumption	Zero to four days per week	75	11.2	12.6
	Five to six days per week	257	38.2	37.6
	Every day	340	50.6	49.8
Use of dietary supplements	Yes	504	75.0	74.1
	No	168	25.0	25.9
Use of vitamin D supplements in winter and/or rest of the year	Yes	406	60.4	59.1
	No	266	39.6	40.9
Use of vitamin D containing supplements in winter and/or rest of the year[5]	Yes	491	73.1	71.9
	No	181	26.9	28.1

[1]Body mass index (BMI) was calculated per person as the bodyweight divided by the height squared (kg/m2). For BMI, age and gender-specific values based on the extended international (IOTF) body mass cut-offs were used [27]. [2]Native countries of the parents. Dutch: both parents were born in the Netherlands; Western immigrant: from Europe, United States, Australia; and non-Western immigrant. For Western and non-Western immigrants, at least one parent was born abroad. [3]Highest education of the parents. Low: primary education, lower vocational education, advanced elementary education; middle: intermediate vocational education, higher secondary education; and high: higher vocational education and university. [4]Region of household location was based on Nielsen CBS division and included the three largest cities Amsterdam, Rotterdam, and The Hague. [5]Supplements containing vitamin D: vitamin D only, a combination of calcium and vitamin D, multivitamins, including minerals, and multivitamins without minerals.

of vegetables. Furthermore, 74% of the toddlers used dietary supplements in general. In total, 59% used vitamin D supplements, and 72% used vitamin D-containing supplements (i.e., vitamin D, a combination of calcium and vitamin D, multivitamins, including minerals, and multivitamins without minerals) in winter and/or during the rest of the year.

Habitual Nutrient Intake

The habitual mean intake and percentiles of the intake distribution of macronutrients and micronutrients are shown in Table 2a,b, respectively.

The intakes of total protein, total fat, polyunsaturated fatty acids, cis-unsaturated fatty acids, trans-fatty acids, linoleic acid, and total carbohydrates met the recommendations of adequate and safe intakes. The total protein intake was adequate as the median protein intake (13.0 En%) was larger than (more than twice) the AI (5.0 En%). Four percent of the toddlers had an intake of saturated fatty acids above the UL. No statement on inadequacy was possible for alpha-linoleic acids and N-3 fish fatty acids (EPA + DHA) as the median in- takes were below the AI. The median intake of N-3 fish fatty acids (EPA + DHA) was almost four times slower than the AI. The median fiber intake was below the recommended level.

Table 2. (a). The distribution of habitual macronutrient intake (per day) from food only ("f") and, if relevant, from food and dietary supplements ("f + s") by Dutch children aged one to three years (DNFCS 2012–2016, n = 672, weighted for demographic characteristics, season, and day of the week). (b) The distribution of habitual micronutrient intake (per day) from food only ("f") and, if relevant, from food and dietary supplements ("f + s") by Dutch children aged one to three years (DNFCS 2012–2016, n = 672, weighted for demographic characteristics, season, and day of the week.

(a)

Macronutrient	Source	Mean (95% CI)	P5	P25	P50 (95% CI)	P75	P95	EAR	%<EAR	AI	P50≥AI?	UL	% > UL	Evaluation*
Protein (g/kg)	f	3.1 (3.1–3.2)	1.9	2.5	3.0 (3.0–3.0)	3.6	4.8	0.7	0					EAR: adequate intake
Total protein (g)	f	41 (41–42)	25	34	40 (40–41)	48	61	11	0					EAR: adequate intake
Total protein (En%)	f	13.2 (13.1–13.2)	9.8	11.6	13.0 (13.0–13.1)	14.6	17.1			5	Yes	20	0.5	AI: seems adequate; UL: tolerable intake
Total fat (EN%)	f	29.4 (29.3–29.5)	22.1	26.4	29.4 (29.3–29.5)	32.5	36.9			25	Yes	40	1.1	AI: seems adequate; UL: tolerable intake
Saturated fatty acids (En%)	f	11.0 (11.0–11.1)	7.6	9.5	10.9 (10.9–11.0)	12.5	14.8					15	4.2	UL: high intake
Polyunsaturated fatty acids (En%)	f	5.6 (5.6–5.6)	3.6	4.7	5.5 (5.5–5.5)	6.4	8.0					12	0	UL: tolerable intake
Cis-unsaturated fatty acids (En%)	f	15.7 (15.6–15.7)	11.1	13.6	15.5 (15.5–15.6)	17.6	20.7					38	0	UL: tolerable intake
Trans fatty acids (En%)	f	0.3 (0.3–0.3)	0.1	0.2	0.3 (0.3–0.3)	0.3	0.5					1	0	UL: tolerable intake
Linoleic acid (En%)	f	4.6 (4.6–4.7)	2.9	3.8	4.5 (4.5–4.6)	5.4	6.8			2	Yes			AI: seems adequate
Alpha linoleic acid (En%)	f	0.6 (0.6–0.6)	0.4	0.5	0.6 (0.6–0.6)	0.7	0.9			1	No			AI: no statement
N-3 fish fatty acids (EPA + DHA, mg)	f	54 (51–58)	8	20	38 (35–40)	68	158			150	No			AI: no statement
	f + s	57 (52–62)	8	20	38 (36–41)	69	167			150	No			AI: no statement
Total carbohydrates (g)	f	174 (172–175)	100	138	169 (167–171)	204	260	92	3					EAR: adequate intake
Total carbohydrates (En%)	f	54.9 (54.8–55.0)	46.6	51.6	55.0 (54.8–55.1)	58.3	63.1			45	Yes			AI: seems adequate
Fiber (g/MJ)	f	2.4 (2.4–2.5)	1.6	2.1	2.4 (2.4–2.4)	2.8	3.4			2.8[1]	No			Guideline: no statement

Table 2. ***Continued***

(b)

Micronutrient	Source	Mean (95% CI)	P5	P25	P50 (95% CI)	P75	P95	AI	P50≥AI?	UL	% > UL	Evaluation*
Retinol activity equivalents (RAE, µg)[1]	f	558 (534–80)	237	371	508 (481–524)	685	1062	300	Yes			AI: seems adequate
	f + s	594 (579–609)	246	387	533 (520–546)	735	1147	300	Yes			AI: seems adequate
Retinol (µg)	f	422 (405–438)	149	256	373 (353–383)	528	874		Yes	800	7.0	UL: high intake
	f + s	469 (456–482)	163	282	411 (400–422)	593	969		Yes	800	10.5	UL: high intake
Vitamin B_1 (mg)	f	0.6 (0.6–0.6)	0.4	0.5	0.6 (0.6–0.6)	0.7	1.0	0.3	Yes			AI: seems adequate
	f + s	1.0 (0.6–1.3)	0.4	0.5	0.6 (0.6–0.7)	0.8	1.3	0.3	Yes			AI: seems adequate
Vitamin B_2 (mg)	f	1.1 (1.0–1.1)	0.6	0.8	1.0 (1.0–1.0)	1.3	1.7	0.5	Yes			AI: seems adequate
	f + s	1.4 (1.0–1.9)	0.6	0.9	1.1 (1.1–1.1)	1.4	2.0	0.5	Yes			AI: seems adequate
Vitamin B_3 (mg)	f	8.5 (8.5–8.6)	4.8	6.6	8.2 (8.1–8.2)	10.1	13.6	4	Yes			AI: seems adequate
	f + s	9.9 (9.5–10.4)	4.9	6.8	8.6 (8.5–8.8)	11.1	17.0	4	Yes			AI: seems adequate
Vitamin B_6 (mg)	f	1.0 (1.0–1.0)	0.6	0.8	0.9 (0.9–0.9)	1.1	1.5	0.4	Yes			AI: seems adequate; UL: tolerable intake
	f + s	1.1 (1.0–1.3)	0.6	0.8	1.0 (1.0–1.0)	1.2	1.8	0.4	Yes	5	0	AI: seems adequate; UL: tolerable intake
Folate equivalents (µg)[2]	f	141 (140–142)	82	111	136 (134–137)	165	219	85	Yes	5	0.4	AI: seems adequate
	f + s	172 (164–179)	88	119	149 (146–152)	193	334	85	Yes			AI: seems adequate
Folic acid (µg)	f	9 (8–10)	0	0	4 (3–5)	13	37			200	0	UL: tolerable intake
	f + s	25 (21–28)	0	1	9 (7–10)	29	106			200	0.7	UL: tolerable intake
Vitamin B_{12} (mg)	f	2.7 (2.6–2.7)	1.2	1.9	2.5 (2.5–2.5)	3.2	4.7	0.7	Yes			AI: seems adequate
	f + s	4.9 (2.3–7.6)	1.4	2.0	2.7 (2.7–2.7)	3.6	5.4	0.7	Yes			AI: seems adequate
Vitamin C (mg)	f	77 (76–78)	29	50	71 (70–72)	96	145	25	Yes			AI: seems adequate
	f + s	96 (75–118)	32	55	79 (77–80)	108	172	25	Yes			AI: seems adequate
Vitamin D_3 (µg)	f	2.6 (2.6–2.7)	0.9	1.6	2.4 (2.3–2.4)	3.3	5.3	3	No			AI: no statement
	f + s	8.4 (8.0–8.9)	1.3	3.7	7.6 (6.9–8.3)	11.9	17.5	3	Yes			AI: seems adequate
Vitamin E (mg)	f	7.2 (7.1–7.3)	3.6	5.3	6.8 (6.7–6.9)	8.7	12.0	4	Yes	100	0	AI: seems adequate; UL: tolerable intake
	f + s	8.7 (8.1–9.3)	3.9	5.7	7.4 (7.2–7.5)	9.8	15.8	4	Yes	100	0.3	AI: seems adequate; UL: tolerable intake
Vitamin K_1 (µg)	f	39.2 (37.3–41.1)	9.5	19.0	30.4 (29.1–31.8)	49.0	98.9	12	Yes			AI: seems adequate
Calcium (mg)	f	700 (696–705)	361	527	671 (665–676)	841	1144	500	Yes			AI: seems adequate

Table 2. ***Continued***

(b)

Micronutrient	Source	Mean (95% CI)	P5	P25	P50 (95% CI)	P75	P95	AI	P50≥AI?	UL	% > UL	Evaluation*
Copper (mg)	f + s	720 (711–729)	371	539	686 (679–693)	860	1185	500	Yes		10.2	AI: seems adequate;
	f	0.7 (0.7–0.7)	0.5	0.6	0.7 (0.7–0.7)	0.9	1.1	0.3	Yes	1		UL: high intake
											11.5	AI: seems adequate;
	f + s	0.8 (0.7–0.8)	0.5	0.6	0.7 (0.7–0.7)	0.9	1.1	0.3	Yes	1		UL: high intake
Iodine (µg)											2.7	AI: seems adequate;
	f	121 (119–125)	70	96	117 (116–121)	143	186	70	Yes	200		UL: high intake
											5.1	AI: seems adequate;
	f + s	127 (125–131)	73	99	122 (119–125)	149	200	70	Yes	200		UL: high intake
Iron (mg)												AI: no statement
	f	5.8 (5.7–5.8)	3.4	4.6	5.6 (5.5–5.6)	6.7	8.6	8	No			AI: no statement
Magnesium (mg)	f + s	6.2 (6.0–6.4)	3.6	4.8	5.9 (5.8–5.9)	7.1	9.7	8	No			AI: seems adequate
	f	182 (180–183)	112	148	177 (175–178)	210	267	85	Yes			AI: seems adequate
Phosphorus (mg)	f + s	186 (184–188)	115	151	180 (179–182)	215	275	85	Yes			AI: seems adequate
	f	851 (845–857)	520	691	829 (823–836)	988	1253	470	Yes			AI: seems adequate
Potassium (mg)	f + s	848 (841–854)	521	690	826 (819–833)	983	1249	470	Yes			AI: seems adequate
	f	1840 (1830–1851)	1141	1509	1799 (1787–1811)	2131	2677	1400	Yes			AI: seems adequate
Selenium (µg)	f + s	1831 (1818–1843)	1131	1495	1790 (1776–1804)	2125	2660	1400	Yes		0.1	AI: seems adequate;
	f	23 (23–24)	13	18	22 (22–22)	27	37	20	Yes	60		UL: tolerable intake
											0.5	AI: seems adequate;
	f + s	25 (24–25)	14	19	23 (23–24)	29	41	20	Yes	60		UL: tolerable intake
Sodium (g)											47.5	Guideline: high intake
Zinc (mg)	f	3.1 (3.0–3.1)	1.7	2.3	2.9 (2.9–3.0)	3.6	4.8			3[4]	18.6	AI: seems adequate;
	f	5.7 (5.7–5.8)	3.6	4.7	5.6 (5.5–5.6)	6.6	8.4	5	Yes	7		UL: high intake
											24.3	AI: seems adequate;
	f + s	6.0 (5.9–6.1)	3.7	4.9	5.8 (5.8–5.9)	7.0	8.9	5	Yes	7		UL: high intake

(a) CI = confidence intervals; EAR = estimated average requirement; AI = adequate intake; UL = upper tolerable level. * The habitual intake seemed or was considered to be adequate or tolerable if % < EAR is below 10%, P50 ≥ AI or % > UL is equal to or smaller than 2.5%. 1 This is a guideline rather than an AI [28]. (b) CI = confidence intervals; EAR = estimated average requirement; AI = adequate intake; UL = upper tolerable level. * The habitual intake seemed or was considered to be adequate or tolerable if % < EAR is below 10%, P50 ≥ AI or % > UL is equal to or smaller than 2.5%. The EAR was not incorporated in the table as there were no values for EAR for the observed micronutrients. 1 Calculated as µg retinol + µg β carotene/12 + µg other carotenoids/24 [29]. 2 Calculated using the amount of folate naturally present in foods (in µg) plus 1.7 times the amount of folic acid in enriched foods (in µg) plus 2.0 times the amount of folic acid in dietary supplements (in µg) [14]. 3 Assuming that two-thirds of the requirement is covered by vitamin D production in the skin by sunlight exposure with light skin types [25]. 4 This is a guideline rather than a UL [30].

The intakes of vitamins B1, B2, B3, B6, B12, C, E, and K_1, as well as folate equivalents, folic acid, calcium, magnesium, potassium, and selenium, met the recommendations. Under the assumption of sufficient sunlight exposure (i.e., two-thirds of the requirement was covered by vitamin D production in the skin by sunlight exposure with light skin types) for the toddlers, the median vitamin D intake from food and supplements was higher than the AI (as shown in Table 2b); thus, the intake met the recommendation. However, when using the AI for vitamin D intake when sunlight exposure is insufficient (i.e., 10 µg), the median vitamin D intake from food and supplements was below that AI. The intake of retinol from food only and from both food and dietary supplements was considered high as the proportion exceeding the UL was 7.9% and 10.5%, respectively. The median intake of retinol activity equivalents (RAE) from both food only (508 µg) and food and supplements combined (533 µg) was above the AI (300 µg). Therefore, there was a low risk of inadequate intakes. For copper and zinc, the intakes seemed to be adequate according to the AI. However, high intakes of copper and zinc from both food only as from food combined with supplements were observed (for copper 10.2% and 11.5%, and zinc 18.6% and 24.3%, respectively had an intake above the UL). For iodine via food combined with dietary supplements, the intake was considered high for a subgroup of the children (5.1% exceeded the UL). For iron, the median intake from food only (4.6 mg) as well as from food and dietary supplements (4.8 mg) was quite below the AI (8 mg); therefore, no statement on inadequacy could be provided. On the contrary, the median intake of vitamin C and magnesium was twice the AI. Sodium intake was considered high as the proportion exceeding the guideline of 6 g per day was 47.5%. Except for vitamin D, no major differences were observed between the intake via food or via food combined with dietary supplements.

Not reported in tables is the habitual intake of energy. The EAR for the energy intake was 5 MJ per day, and the observed median intake was 5.2 MJ per day. However, the energy intake could not be evaluated with the EAR.

Food Group Consumption

The mean habitual consumption and percentiles of the consumption distribution of food groups mentioned in the wheel of five are shown in Table 3. For each food group, the consumption was compared with recommended consumption levels and evaluated for products that fit the wheel of five (categorized as "in" the wheel of five) and the "total" consumption (in and outside the wheel of five). Evaluation of food groups that do not consist of products that fit the wheel of five ("out") are not shown in Table 3 as there are no recommended consumption levels for these products. However, it is recommended to limit the consumption of products that do not fit the guidelines.

The total median intakes (thus, of products both in and outside the wheel of five) of vegetables, bread, and milk products were larger than the (lower bound of the) recommended consumption levels. The 95th percentile of the consumption of these food groups equalled to or exceeded the (lower bound of the) recommendations. However, the median intake of products that fit the wheel of five of these food groups remained below the recommended consumption levels. For several food groups, less than 25% of the toddlers consumed following the recommendations (legumes and pulses, nuts, fish, eggs, and fats). For the food groups bread, potatoes and cereals, milk products, fats, and drinks, a large part of the total consumption came from products outside the wheel of five, despite the guidelines to minimize the consumption of sugar-sweetened beverages, to replace refined grains with whole wheat and whole-grain products, and to replace solid fats and butter by liquid fats, margarine and plant-based oils.

Of the food groups, of which all products are categorized outside the wheel of five, the daily consumption was the highest for snacks. It is recommended that toddlers do not consume cheese (0 g per day); however, in practice, they do (median intake is 10 g per day). The median intake of meat was 33 g per day, close to the recommended maximum level of 35 g per day.

Table 3. The distribution of habitual consumption of several food groups (in g/day) by Dutch children aged one to three years, compared to the guidelines of the wheel of five (DNFCS 2012–2016, n = 672, weighted for demographic characteristics, season and day of the week).

Food Group	Wheel of Five*	Mean (95% CI)	P5	P25	P50 (95% CI)	P75	P95	Wheel of Five Recommendation (Min-Max)	P50 ≥ Recommendation?
Vegetables	In	47 (45–49)	14	27	41 (39–43)	60	100	75 (50–100)	No
	Total	56 (54–59)	19	35	51 (48–53)	72	113	75 (50–100)	Yes[1]
Fruit	In	123 (119–128)	30	74	114 (110–119)	162	249	150	No
	Total	136 (132–140)	36	83	125 (121–130)	179	269	150	No
Bread	In	59 (57–61)	16	37	55 (54–57)	77	115	88 (70–105)	No
	Total	89 (87–91)	41	64	84 (83–87)	109	154	88 (70–105)	Yes[1]
Potatoes	In	27 (25–29)	7	16	24 (22–26)	35	57	53	No
	Total	38 (36–39)	13	24	34 (32–36)	48	73	53	No
Cereal products	In	4 (3–5)	0	0	0 (0–0)	3	22	38	No
	Total	28 (26–30)	5	13	23 (21–24)	37	69	38	No
Potatoes and cereals[2]	In	31 (29–33)	7	16	26 (25–28)	41	70	120 (60–120)	No
	Total	63 (61–65)	24	42	59 (57–61)	80	116	120 (60–120)	No
Legumes, pulses	In	2 (1–2)	0	0	0 (0–1)	2	8	4	No
	Total	2 (1–2)	0	0	0 (0–1)	2	8	4	No
Nuts	In	0 (0–1)	0	0	0 (0–0)	0	2	15	No
	Total	4 (4–5)	0	0	2 (2–2)	6	15	15	No
Fish	In	5 (4–6)	0	1	3 (2–4)	6	18	7	No
Eggs	In	6 (5–6)	1	3	5 (4–6)	8	14	11	No
Milk products	In	195 (188–203)	17	91	174 (166–183)	274	446	300	No
	Total	343 (333–354)	96	213	319 (309–329)	448	671	300	Yes
Fats	In	7 (7–8)	2	4	6 (6–7)	10	17	30	No
	Total	14 (14–15)	5	9	13 (13–13)	18	29	30	No
Drinks	In	178 (167–189)	10	54	124 (114–134)	245	527	636	No
	Total	560 (552–568)	198	365	521 (510–527)	713	1057	636	No
Meat	In	8 (8–9)	2	4	7 (6–8)	11	21	35[3]	Yes[4]
	Total	37 (35–38)	13	24	33 (32–35)	46	70	35[3]	Yes[4]
Cheese	In	2 (2–2)	0	0	0 (0–1)	2	10	0[3]	No[4]
	Total	12 (11–13)	2	6	10 (10–11)	16	28	0[3]	Yes[4]

Table 3. ***Continued***

Food Group	Wheel of Five*	Mean (95% CI)	P5	P25	P50 (95% CI)	P75	P95	Wheel of Five Recommendation (Min-Max)	P50 ≥ Recommendation?
Soups	Out	8 (7–9)	0	0	2 (1–3)	9	38		
Sauces	Out	9 (8–9)	2	4	7 (6–8)	11	22		
Snacks	Out	50 (48–52)	15	29	44 (43–46)	65	105		
Bread toppings	Out	14 (13–14)	2	6	11 (11–12)	18	33		
Other	Out	20 (18–23)	0	1	3 (3–4)	14	91		

* Categorized in the wheel of five ('in"), outside the wheel of five ("out"), and both in as outside the wheel of five ("total"). 1Within the range of recommendation. 2This food group, including both potatoes and cereals, was included as their products are interchangeable. 3Maximum consumption recommendation. 4In this case, when P50 is equal to or larger than the recommendation, the consumption does not meet the recommended level as it involves a maximum level.

Discussion

In the present study, it was observed that for most nutrients, the estimated habitual intake of Dutch children aged one to three years met the recommendations for adequate and safe intakes. However, there are still opportunities for improvement of the nutrient intake and food consumption of these children.

For toddlers in several other European countries, results similar to those of the present study were found. The intakes of N-3 fatty acids, iron, and vitamin D and the consumption of vegetables were consistently below recommended levels, while intakes of saturated fatty acids, sodium, free sugar, and protein were often higher than recommended levels [11].

Compared to a previous study of the DNFCS among young children, conducted in 2005–2006, similar results were found regarding the consumption of vegetables and fruit and the intakes of fiber, retinol, iron, copper, and zinc [31]. The results refer to children aged two to three years rather than to children aged one to three years as in the present study; however, similar conclusions were drawn. Compared to the previous DNFCS, the folate equivalents intake seemed to be improved [32]. A high intake of copper among young children was also observed [33], for which the main source of copper was cereals and cereal products. In the present study, copper intake is still considered high, and cereal products are still the main source [34]. However, also products, which are not needed for a healthy diet contribute to copper intake. For instance, non-alcoholic beverages (waters excluded) contribute 9.2–11.7% of the copper intake among boys and girls in this age group [34]. In addition, as far as we know, there are no indications of health problems in the Netherlands due to high copper intake reported in the literature; therefore, the copper intake is not considered a dietary nutritional challenge, yet this may be further studied. Vitamin D intake from food and dietary supplements did not meet the AI in the previous study, though it did in the present study. However, in the present study, a lower AI was used, as sufficient sunlight exposure was assumed.

In the present study, 74% of the toddlers used dietary supplements in general, and 59% used vitamin D supplements specifically. The median vitamin D intake from food only was 2.4 μg per day, whereas the median vitamin D intake from food and dietary supplements was 7.6 μg per day. For children in the Netherlands aged up to four years, it is advised to take an additional 10 μg of vitamin D supplements daily [29]. This advice was based on the dietary reference values for adults whose levels below 25 nmol/L were estimated to result in vitamin D deficiency [35]. In 2019, a study on the vitamin D status of Dutch children concluded that one-third of the children were vitamin D deficient in winter, which was likely due to low adherence to the supplementation advice [36]. However, vitamin D deficiency was defined as <50 nmol/L, which is twice the threshold level used by the Dutch Health Council. Nevertheless, more emphasis could be put on compliance with the supplementation advice. Therefore, the intake of vitamin D is a potential nutritional challenge in the dietary habits of Dutch toddlers, depending on the sufficiency of sunlight exposure. In addition, studies on the status of other nutrients, for example, of those of which no statement could be done or of which low intakes were observed in the present study, could be useful in identifying potential nutritional challenges.

For toddlers in the present study, the total protein intake was adequate. However, even the 5th percentile (10 En%) of the protein intake was above the AI (5 En%). Currently, an upper intake level of protein is not yet set. However, a high intake of protein during early childhood is reported to be associated with higher BMI in childhood and a higher risk of obesity in later life [37]. Eight percent of the toddlers in the present study were overweight or obese.

For 50% of the toddlers, it was reported that they ate vegetables every day. The median habitual consumption of vegetable products categorized in the wheel of five was below the recommended level. However, the total consumption of vegetable products (both favorable and unfavorable products categorized in and outside the wheel of five) did meet the recommended consumption level. Toddlers also consumed unfavorable products from several other food groups, especially from bread, potatoes and cereals, milk products, fats, and drinks, which contrasts with the guidelines. The guidelines specifically mention limiting sugar-sweetened beverages, increasing the consumption of whole wheat and whole grain products instead of refined grains, and replacing solid fats and butter with liquid fats, margarine, and plant-based oils. Those products that do not fit the wheel of five are low in fiber or high in unfavorable fats, sugar or salt. The relatively high consumption of unfavorable products may have been the cause for the observed high intake of saturated fatty acids and the median intake of fiber far below the guideline.

As far as we know, no indications of health problems were observed (as it was not examined in the present study) and of insufficient intakes of nutrients. A potential nutritional challenge in the dietary intake of Dutch toddlers is the vitamin D intake, which has been found to be similar for other countries. Therefore, supplementation advice exists for this age group in the Netherlands. However, it remains difficult to assess the adequacy of vitamin D with dietary assessment due to the substantial effect of sunlight exposure. For alpha-linoleic acids, N-3 fish fatty acids, and iron, no statement on adequacy could be provided, though the median intakes were not close to the AI; therefore, these nutrients may be potential nutritional challenges. To gain more in-depth knowledge on potential nutritional challenges and the causal associations between the dietary habits of Dutch toddlers and the impact on their health, further (additional, long-term follow- up) research should be done concerning growth and neuro-development. Insight into the nutrient intake, of which no statement could be done or of which low estimations were observed in the present study, could be provided by additional research, such as on nutritional status. This could be valuable for listing potential nutritional challenges, as was done by studying vitamin D status in Dutch children [36]. In addition, additional analyses within subgroups of this population could potentially provide insight into more class-specific dietary habits related to, for example, age group or socioeconomic status.

There were a few limitations in this study, as in a study involving (self-reporting of) dietary intake, misreporting (underreporting or overreporting) of dietary intake was likely. With self-reporting of dietary intake, misreporting cannot be fully avoided. This is possibly even more the case when the recall day is known. For energy intake, the average level of misreporting than the expected energy intake was estimated as underreported by about ten percent on average, with 2% of the study participants who reported an unlikely low-energy intake [12]. Based on this, the underreporting seems limited. However, bias in the intakes can still not be fully excluded. To estimate the intake of macronutrients and micronutrients, data were combined with the databases NEVO and NES. It is evaluated that the NEVO database is complete though not all products and their declarations are listed and/or available, for which a comparable food product was selected. In the end, the average percentage of missing values for the nutrients presented in this study was only 3% [12]. For the data on supplements, NES uses the nutrient declaration available on the packaging rather than data available through laboratory analyses, which involves average compositions and may lead to overestimation and underestimation of nutrient intake via supplements [38]. In addition, the reference values used for the comparison with the habitual intake of children are ad interim values of the Dutch Health Council, which may be adjusted, as they are working on new reference values for children [39].

For evaluating the intake of food groups, the Dutch food-based dietary guidelines (presented in the wheel of five) were used [16]. However, no compliance with the guidelines does not necessarily mean that the food pattern is inadequate because consumption of various foods and food groups can still lead to adequate intakes of nutrients, as was shown in the present study. The guidelines are set as guidance for individuals rather than for populations. Because the individual requirement is unknown in individual nutritional advice, the recommended daily intake (RDI) is used for guidelines rather than the EAR. The RDI is a value that meets the requirement of 97.5% of the population; thus, for most individuals, it will be more than their individual requirement [29]. For this reason, the EAR cut-point method is usually applied to evaluate the adequacy of intake in populations [23]. Unfortunately, the food-based dietary guidelines are not available in an EAR-like measure. Therefore, in the present study, we made a qualitative comparison of the median consumption of a food group with the guidelines to gain knowledge at a population level rather than assuming that every individual must meet the guidelines.

One of the strengths of the present study was that due to sampling and weighing the results on small deviances on the sociodemographic characteristics. It was possible to obtain results that are representative of the target population. Data were retrieved by using food diaries and repeated 24 h-recalls conform the European guidance for harmonized food consumption data in EU member states by EFSA [40], of which the habitual intake could be estimated and compared with reference values. In addition, of all nutrients from food only as well as from food combined with dietary supplements, the habitual intake was estimated rather than the reported intake on two individual days; therefore, the day-to-day (intraindividual) variation was accounted for, and a better estimate of the proportion with inadequate intakes could be made.

Conclusions

The dietary intake of Dutch children aged one to three years seems adequate for most nutrients. Vitamin D is a potential nutritional challenge, and several nutrients need to be further looked at for potential nutritional challenges: alpha-linoleic acids, N-3 fish fatty acids, and iron. The dietary pattern of the toddlers consists partially of unfavorable products that may have been the cause of the high intakes of several nutrients, such as sodium and saturated fatty acids, and the low intake of fiber.

Therefore, for young children, shifting to and following a healthy diet, which is (more) in line with the guidelines, may improve the nutrient intake, of which in the present study was found to be low or for which no statement on adequacy could be done. This is important as early-life dietary habits affect health, also later in life. Further research or potential intervention studies on indicators and predictors of a healthy diet for children aged one to three years may be useful to prevent negative health impacts and encourage a healthy life in the future. This knowledge could be incorporated into the screening tool that is being developed for toddlers in The Netherlands.

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Chapter 3

Clusters of lifestyle behaviours and their associations with socio-demographic characteristics in Dutch toddlers

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Abstract

Purpose: This study aimed to identify clusters of lifestyle behaviours in toddlers and assess associations with socio-demographic characteristics.

Methods: We used data from the Dutch National Food Consumption Survey 2012-2016 and included 646 children aged 1-3 years. Based on 24-h dietary recalls and a questionnaire, a two-step cluster analysis was conducted to identify clusters in intake of fruit, vegetables, sugar-sweetened beverages and unhealthy snacks, physical activity and screen time. Logistic regression models assessed associations between socio-demographic characteristics and cluster allocation.

Results: Three clusters emerged from the data. The 'relatively healthy cluster' demonstrated a high intake of fruit and vegetables, low sugar-sweetened beverage and unhealthy snack intake and low screen time. The 'active snacking cluster' was characterised by high unhealthy snack intake and high physical activity, and the 'sedentary sweet beverage cluster' by high intake of sugar-sweetened beverages and high screen time. Children aged 1 year were most likely to be allocated to the 'relatively healthy cluster'. Compared to children of parents with a high education level, children of parents with a low or middle education level were less likely to be in the 'relatively healthy cluster' but more likely to be in the 'sedentary sweet beverage cluster'.

Conclusion: Clusters of lifestyle behaviours can be distinguished already in children aged 1-3 years. To promote healthy lifestyle behaviour, efforts may focus on maintaining healthy behaviour in 1-year-olds and more on switching towards healthy behaviour in 2- and 3-year olds.

Introduction

Overweight and obesity can occur as early as toddlerhood. Globally, 5.7% of children under 5 years were overweight or obese in 2020 [1]. This is a major public health concern as childhood obesity increases the risk of other (chronic) diseases, affecting both physical and mental health [2]. Moreover, childhood obesity often tracks into adulthood [3]. The main underlying cause of overweight and obesity lies in lifestyle behaviour, which may be established at a young age and likely persists as the child ages [2, 4, 5]. Unfavourable lifestyle behaviours, such as the intake of energy-dense, nutrient-poor foods, including sugar-sweetened beverages and snacks, as well as high levels of sedentary behaviour, are positively associated with obesity [6, 7]. Contrarily, diets characterised by high amounts of fruits and vegetables, and regular physical activity are associated with lower obesity risk [8, 9].

Many children do not meet the daily recommendations for dietary intake, physical activity and sedentary behaviour [10, 11]. However, children's lifestyles can comprise both healthy and unhealthy behaviours simultaneously. Characterising lifestyle behaviour patterns in children can support the understanding of interrelationships (i.e. co-occurrence and interaction) between multiple lifestyle behaviours. Ultimately, this can contribute to developing guidelines and interventions that simultaneously address multiple unfavourable lifestyle behaviours in children.

Exploratory, data-driven techniques, such as cluster analysis and principal component analysis, can be used to gain insight into behaviour patterns [12]. Reviews of studies applying these methods to identify lifestyle behaviour clusters in children found that diet, physical activity and sedentary behaviour cluster in complex ways [13, 14]. In addition to clusters entirely characterised by healthy or unhealthy diets, physical activity and sedentary behaviours, clusters with a mixture of healthy and unhealthy behaviours have been commonly distinguished. To reach children most at risk of adverse health effects, it is essential to identify shared determinants of lifestyle behaviour clusters. As to determinants of lifestyle behavioural patterns in children, it has been shown that age, sex and socio-economic status (SES) are associated with lifestyle behaviour patterns [13, 14]. Lower SES, mostly indicated by parental education level, was found to be associated with unhealthier lifestyle patterns [13-15]. How other socio-demographic factors are associated with lifestyle behaviour patterns in children remains unclear.

To our knowledge, most studies on the clustering of lifestyle behaviours in children have been conducted in older children (≥5years). Nevertheless, lifestyle habits develop early in life, and early identification of patterns and associated socio-demographic determinants might help to initiate timely interventions for modifying lifestyle behaviours when needed. Therefore, our study aims to identify clusters of co-occurring lifestyle behaviours, including intake of fruit, vegetables, sugar-sweetened beverages and unhealthy snacks, physical activity and screen time, and analyse their associations with socio-demographic characteristics in children aged 1-3 years who participated in the Dutch National Food Consumption Survey (DNFCS) 2012-2016.

Methods

Study Population and Data Collection

We used data from the most recent DNFCS (2012-2016). The DNFCS is a recurrent survey on food and drinks consumption among the general Dutch population and specific subgroups. A detailed description of the DNFCS 2012-2016 has been published elsewhere [16]. Between November 2012 and January 2017, 6,733 people aged 1-79 years were invited to participate in the study. Participants were drawn from market research consumer panels, representative for the Dutch population with regard to age, sex, education level (of the parents or caretakers for children up to 18 years), household region and household location urbanisation level. Data collection was completed for a set of 4,313 participants, comprising 672 children aged 1-3 years. For the current study, we included children with complete data on all lifestyle behaviours of interest (n=646). A flowchart of the study population selection is presented in Supplementary File 1.

An age-specific, general questionnaire completed by the parent(s) or caregiver(s) provided socio-demographic characteristics and information on lifestyle (e.g. amount of physical activity and electronic screen time) of the participating children. Dietary assessment was performed according to European Food Safety Authority (EFSA) guidelines [17]. Trained dieticians carried out two non-consecutive 24-h dietary recalls [19], equally spread across days of the week and seasons. The first 24-h dietary recall was conducted with a parent or caregiver during a home visit. The second 24-h dietary recall was completed by telephone about four weeks later. To adequately capture nutritional intake outside the home, for example at day care, both dietary recalls were combined with a food diary concerning the same day.

The Medical Ethical Committee of the University Medical Centre Utrecht approved the protocol and declared that the Dutch Medical Research Involving Human Subjects Act (WMO) was not applicable to the DNFCS 2012-2016 (reference number 12-359/C). Written informed consent was obtained from all parents/caregivers of participating children during the home visit.

Lifestyle Behaviours

Diet

The foods and drinks consumed as obtained by the 24-h dietary recalls were classified according to the food groups of the Dutch food-based dietary guidelines ('Wheel of

Five' guidelines) [20]. Foods and drinks are categorised 'within the Wheel of Five' when consumption is advised by the Dutch food-based dietary guidelines and 'outside the Wheel of Five' when it is recommended to limit consumption of that particular food or drink. For the drinks category, for example, water and tea are categorised within the Wheel of Five, whereas sugar-sweetened beverages are not part of it. All sweet and savoury snacks, such as cookies, ice cream, and crisps, are categorised outside the Wheel of Five. We used the average intake of the two recall days per participant of the food groups fruit, vegetables, drinks outside the Wheel of Five (mainly sugar-sweetened beverages, therefore referred to as sugar-sweetened beverages in this paper) and snacks outside the Wheel of five (in this paper referred to as unhealthy snacks) in our analyses (grams/day).

Physical Activity

Time spent playing outside and participation in organised physical activity, such as swimming, toddler sports classes and dancing, was obtained from the general questionnaire. Parents or caregivers reported frequency of both activities on response categories ranging from 'never/less than 1 day per week' to 'every day'. Response categories for average duration of playing outside ranged from 'less than half an hour per day' to 'more than 3 hours per day'. Average duration was converted from hours to minutes. Regarding organised physical activity, we translated one session as 60 minutes. We calculated the amount of physical activity (minutes/day) by the following equation: ((days playing outside * average duration of playing outside) + (days participating in organised physical activity * 60)) / 7.

Screen Time

Time spent watching television or videos and using the computer or other types of electronic screens (such as a handheld game console or tablet) was also obtained from the general questionnaire. Frequency and average duration per session were reported by the parents on scales ranging from 'never/less than 1 day per week' to 'every day' and 'less than half an hour per day' to 'more than 3 hours per day', respectively. Duration values were converted from hours to minutes. We calculated total screen time (minutes/day) by adding the amount of watching television/videos to the amount of computer/other screen use: ((days watching television * average duration of watching television) + (days using the computer * average duration of using the computer)) / 7.

Socio-demographic Characteristics

Information on age, sex, migration background, parental education level and household size were obtained from the general questionnaire. Children's migration background (Dutch, Western migration, non-Western migration) was defined based on the parents' or caregivers' country of birth. Children were assigned to the latter two categories when at least one parent or caregiver was born abroad [21]. Parental education level was divided into three categories (low, primary education, lower vocational education, advanced elementary education; middle, intermediate vocational education, higher secondary education; high, higher vocational education and university). The market research agency held data on household location region based on the Nielsen CBS division (West, North, East, South (of the Netherlands) and urbanisation level (strongly urbanised, >1.500 addresses/km^2; moderately urbanised, 1.000-1.500 addresses/km^2; hardly urbanised, <1.000 addresses/km^2).

Statistical Analyses

All analyses were performed by using SPSS Statistics software (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.). Characteristics of the children were described in percentages and medians. After standardisation (by calculating Z-scores) of the lifestyle behaviour data, we performed a cluster analysis procedure comprising a hierarchical and consecutive non-hierarchical step. This cluster analysis approach was previously used by Fernández-Alvira et al. [22] and Yang et al. [23]. First, Ward's method using squared Euclidean distance was applied to create initial cluster centres, with solutions ranging from 2 to 6 clusters. Thereafter, non-hierarchical k-means cluster analysis based on these cluster centres was conducted. The stability of the generated cluster solutions was examined by repeating the clustering procedure in a random sample of 50% of the study population and testing cluster allocation agreement by Cohen's kappa. Mean values of lifestyle behaviours per cluster were described. Logistic regression models (univariable and multivariable) were used to calculate odds ratios (OR) for allocation to the generated clusters based on the socio-demographic determinants. We applied Bonferroni correction to adjust for multiple testing [p = 0.05/(number of clusters * number of socio-demographic characteristics)] [23].

Non-response analysis

Of the 672 children aged 1-3 years that participated in the DNFCS, children with missing data on the lifestyle behaviours of interest (n=26) were compared (on lifestyle behaviours and socio-demographic characteristics) with children with complete data (n=646) by using independent t-tests and chi-square tests.

Results

Population Characteristics

The study sample included 646 children aged 1 (34.2%), 2 (31.0%) or 3 (34.8%) years, of which 49.7% were boys (Table 1). The majority of them were of Dutch origin (92.6%), and had parents with a high education level (66.7%). The most common household size consisted of four persons (43.5%). Participating children most often lived in the Western part of the Netherlands (45.5%), which is analogous to a strongly urbanised household location (45.7%). The children consumed a median of 140 (IQR 114) grams of fruit, 49 (IQR 60) grams of vegetables, 362 (340) grams of sugar-sweetened beverages, and 32 (IQR 44) grams of unhealthy snacks per day. Further, they spent 54 (IQR 62) minutes/day on physical activity and used electronic screens for 39 (IQR 78) minutes/day (median values).

Table 1: Characteristics of children aged 1-3 years in the DNFCS 2012-2016 (n=646)

Characteristic	Value
Age	
1 year	221 (34.2)
2 years	200 (31.0)
3 years	225 (34.8)
Sex (boys)	321 (49.7)
Migration background	
Dutch	598 (92.6)
Western migration	17 (2.6)
Non-Western migration	31 (4.8)
Parental education	
Low	27 (4.2)
Middle	188 (29.1)
High	431 (66.7)
Size of household	
Two or three persons	186 (28.8)
Four persons	281 (43.5)
Five or more persons	179 (27.7)
Region of household location	
West	294 (45.5)
North	75 (11.6)
East	146 (22.6)
South	131 (20.3)
Household location urbanisation level	
Strongly urbanised	295 (45.7)
Moderately urbanised	141 (21.8)
Hardly urbanised	210 (32.5)
Fruit intake (grams/d)	140 (114)
Vegetable intake (grams/d)	49 (60)
Sugar-sweetened beverage intake (grams/d)	362 (340)
Unhealthy snack intake (grams/d)	32 (44)
Duration of physical activity (minutes/d)	54 (62)
Duration of screen time (minutes/d)	39 (78)

Values are frequencies with percentages for categorical variables and medians with interquartile ranges for continuous variables.

Non-response Analysis

Children with missing data on the lifestyle behaviours of interest (n=26) all lacked data on physical activity only. These children did not differ with regard to the other lifestyle behaviours, nor in socio-demographic characteristics (for all, $p>0.05$) with the children that had complete data (n=646, data not shown).

Cluster Description

Based on the dendrogram and highest Cohen's kappa coefficient, a three cluster solution based on the six lifestyle behaviours appeared to be the most accurate ($\beta=0.937$). Cluster 1 (comprising 49.7% of all children) was labelled the 'relatively healthy cluster' because compared to children in the other clusters, children in this cluster complied with guidelines relatively most [20, 24]. It was characterised by healthy dietary factors and low screen time as the Z-score was 0.14 (SE 0.05) for fruit intake, 0.25 (SE 0.06) for vegetable intake, -0.54 (SE 0.03) for sugar-sweetened beverage intake, -0.48 (SE 0.03) for unhealthy snack intake, and -0.49 (SE 0.03) for screen time. High unhealthy snack intake (Z-score = 0.89, SE 0.11) and high physical activity (Z-score = 1.23, SE 0.09) were the main features of cluster 2, which was therefore labelled the 'active snacking cluster'. Cluster 3 was mainly characterised by high intake of sugar-sweetened beverages (Z-score = 0.93, SE 0.07) and high screen time (Z-score = 0.83, SE 0.08) and was labelled 'sedentary sweet beverage cluster'. The 'relatively healthy cluster' comprised 76% of the 1-year-olds. The mean age

Table 2: Lifestyle behaviours by clusters of children aged 1-3 years in the DNFCS 2012-2016

	Cluster 1	**Cluster 2**	**Cluster 3**
	'relatively healthy cluster'[a]	**'active snacking cluster'[b]**	**'sedentary sweet beverage cluster'[b]**
	N =321 (49.7%)	**N =135 (20.9%)**	**N =190 (29.4%)**
Age, y, mean (SD)	1.7 (0.8)	2.3 (0.7)	2.3 (0.7)
Fruit consumption, mean (SD)[c]	160 (81)	147 (103)	129 (83)
Z-score (SE)	0.14 (0.05)	-0.01 (0.10)	-0.22 (0.07)
Vegetable consumption, mean (SD)[c]	69 (51)	53 (44)	40 (34)
Z-score (SE)	0.25 (0.06)	-0.09 (0.08)	-0.36 (0.05)
Sugar-sweetened beverage consumption, mean (SD)[c]	242 (174)	398 (225)	676 (298)
Z-score (SE)	-0.54 (0.03)	-0.02 (0.07)	0.93 (0.07)
Unhealthy snack consumption, mean (SD)[c]	24 (20)	72 (45)	47 (29)
Z-score (SE)	-0.48 (0.03)	0.89 (0.11)	0.19 (0.06)
Physical activity, mean (SD)[d]	44 (35)	133 (52)	63 (39)
Z-score (SE)	-0.45 (0.04)	1.23 (0.09)	-0.11 (0.05)
Screen time, mean (SD)[d]	24 (26)	48 (43)	90 (57)
Z-score (SE)	-0.49 (0.03)	-0.01 (0.07)	0.83 (0.08)

[a]Overall most consistent with national guidelines; [b]named after most distinguishing lifestyle behaviours; [c]grams/day; [d]minutes/day

for the 'relatively healthy cluster' was 1.7 (SD 0.8) years and 2.3 (SD 0.7) years for the other two clusters (Table 2). Figure 1 demonstrates the lifestyle behaviour Z-scores of the various clusters in a radar chart.

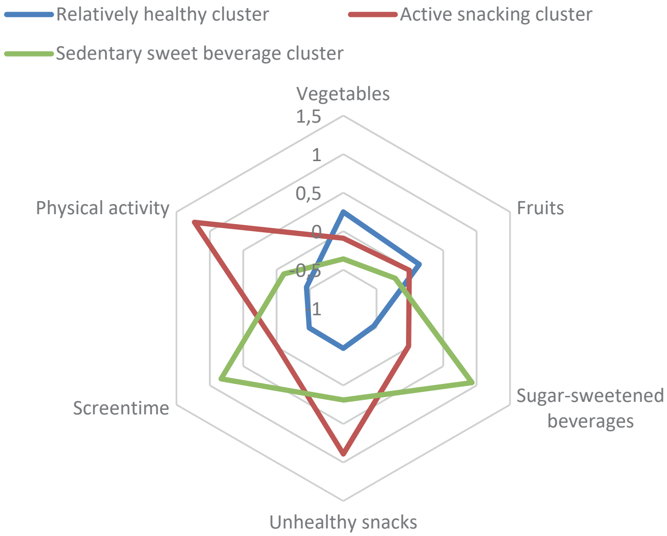

Figure 1: Z-scores of lifestyle behaviours in clusters of children aged 1-3 years in the DNFCS 2012-2016

Association between Socio-demographic Characteristics and Cluster Allocation

The ORs for cluster allocation based on the socio-demographic characteristics are presented in Table 3. Based on the three cluster solution, we used a Bonferroni adjusted p-value of 0.003 [p =0.05/(3*6)]. Children aged 1 year had higher odds for allocation to the 'relatively healthy cluster' than children aged 3 years old, with an OR of 7.48 (95% CI 4.91, 11.39; p<0.001). Moreover, children aged 1 year had lower odds for allocation to the 'active snacking cluster' and 'sedentary sweet beverage cluster' compared to children aged 3 years, with ORs of 0.27 (95% CI 0.16, 0.46; p<0.001) and 0.23 (95% CI 0.15, 0.37; p<0.001), respectively. Compared to children of parents with a high education level, children of parents with a low education level had an OR of 0.06 (95% CI 0.01, 0.26; p<0.001) for allocation to the 'relatively healthy cluster', and children of parents with a middle education level of 0.48 (95% CI 0.34, 0.68; p<0.001). Contrarily, children of parents with a low education level had an OR of 6.71 (95% CI 2.92, 15.40; p<0.001) for allocation to the 'sedentary sweet beverage cluster', and children of parents with a middle education level of 2.13 (95% CI 1.47, 3.08; p<0.001), compared to children of parents with a high education level. We found no associations between parental education level and the 'active snacking cluster'. Children from households of two or three persons had higher odds for

Table 3: Association of socio-demographic characteristics with clusters of children aged 1-3 years in the DNFCS

	Univariable models			**Multivariable models[b]**		
	'relatively healthy cluster'[c] N=321	**'active snacking cluster'[d] N=135**	**'sedentary sweet beverage cluster'[d] N=190**	**'relatively healthy cluster'[c] N=321**	**'active snacking cluster'[d] N=135**	**'sedentary sweet beverage cluster'[d] N=190**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Age						
1 year	7.48 (4.91, 11.39)**	0.27 (0.16, 0.46)**	0.23 (0.15, 0.37)**	7.78 (4.92, 12.31)**	0.30 (0.17, 0.52)**	0.22 (0.14, 0.37)**
2 years	1.78 (1.19, 2.65)*	0.78 (0.50, 1.20)	0.70 (0.47, 1.04)	1.81 (1.18, 2.76)*	0.82 (0.53, 1.28)	0.67 (0.44, 1.02)
3 years	Ref	Ref	Ref	Ref	Ref	Ref
Sex						
Girl	Ref	Ref	Ref	Ref	Ref	Ref
Boy	1.01 (0.74, 1.38)	1.16 (0.79, 1.69)	0.88 (0.63, 1.23)	1.00 (0.70, 1.43)	1.23 (0.83, 1.84)	0.82 (0.57, 1.18)
Migration background						
Dutch	Ref	Ref	Ref	Ref	Ref	Ref
Western migration	2.57 (0.89, 7.37)	0.22 (0.03, 1.66)	0.74 (0.24, 2.29)	3.42 (1.13, 10.39)*	0.19 (0.02, 1.44)	0.67 (0.21, 2.18)
Non-Western migration	1.94 (0.92, 4.13)	0.12 (0.02, 0.86)*	1.14 (0.53, 2.47)	1.50 (0.63, 3.60)	0.16 (0.02, 1.18)	1.62 (0.69, 3.79)
Parental education						
Low	0.06 (0.01, 0.26)**	1.40 (0.58, 3.43)	6.71 (2.92, 15.40)**	0.06 (0.01, 0.27)**	1.03 (0.40, 2.64)	5.91 (2.47, 14.11)**
Middle	0.48 (0.34, 0.68)**	1.15 (0.76, 1.75)	2.13 (1.47, 3.08)**	0.41 (0.28, 0.61)**	1.18 (0.76, 1.82)	2.21 (1.50, 3.26)**
High	Ref	Ref	Ref	Ref	Ref	Ref
Size of household						
Two or three persons	1.87 (1.28, 2.73)**	0.55 (0.33, 0.91)*	0.71 (0.47, 1.08)	1.18 (0.76, 1.83)	0.73 (0.42, 1.24)	1.03 (0.65, 1.65)
Four persons	Ref	Ref	Ref	Ref	Ref	Ref
Five or more persons	0.78 (0.53, 1.14)	1.29 (0.84, 2.00)	1.07 (0.72, 1.60)	0.65 (0.42, 1.00)	1.32 (0.84, 2.08)	1.21 (0.78, 1.87)
Region of household location						
West	Ref	Ref	Ref	Ref	Ref	Ref
North	0.64 (0.38, 1.07)	1.13 (0.60, 2.10)	1.51 (0.89, 2.58)	0.70 (0.37, 1.29)	0.88 (0.44, 1.75)	1.55 (0.84, 2.86)
East	0.91 (0.61, 1.35)	1.26 (0.78, 2.04)	0.93 (0.59, 1.45)	1.05 (0.66, 1.68)	1.11 (0.66, 1.88)	0.87 (0.53, 1.44)
South	0.84 (0.56, 1.27)	1.13 (0.68, 1.88)	1.12 (0.71, 1.75)	1.04 (0.64, 1.70)	0.96 (0.56, 1.64)	1.00 (0.61, 1.64)

Table 3: ***Continued***

	Univariable models			**Multivariable models[b]**		
	'relatively healthy cluster'[c] N=321	**'active snacking cluster'[d] N=135**	**'sedentary sweet beverage cluster'[d] N=190**	**'relatively healthy cluster'[c] N=321**	**'active snacking cluster'[d] N=135**	**'sedentary sweet beverage cluster'[d] N=190**
	OR (95% CI)	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Household location urbanisation level						
Strongly urbanised	Ref	Ref	Ref	Ref	Ref	Ref
Moderately urbanised	0.87 (0.58, 1.30)	1.03 (0.62, 1.72)	1.16 (0.75, 1.79)	1.12 (0.70, 1.78)	0.88 (0.51, 1.50)	1.05 (0.65, 1.69)
Hardly urbanised	0.71 (0.50, 1.02)	1.47 (0.96, 2.26)	1.10 (0.74, 1.62)	0.90 (0.58, 1.40)	1.23 (0.76, 2.00)	0.96 (0.60, 1.51)

Values are ORs with 95% CI, calculated by using logistic regression. aIn the univariable models, each independent variable was entered separately. bIn the multivariable models, all independent variables were entered simultaneously. cOverall most consistent with national guidelines. dNamed after most distinguishing lifestyle behaviours *p<0.05, **p<0.003 (Bonferroni-corrected p-value).

3

the 'relatively healthy cluster' than children from four-person-households, OR 1.87 (95% CI 1.28, 2.73, p=0.001). This association disappeared in the multivariable model. Sex, migration background, region of household location, and household location urbanisation level were not associated with allocation to any cluster.

Discussion

We aimed to identify clusters of lifestyle behaviours in Dutch children aged 1-3 years and assess associations with socio-demographic characteristics. Three distinct lifestyle clusters emerged from the data: the 'relatively healthy cluster', 'active snacking cluster' and 'sedentary sweet beverage cluster'. The socio-demographic factors age, parental education level and household size were associated with cluster allocation. We found no associations with sex, migration background, region of household location and household location urbanisation level.

In accordance with our findings, previous studies demonstrated healthy, unhealthy and mixed clusters in children [13, 14]. However, precise results differ, partly due to differences in the behaviours considered and in behavioural assessment and clustering techniques. Gubbels et al. and Wang et al. also examined clustering of lifestyle behaviours in Dutch toddlers and identified two and three clusters, respectively [25, 26]. Among 2-year-olds, a 'sedentary snacking cluster', characterised by high screen time and high intake of unhealthy snacks and drinks, and a 'fibre cluster', mainly depicted by high intakes of fruit, vegetables and brown bread, and low white bread intakes, emerged [25]. Clusters labelled as 'unhealthy lifestyle pattern', 'low snacking and low screen time pattern', and 'active, high fruit and vegetable, high snacking and high screen time pattern' were distinguished among 3-year-olds [26]. Similar to these Dutch studies [25, 26] and to results from other countries [4, 27, 28], we demonstrated that high screen time levels often cluster with high consumption of energy-dense products. Studies in children 5 years and older have suggested that screen time activities, such as watching TV, act as a conditioned cue to drink or eat and distract from feelings of satiety, which might be the two most important underlying mechanisms [29]. In addition, unhealthy food advertisements on TV, computer or other electronic screens may enhance this consumption behaviour [30]. Our other cluster demonstrated high physical activity co-occurring with high intake of unhealthy snacks. This was previously also found in Dutch children of 6 years old [23]. One could argue that parents offer their child a snack as a reward or energy replenishment after physical activity; however, possible explanations need to be further elucidated.

Children aged 1 year were most likely to be allocated to the 'relatively healthy cluster'. As 1-year-olds have not been included in previous cluster-analyses, this is a novel finding. Nevertheless, there are several reasons why lifestyle behaviour in this age group might differ from those of 2- and 3-year-olds. Children aged 1 year have just transitioned from breast or bottle feeding and complementary foods to the family meal time routine. One could argue that parents are, therefore, still conscious of their child's diet, which is reflected in a relatively higher intake of fruit and vegetables and lower intake of sugar sweetened beverages and unhealthy snacks. This reason, more focus and consciousness, may also be underlying the fact that children from a household with two or three persons -and therefore most likely one child- had higher odds for allocation to the 'relatively healthy cluster'. The absence of an association with household size in the multivariable model argues that another factor, possibly age, plays an underlying role. Children aged 1 year might also be more accepting of the (healthy) food their parents offer and most likely will not ask for unhealthy snacks, sugar sweetened beverages or screen time themselves. They might also consume less of those unhealthier foods because of their lower nutritional needs and longer sleep duration than children aged 2 and 3 years. We presume that the low amount of physical activity in the 'relatively healthy cluster' is an underestimation attributable to the physical activity items in the questionnaire. As forms of movement for children aged 1 year (e.g. creeping, crawling, floor play) had not been assessed in this questionnaire, the total amount of physical activity would probably have been greater. Nonetheless, as our results indicate that lifestyle behaviours are healthier in 1-year-olds than in 2- and 3-year-olds, preventive efforts should focus on preserving healthy behaviours in 1-year-old children, i.e. before unhealthy behaviours have rooted.

Although we have to be careful with strong statements given the small group of parents with a low education level, our results support previous studies that have shown that a lower parental education level is associated with clusters comprising less healthy behaviours in young children [4, 23, 25-28]. It seems possible that lower-educated parents possess less knowledge about healthy lifestyle habits for their children or that parenting practices and food environment mediate this association [31-33]. Howbeit, as parents play a crucial role in providing and controlling food and activity habits of children aged 1-3 years, interventions aimed at improving these habits should be tailored to the needs of parents with lower education levels.

Strengths and Limitations

Dietary assessment through 24-hour dietary recalls is a major strength of our study, as it does not alter food consumption and has an infinite degree of specificity of the foods consumed. In addition, 24-hour dietary recalls are sensitive to culture-specific differences and, when repeatedly conducted, can capture habitual dietary habits. The young age of the study participants, especially 1-year-olds, is another asset and adds new evidence to the importance of early preventive health care.

The young age of the participants might also be a limitation, as age might have been the most important factor in distinguishing lifestyle clusters. Furthermore, it was technically impossible to calculate the exact habitual intake for every individual separately. Therefore, we used the average intake of the two recall days per participant as a reflection of habitual intake, but we are aware that this method might be less accurate. Data on physical activity and screen time were obtained by means of categorical questions. Although included as continuous variables in our analyses, the results of physical activity and screen time, therefore, have limited precision, i.e. are accurate to half an hour. We also acknowledge the sample size as a limitation that may have hampered the robustness of the clusters identified and may have led to selection bias. The low number of participants of non-Dutch origin and from parents with a low education level is another limitation that possibly affected the reliability and generalisability of our results. Due to the cross-sectional design of the DNFCS, we could not draw causal conclusions on the association between cluster allocation and weight status. Besides, data was obtained between 2012-2017 and new 'Wheel of Five' guidelines have been published in the meantime, which may affect current dietary intake.

Conclusions

We distinguished three clusters of lifestyle behaviours in children as young as 1-3 years of age. Children aged 1 year were more likely to be in the cluster that portrayed healthy behaviour than children aged 2 and 3 years, which suggests that maintaining healthy behaviour and changing towards more healthy behaviour should be promoted in these age groups, respectively. These preventive efforts should take parental education level into consideration. Future longitudinal research should assess cluster allocation evolution and its association with weight status.

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Chapter 4

Diet quality at age 5-6 and cardiovascular outcomes in preadolescents

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Abstract

Background & aims: Specific dietary components during childhood may affect risk factors for cardiovascular disease. Whether overall higher diet quality prevents children from adverse cardiovascular outcomes remains contradictive. We aimed to examine the associations between diet quality at age 5-6 years and cardiovascular outcomes after a 6-year follow-up.

Methods: We used data from the Amsterdam Born Children and their Development study, a multi-ethnic birth cohort. Dietary intake was assessed at age 5-6 using a semi-quantitative food frequency questionnaire and diet quality was ascertained with the Dietary Approaches to Stop Hypertension (DASH) score and the child diet quality score (CDQS), an index specifically developed for Dutch school-age children. Cardiovascular outcomes were examined after 6-years follow-up (age 11-12, N = 869). Outcomes were body mass index (BMI), waist circumference (WC), blood pressure (BP), lipid profile, fasting glucose and carotid intima-media thickness (CIMT). Multivariable linear and logistic regression models adjusted for baseline value were used to examine associations between diet quality and cardiovascular outcomes.

Results: Higher diet quality at age 5-6 was associated with lower BMI (DASH score: Δ quintile (Q) 5 and Q1: -0.35 kg/m2, p for trend = 0.016), lower WC (DASH score: Δ Q5 and Q1: -1.0 cm, p for trend = 0.028), lower systolic (DASH score: Δ Q5 and Q1: -2.7 mmHg, p for trend = 0.046) and diastolic BP (DASH score: Δ Q5 and Q1: -2.4, p for trend < 0.001) and with lower plasma triglycerides (DASH score: Δ Q5 and Q1: -0.20 mmol/L, p for trend = 0.032) after 6-years follow-up. Associations of the CDQS with these outcomes showed similar trends, but less pronounced. We found no statistically significant associations between diet quality and LDL-C, HDL-C, total cholesterol, fasting glucose or CIMT.

Conclusions: Higher diet quality in childhood at age 5-6 years predicted better health on some cardiovascular outcomes in preadolescence.

Introduction

In recent decades, cardiovascular diseases (CVD) became a leading cause of health loss and premature death worldwide [1]. Atherosclerosis, a complex process in patients' arteries, already begins at a young age and is considered the root cause of CVD [2,3]. Among the contributing factors for developing atherosclerosis are hypertension, obesity and high levels of cholesterol and glucose, which in turn are influenced by lifestyle, including diet [2,4].

Few data exist on the relation between diet during childhood and incidence of CVD in adulthood. Nevertheless, childhood nutrition seems to be an important target to prevent CVD and risk factors for CVD that predict CVD risk later in life can already be measured in childhood [4,5]. In children and adolescents, several individual foods, like dairy products and sugar-sweetened beverages, have been associated with CVD risk factors in cross-sectional studies [6,7]. However, because diets consist of multiple different components rather than isolated foods, nutritional epidemiology has focused more on assessing dietary patterns. One method to define dietary patterns is using dietary quality indices, which determine the degree of adherence to, for example, specific dietary guidelines or the Mediterranean Diet. Such 'a priori'-derived dietary pattern approaches make it possible to evaluate whether adherence to a particular diet reduces the risk of certain diseases, like CVD [8,9].

Current evidence on associations between diet quality and cardiovascular risk in children is less clear than in adults. Cross- sectional research showed lower overall cardiometabolic risk in boys with higher Finnish Children Healthy Eating Index scores at age 6-8 [10]. However, this was not found in girls, nor in relation with the DASH score, Baltic Sea Diet Score or Mediterranean Diet Score [10]. A longitudinal study concluded that better compliance to Australian dietary guidelines at age 14 was associated with higher body mass index (BMI), but with lower waist-hip ratio and lower triglycerides and not associated with blood pressure (BP) or other blood lipids at age 17 years [11].

The DASH score has frequently been used in studying the association between diet quality and risk factors for CVD in childhood [10,12-17]. These studies tend to confirm an association between higher DASH score and lower BP. However, they are mostly conducted cross-sectionally, in a variety of age groups and associations with other cardiovascular outcomes are inconsistent. Recently, a food-based child diet quality score (CDQS) based on dietary guidelines for school-age children in the Netherlands was developed [18]. This score has been used to examine the relationship between diet quality and body composition in childhood and found a positive association between diet quality and BMI over time [19]. Associations between the CDQS and other cardiovascular risk factors in children have not yet been studied.

The objective of the present study was to examine associations between diet quality, operationalised as the DASH score and CDQS, at age 5-6 and cardiovascular risk factors at age 11-12 in a sample of Dutch children.

Materials and methods

Study Design and Population

We used data from the Amsterdam Born Children and their Development (ABCD) study, a prospective cohort study with the aim to examine the associations of early life circumstances with health at birth and later in life. A detailed description of the study has been published previously [20]. In brief, between January 2003 and March 2004, all pregnant women in Amsterdam attending their first pregnancy check-up were invited for participation in the study. Of the in total 12,373 addressed women, 8266 completed a pregnancy questionnaire. Mothers of singleton infants, who granted permission for follow-up, were invited for the 5-year measurement (N = 6161). For this measurement, a questionnaire and an invitation for a health check, comprising various physical assessments, were sent [21]. A self-administered food frequency questionnaire (FFQ) was received by the mothers who gave permission for the health check and returned by 2851 of them. After excluding the children with more than 50% missing information per food component or per page of the FFQ, FFQ data for 2782 children were applicable for analysis. Of this group, a sample of 2724 had data on at least one cardiovascular risk factor (BMI, waist circumference (WC), blood pressure (BP), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), total cholesterol, triglycerides, or fasting glucose). At the age of 11-12, in a randomly selected subgroup again a questionnaire was sent and a health check was performed. Carotid intima-media thickness (CIMT) measurement had been added to the health check by that time. 1082 children participated in the cardiovascular measurements. A set of 873 children had complete FFQ data and data on at least one cardiovascular outcome at age 11-12. We excluded children with congenital CVD and those who used drugs intervening with cardiovascular risk factors (antihypertensive or anti- hypotensive drugs, vasoprotective drugs, insulin or statins) from all analyses. A flowchart of the methodology is presented in Supplementary Fig. 1.

The Central Committee on Research Involving Human Subjects in the Netherlands, the medical ethics review committees of the participating hospitals and the Registration of the Municipality of Amsterdam approved the protocol of the ABCD study and written informed consent of all the participants was obtained.

Participant Characteristics

Baseline characteristics were obtained from questionnaires and the health check at age 5-6. Total energy intake per day and total scores of the dietary quality indices were calculated based on the data from the FFQ. Details about duration of physical activity (including walking and cycling to school, playing outside and exercise at sports clubs) and electronic screen time (watching television and playing computer games) were obtained from the questionnaire at age 5-6 [22]. This questionnaire also provided information on maternal educational level (low, primary school or lower general secondary education; middle, higher general secondary education; high, graduate school or university), BMI of the parents (self-reported) and the presence of cardiovascular risk factors and CVD among close relatives. Ethnicity (Dutch, Surinamese, Turkish, Moroccan, other Western or other Non-Western) was derived from the pregnancy questionnaire. The questionnaire at age 11-12 also yielded information on physical activity, screen time and sexual maturation by means of the Puberty Development Scale [23].

Assessment of Dietary Intake

A 71-item semi-quantitative FFQ developed by TNO Food & Nutrition (Zeist, the Netherlands) was administered by the parents to assess the children's habitual dietary intake. This FFQ had been validated against doubly labelled water and was ascertained to be an accurate instrument for determining energy intake in children aged 4-6 years old in the Netherlands [24]. Information on consumption frequency (ranging from never to six/seven days per week), quantity (natural units, household units or grams) and precise food type was converted into the amount consumed per individual food item in grams per day using the Dutch Food Composition Database 2010 (RIVM, Bilthoven, the Netherlands) [25].

DASH Score

The DASH score used in this study was based on the score developed by Fung et al. and addressed the following components: fruits, vegetables, nuts and legumes, whole grains, low-fat dairy, red and processed meat and sweetened beverages [26]. Since the FFQ used in the ABCD cohort is not appropriate for salt intake determination, we omitted this component. Supplementary Table 1 shows the food items of our FFQ that were sorted into the different components. The applied DASH score uses a ranking system in quintiles where quintile one represents participants with the lowest intake of a certain component and is awarded one point, quintile two, two points, and so on. The components red and processed meat and sweetened beverages, for which a lower intake is advised, are scored in reverse. The total DASH score is a sum of scores of all individual components (range 7-35) and was calculated for all children with a complete FFQ and at least one cardiovascular outcome at age 5-6.

CDQS

The CDQS developed by Nguyen et al. was specifically established for school-age children in the Netherlands and based on Dutch dietary guidelines [18,27]. The score consists of ten components, each yielding a maximum score of 1 when the dietary recommendation is met. The included recommendations are: fruits ≥150 g/day, vegetables ≥125 g/day, whole grains ≥90 g/day, fish ≥55 g/week, legumes ≥84 g/week, nuts ≥15 g/day, dairy ≥300 g/ day, oils and soft or liquid fats ≥30 g/day, sugar-containing beverages ≤150 g/ day and processed meat ≤250 g/week. When the recommendation is not met, the score is calculated proportionally. For example, when only a quarter of the advised amount is consumed, the score is 0.25 for that particular component. For sugar-containing beverages and processed meat the score is reversed. The total CDQS was a sum of the scores of individual components, with a theoretical range from 0 to 10 on a continuous scale.

Assessment of Cardiovascular Outcomes

Assessed cardiovascular outcomes were BMI, WC, systolic and diastolic BP, LDL-C, HDL-C, total cholesterol, triglycerides, fasting glucose and CIMT. Anthropometric measurements at both ages were performed in the same manner [28]. A portable Leicester stadiometer (Seca, Hamburg, Germany) and a Marsden weighing scale (Model MS-4102, Rotherham, United Kingdom) were used to measure height and weight, respectively. WC was determined with non-elastic measuring tape (Seca, Hamburg, Germany) at the midpoint between the lower costal margin and the iliac crest. BP was determined in lying position using the Omron 705 IT (Omron Healthcare Inc., Bannockburn, IL, USA) with a small cuff [29]. It was measured twice and after five minutes of rest. When a difference >10 mm Hg between the two measurements occurred, a third assessment was applied. The mean of the two systolic BP measurements and the two diastolic BP measurements that were closest to each other was used in the analyses [28].

Capillary blood samples were drawn by a finger-prick after an overnight fast in children aged 5-6 using a validated collection kit (Demecal, Lab Anywhere, Haarlem, the Netherlands) [30]. In the 11-12 year old children, blood sample collection was performed after three hours of fasting, also with a finger-prick and analysed by the Alere Cholestech LDX Analyzer (Alere Inc, Abbott, Chicago, IL, USA). Blood samples at both ages were analysed on concentrations of LDL-C, HDL-C, total cholesterol, triglycerides and fasting glucose.

At age 11-12, the CardioHealth Station V1.8 (Panasonic, Osaka, Japan) was used to perform real-time automated CIMT measurements. The CIMT is a validated surrogate marker for CVD and essentially a measure of atherosclerosis in adults and atherosclerotic changes in children and thereby a powerful indicator for future cardiovascular outcomes [31,32]. With the child's head in an angle of 45° and in supine position, CIMT was bilaterally measured in three different angles. Mean CIMT was used in our analyses and calculated with measurements of at least three angles.

In addition to continuous cardiovascular risk factors, we also analysed associations of diet with presence of overweight, prehypertension, dyslipidaemia, high risk CIMT and metabolic syndrome as dichotomous variables. Overweight was defined as BMI > +1 age and sex standardized SDS using WHO reference curves [33]. We considered prehypertension as systolic and/or diastolic BP levels ≥90th percentile of our study population [34]. Criteria for dyslipidaemia were set at total cholesterol >5.2 mmol/L, or

LDL-C >3.4 mmol/L, or HDL-C <0.9 mmol/L, or triglycerides >1.7 mmol/L, or a combination of them [35]. CIMT measurements ≥90th percentile were considered high risk [36]. Children were regarded as having metabolic syndrome when having three or more of the following criteria: WC ≥75th percentile, systolic or diastolic BP ≥75th percentile, HDL-C ≤25th percentile, triglycerides ≥75th percentile or fasting glucose ≥75th percentile [37].

Statistical Analysis

We performed all analyses using IBM SPSS Statistics software (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.). P-values < 0.05 were considered statistically significant. To be able to compare the two dietary quality indices, we divided total scores of both indices in quintiles. Baseline characteristics of the study population were described according to the diet quality distribution at age 5-6. To study the association between diet quality at age 5-6 and risk factors for CVD at age 11-12, we used multivariable linear and logistic regression models for continuous and categorical outcomes, respectively. Covariates in our regression models were gender, educational level of the mother, total energy intake and baseline value of the studied risk factor (measured at age 5-6) and age, physical activity, screen time and sexual maturation (measured at age 11-12) [38-40]. Analyses on the association between diet quality and CIMT were not adjusted for baseline value (as this measure was not available), but additionally adjusted for person assessing the CIMT. Considering diet quality in quintiles as a continuous variable, p-value for trend was calculated for all regression analyses. We conducted two sensitivity analyses; because total energy intake and maternal educational level are factors likely playing a role in diet quality, we re-run our analyses without adjustments for these variables to study their impact [39,41].

Results

Baseline characteristics of the study sample stratified by quintiles of the DASH score are displayed in Table 1. A total of 869 children was included with a mean age of 5.1 years (SD ± 0.2). Boys and girls were approximately equally distributed, with 52.0% boys in the whole sample. The majority of children had mothers of Dutch origin (75.9%). Mean DASH score was 21.1 (SD ± 4.2) and children with higher DASH scores had higher energy intakes per day. Moreover, children with higher DASH scores were more physically active, spent less time using screens and more often had parents with a normal body weight. Children with low educated mothers or an ethnic minority background were proportionally more represented in the lowest quintile of the DASH score. Higher DASH score was also associated with higher BMI and larger WC and with lower scores on other cardiovascular outcomes at baseline, although differences were rather small. Similar distributions of participant characteristics were observed per quintiles of the CDQS, presented in Supplementary Table 2.

Table 1. Baseline characteristics of children and parents according to children's DASH score at age 5-6 years.

	DASH score			
	All	**Q1**	**Q2-4**	**Q5**
N	869	174	559	136
Age (y)	5.1 ± 0.2	5.1 ± 0.2	5.1 ± 0.2	5.1 ± 0.1
Boy (%)	52.0	52.9	52.2	50.0
DASH score	21.1 ± 4.2	15.1 ± 1.9	21.4 ± 2.2	27.5 ± 1.5
Total energy intake (kcal/d)	1520.9 ± 318.0	1411.3 ± 282.0	1532.3 ± 324.2	1614.1 ± 298.7
Energy intake per kg body weight (kcal/kg/d)	73.6 ± 17.1	68.7 ± 16.4	74.1 ± 17.3	77.7 ± 16.0
Height (cm)	116.5 ± 5.7	116.5 ± 5.3	116.6 ± 6.0	116.5 ± 5.2
BMI (kg/m^2)	15.39 ± 1.30	15.36 ± 1.47	15.37 ± 1.24	15.48 ± 1.30
Overweight (%)	12.0	10.9	12.0	13.2
WC (cm)	52.3 ± 3.4	52.1 ± 3.7	52.2 ± 3.4	52.6 ± 3.0
Systolic BP (mm Hg)	98.9 ± 7.0	99.7 ± 7.9	98.8 ± 6.6	98.3 ± 7.0
Diastolic BP (mm Hg)	56.7 ± 6.0	57.1 ± 6.7	56.7 ± 5.6	56.6 ± 6.6
LDL-C (mmol/L)	2.34 ± 0.68	2.34 ± 0.67	2.36 ± 0.72	2.29 ± 0.53
HDL-C (mmol/L)	1.30 ± 0.30	1.35 ± 0.28	1.29 ± 0.31	1.29 ± 0.30
Total cholesterol (mmol/L)	4.05 ± 0.71	4.07 ± 0.70	4.04 ± 0.74	4.02 ± 0.57
Triglycerides (mmol/L)	0.65 ± 0.31	0.61 ± 0.29	0.66 ± 0.32	0.64 ± 0.27
Fasting glucose (mmol/L)	4.59 ± 0.51	4.62 ± 0.49	4.58 ± 0.52	4.59 ± 0.46
Physical activity (min/d)	126.0 ± 43.8	118.0 ± 43.0	126.9 ± 43.8	132.1 ± 43.4
Screen time (min/d)	75.7 ± 48.6	92.3 ± 58.4	74.2 ± 45.8	60.6 ± 39.3
Ethnicity (%)				
Dutch	75.9	70.7	78.4	72.8
Surinamese	4.1	7.5	3.6	2.2
Turkish	1.0	2.9	0.5	0.7
Moroccan	3.3	2.9	3.4	3.7
Other Western	11.6	10.9	10.6	16.9
Other non-Western	3.9	5.2	3.6	3.7
Maternal educational level (%)				
Low	6.9	13.3	6.1	2.2
Middle	19.9	31.2	18.7	10.3
High	73.2	55.5	75.2	87.5

Table 1. ***Continued***

	DASH score			
	All	**Q1**	**Q2-4**	**Q5**
Parent weight status (%)				
Normal weight	50.7	42.6	51.5	57.4
One overweight parent	37.1	43.8	36.8	30.1
Two overweight parents	12.1	13.6	11.6	12.5
Family risk factors for CVD (%)				
None affected	41.5	37.9	43.1	39.7
One parent affected	39.9	40.2	39.0	43.4
Two parents affected	18.6	21.8	18.0	16.9

Values are means with standard deviations for continuous variables and percentages for categorical variables. Abbreviations: Q, quintile; N, number; BMI, body mass index; WC, waist circumference; BP, blood pressure; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; CVD, cardiovascular diseases.
[a]According to age- and sex-specific BMI cut-off values [33].

Table 2. Associations of DASH score and CDQS at age 5-6 with cardiovascular outcomes at age 11-12 based on linear regressions.

DASH score	All	Q1	Q2	Q3	Q4	Q5	P for trend
N	869	174	208	161	190	136	
BMI (kg/m2)	17.81 (0.09)	18.00 (0.14)	17.96 (0.14)	17.79 (0.16)	17.61 (0.15)	17.65 (0.17)	0.016
WC (cm)	63.1 (0.3)	63.6 (0.4)	63.5 (0.4)	62.9 (0.4)	62.7 (0.4)	62.6 (0.5)	0.028
Systolic BP (mm Hg)	109.3 (0.4)	110.4 (0.6)	109.0 (0.6)	109.0 (0.7)	109.8 (0.7)	107.8 (0.8)	0.046
Diastolic BP (mm Hg)	61.1 (0.3)	62.3 (0.4)	61.2 (0.4)	60.7 (0.5)	60.8 (0.5)	59.9 (0.5)	<0.001
LDL-C (mmol/L)	2.17 (0.03)	2.17 (0.04)	2.22 (0.04)	2.13 (0.05)	2.13 (0.05)	2.17 (0.05)	0.380
HDL-C (mmol/L)	1.47 (0.02)	1.42 (0.03)	1.49 (0.03)	1.51 (0.03)	1.45 (0.03)	1.47 (0.03)	0.592
Total cholesterol (mmol/L)	4.06 (0.04)	4.08 (0.06)	4.12 (0.05)	4.06 (0.06)	4.03 (0.06)	4.01 (0.06)	0.128
Triglycerides (mmol/L)	0.99 (0.04)	1.09 (0.06)	0.98 (0.06)	0.97 (0.06)	0.98 (0.06)	0.89 (0.07)	0.032
Fasting glucose (mmol/L)	4.90 (0.03)	4.94 (0.05)	4.88 (0.04)	4.88 (0.05)	4.97 (0.05)	4.81 (0.05)	0.350
CIMTa (mm)							
0.456 (0.006)	0.451 (0.007)	0.455 (0.007)	0.457 (0.007)	0.460 (0.007)	0.455 (0.007)	0.095	
CDQS	**All**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**P for trend**
N	869	148	174	179	197	171	
BMI (kg/m2)	17.82 (0.09)	18.12 (0.15)	17.77 (0.15)	17.77 (0.15)	17.85 (0.14)	17.56 (0.16)	0.036
WC (cm)	63.1 (0.3)	63.7 (0.4)	63.0 (0.4)	63.4 (0.4)	62.8 (0.4)	62.7 (0.4)	0.066
Systolic BP (mm Hg)	109.3 (0.4)	109.8 (0.7)	109.2 (0.7)	109.3 (0.7)	109.4 (0.6)	109.0 (0.7)	0.532
Diastolic BP (mm Hg)	61.2 (0.3)	61.7 (0.5)	61.5 (0.5)	60.9 (0.5)	61.4 (0.5)	60.4 (0.5)	0.067
LDL-C (mmol/L)	2.18 (0.03)	2.15 (0.05)	2.13 (0.05)	2.16 (0.04)	2.18 (0.04)	2.24 (0.05)	0.081
HDL-C (mmol/L)	1.47 (0.02)	1.46 (0.03)	1.46 (0.03)	1.46 (0.03)	1.47 (0.03)	1.49 (0.03)	0.323
Total cholesterol (mmol/L)	4.07 (0.04)	4.09 (0.06)	3.99 (0.06)	4.07 (0.06)	4.09 (0.05)	4.09 (0.06)	0.462
Triglycerides (mmol/L)	0.99 (0.04)	1.12 (0.06)	0.94 (0.06)	1.01 (0.06)	1.02 (0.06)	0.87 (0.06)	0.044
Fasting glucose (mmol/L)	4.90 (0.03)	4.96 (0.05)	4.89 (0.05)	4.94 (0.05)	4.86 (0.05)	4.87 (0.05)	0.108
CIMTa (mm)	0.455 (0.006)	0.452 (0.007)	0.453 (0.007)	0.455 (0.006)	0.461 (0.007)	0.456 (0.007)	0.064

Values are estimated means from regressions with standard errors. *P*-values were calculated considering diet quality in quintiles a continuous variable. *P*-values < 0.05 are highlighted in bold. Abbreviations: Q, quintile; N, number; BMI, body mass index; WC, waist circumference; BP, blood pressure; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; CIMT, carotid intima media thickness. All values are adjusted for gender, educational level of the mother, total energy intake and baseline value of the studied risk factor (measured at age 5e6) and age, physical activity, screen time and sexual maturation (measured at age 11e12). [a]Not adjusted for baseline value, additionally adjusted for person assessing CIMT.

Diet Quality

Diet quality at the age of 5-6 years based on the DASH score ranged from 8 to 34 (maximum 35). Total CDQS at this age varied between 0.86 and 9.07 (maximum 10). Mean intake (g/day) per DASH component and per quintile of the DASH component is demonstrated in Supplementary Table 3. Total DASH scores and CDQS were highly correlated (Pearson's r = 0.7, $p < 0.001$). The mean score on the Puberty Development Scale was 1.52 (SD ± 0.54).

Linear Regression Analyses

We observed several associations between diet quality at age 5-6 and cardiovascular outcomes at age 11-12 (Table 2). After adjustments, higher DASH scores were associated with lower BMI (p for trend = 0.016), smaller WC (p for trend = 0.028), lower systolic (p for trend = 0.046) and diastolic BP (p for trend < 0.001) and lower plasma concentrations of triglycerides (p for trend = 0.032). Higher CDQS was associated with lower BMI (p for trend = 0.036) and lower triglycerides (p for trend = 0.044). There were no associations between diet quality at age 5-6 and LDL-C, HDL-C, total cholesterol, fasting glucose or CIMT at age 11-12, using any of the two dietary quality indices.

Our sensitivity analyses demonstrated that excluding adjustments for total energy intake and maternal educational level changed the associations to some extent. Excluding total energy intake from the model meant that the associations between diet and triglycerides were no longer statistically significant, with p-values for trend being 0.069 and 0.096, for DASH and CDQS respectively. Furthermore, after omitting total energy intake, higher CDQS was negatively associated with WC (p for trend = 0.033) and diastolic BP (p for trend = 0.042). No adjustment for maternal educational level did not change the associations found with the DASH score. However, negative associations became apparent between CDQS and WC (p for trend = 0.013), diastolic BP (p for trend = 0.031) and CIMT (p for trend = 0.043).

Logistic Regression Analyses

Multivariable logistic regression showed an association between the DASH score at age 5-6 and risk of prehypertension and dyslipidaemia at age 11-12 (Table 3). One quintile increase of the DASH score was associated with lower risk of prehypertension (aOR: 0.77; 95% CI: 0.64-0.93, p = 0.006) and dyslipidaemia (aOR: 0.79; 95% CI: 0.65-0.95, p = 0.012). The CDQS was also associated with risk of dyslipidaemia 0.79 (95% CI: 0.66-0.95, p = 0.014), but not with prehypertension. We found no associations between diet quality at age 5-6 and risk of overweight, high risk CIMT or metabolic syndrome in preadolescents. Figure 1 shows the predicted probability of prehypertension and dyslipidaemia at age 11-12 as a function of the DASH score.

Table 3. Associations of DASH score and CDQS at age 5-6 with risk for cardiovascular outcomes at age 11-12 based on logistic regressions.

DASH score	aOR	95% CI	% with outcome	P-value
Overweight	0.87	0.73-1.05	12.8%	0.159
Prehypertension	0.77	0.64-0.93	13.5%	0.006
Dysplipidaemia	0.79	0.65-0.95	10.5%	0.012
High risk CIMTa	1.11	0.91-1.36	10.3%	0.293
Metabolic syndrome	0.81	0.65-1.01	9.7%	0.064
CDQS				
Overweight	0.86	0.72-1.04	12.8%	0.113
Prehypertension	0.87	0.72-1.04	13.5%	0.115
Dysplipidaemia	0.79	0.66-0.95	10.5%	0.014
High risk CIMTa	1.12	0.92-1.37	10.3%	0.248
Metabolic syndrome	0.89	0.72-1.10	9.7%	0.282

Abbreviation: aOR, adjusted odds ratio; CIMT, carotid intima-media thickness. *P*- values < 0.05 are highlighted in bold. All values are adjusted for gender, educational level of the mother, total energy intake and baseline value of the studied risk factor (measured at age 5e6) and age, physical activity, screen time and sexual maturation (measured at age 11e12). [a]Not adjusted for baseline value, additionally adjusted for person assessing CIMT.

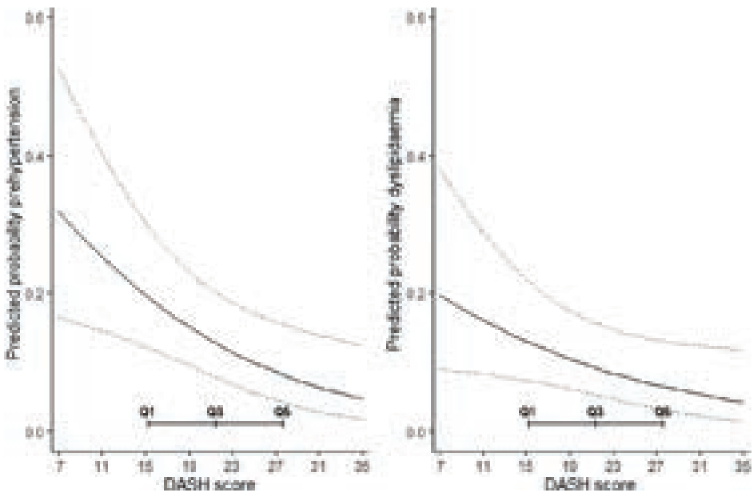


Figure 1. Predicted probability of prehypertension and dyslipidaemia at age 11-12 based on DASH score at age 5-6. Predicted probability figure was based on the following values for the covariates in the model: boy, mean of age, screen time, physical activity and pubertal stage, middle maternal educational level and absence of prehypertension respectively dyslipidaemia at age 5-6.

Discussion

Key Results

We demonstrated that higher diet quality at age 5-6 was associated with modest differences in several risk factors for CVD at age 11-12. Higher DASH scores at age 5-6 were associated with lower BMI, WC, systolic and diastolic BP and triglyceride concentrations at age 11-12. Higher CDQS was associated with lower BMI and lower triglycerides. Furthermore, both dietary quality indices revealed a negative association with dyslipidaemia in preadolescents; higher DASH scores were also inversely associated with prehypertension. We found no statistically significant relationships between diet quality and LDL-C, HDL-C, total cholesterol, fasting glucose or CIMT.

Interpretation of Findings

Higher diet quality was associated with lower BMI after 6 years follow-up. This finding is in line with an Iranian study on the longitudinal relationship between the DASH score and cardiovascular outcomes in adolescents aged 10-18 years [14]. Nguyen et al. used the CDQS in another sample of Dutch children and found a trend contrary to our findings; they showed a positive relationship between diet quality at age 8 years and BMI at the age of 10 years, which was completely driven by a higher fat-free mass [19]. In that sample, after stratification by sex, only the associations in girls remained statistically significant, suggesting that there might be already impact of peri-pubertal changes. Differences with our findings may be due to the slight age differences of both dietary and outcome assessment and the fact that we adjusted our analyses for pubertal stage, which was not the case in the study of Nguyen et al. The difference in prevalence of overweight was small, i.e. 12.8% in our sample compared to 14.5% in Nguyen's, and, although using slightly different BMI cut-offs, not considered large enough to explain the difference between findings of the two studies [33,42]. Our study showed an inverse relationship between both dietary quality indices and plasma triglyceride concentrations which is in agreement with a study using a diet quality score based on Australian dietary guidelines [11]. Not all previously published studies using the DASH score did find a relationship with levels of triglycerides in children [12,14]. The DASH score only takes into account red and processed meat as reflection for fat intake, whereas the CDQS and the diet quality score based on Australian dietary guidelines take into account both meat and fat consumption. Although, the CDQS does not specifically address hard fats or butter, the difference in design of these indices might explain the different findings.

Corresponding to other research, diet quality according to the DASH score was associated with lower systolic and diastolic BP and risk of hypertension in preadolescents in our study [12,17]. These results support the potential beneficial effect of the DASH diet in lowering BP in children, as already has been verified in adults [43]. In their longitudinal study, Farhadnejad et al. observed no relationship between the DASH score and the risk of dyslipidaemia at age 10-18, which is contrary to our findings [14]. Since lipid concentrations in children are usually favourable and their study sample only comprised 430 children, the low number of children with dyslipidaemia could have caused the inability to demonstrate an association.

Regarding the association of diet quality and CIMT, in agreement with our findings, two previously conducted studies indicate that no evident association exists in preadolescents [44,45]. The small differences found in CIMT and relatively short period of follow-up may explain the fact that a relationship between diet quality and CIMT has not yet been affirmed in children.

Excluding total energy intake and maternal educational level from the regression models demonstrated additional associations between higher CDQS and lower WC and diastolic BP, whereas these associations persisted with the DASH score. This could imply that the DASH score is a stronger determinant for cardiovascular outcomes in preadolescents than the CDQS, or that the DASH score is less strongly associated with energy intake and maternal education than the CDQS. Moreover, total energy intake and maternal educational level are determinants for the child's dietary pattern [39,41]. With that, adjustment for these factors is to a certain extent over-adjustment and therefore our results are presumably a conservative estimation.

Strengths and Limitations

Our study had several strengths. Firstly, we were able to study the association between diet quality and outcomes while correcting for baseline levels of all outcomes (except CIMT), which allowed us to account for reverse causality to some degree and provide more evidence for causality compared to evidence from cross-sectional studies. In addition, the availability of many covariates enabled us to adjust for relevant confounding factors. As different dietary quality indices assess diets in different ways, another advantage was that we applied two indices to examine diet quality. The DASH score is calculated on the basis of population intakes and is a relative measure of diet quality, whereas the CDQS is based on an absolute measure (meeting dietary guidelines). Despite their differences in approach, the two indices were highly correlated. To overcome the difference in scoring between the two indices, we divided them both in quintiles and observed overall consistent associations with cardiovascular outcomes. This implies that high diet quality, in general and independently of dietary quality index used, is important in CVD prevention, even at an early age. Finally, we used a validated FFQ that assessed an extensive variety of foods regularly consumed by children [24].

However, some limitations of our study must be acknowledged. The external validity of our study may be low, since we mainly included children from higher educated mothers. Given that lower maternal educational level is associated with lower diet quality, we assume that our selection of children possibly represent an underestimation of the effect of diet quality on cardiovascular outcomes [18]. Considering the subjective nature of self-reporting, our physical activity data may have hinged on some bias. Although both valid and commonly used, the use of two different capillary blood analysis kits at age 5-6 and 11-12 might have influenced our results. Another limitation of our study is the fact that we had CIMT measurements from the age of 11-12 only. Due to this it was not possible to adjust for baseline CIMT measurements and solid longitudinal results with this outcome were not available. Considering that CIMT might be a possible powerful indicator for future cardiovascular outcomes already in children, revealing associations with this measurement is important and could be of great clinical value.

Implications

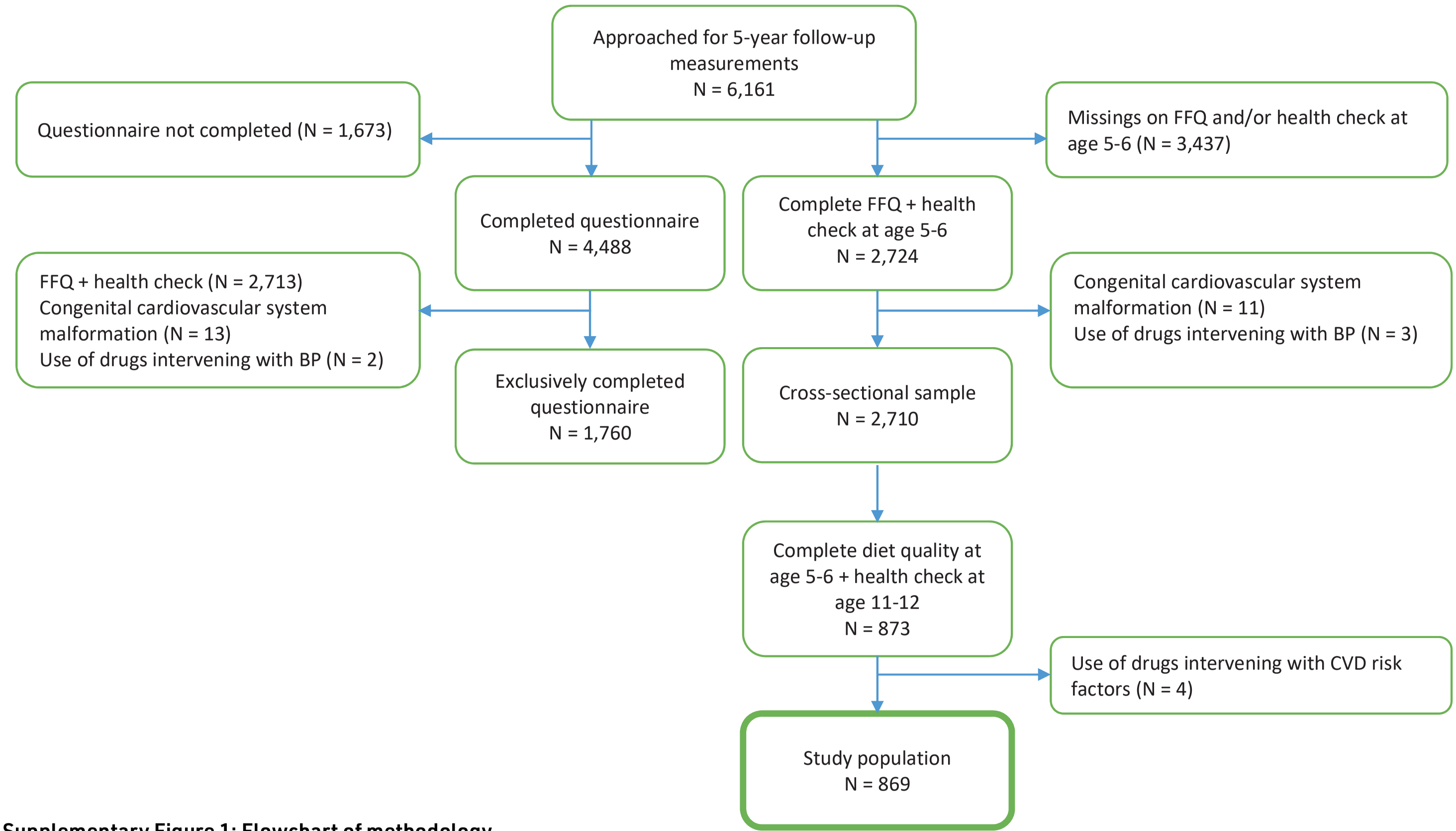
We found that diet quality is already at a young age associated with cardiovascular risk factors. These risk factors in childhood have shown to predict CVD risk in adulthood [5]. Taking this into account and considering that diet is a modifiable feature, it is of great importance to make improving diet quality in childhood a priority in public health.

As we are one of the first to investigate the association between diet quality in childhood and cardiovascular outcomes in preadolescents, our findings need to be confirmed. Future research should also assess whether dietary quality indices are reliable tools in health care settings to predict cardiovascular outcomes in children. Moreover, future studies should actively involve subjects with lower educational level to assure a greater generalisability of the results to the general population.

Conclusions

In conclusion, higher diet quality in children at age 5-6 years was associated with lower BMI, lower plasma concentrations of triglycerides and lower risk of dyslipidaemia in preadolescents. Our findings emphasize the importance of diet quality in childhood in the possible prevention of negative cardiovascular outcomes.

Supplemental material



Supplementary Figure 1: Flowchart of methodology

Supplementary Table 1: Included food items per DASH score component

DASH score component	Included food items from FFQ
Fruits	Fresh citrus fruits, fresh other fruits, freshly squeezed fruit juice, dried raisins
Vegetables	Boiled vegetables, mixed raw vegetables, vegetables from 'stamppot' (a Dutch dish with mashed potatoes) i.e. endive, kale, carrots/onions and sauerkraut, vegetables from Chinese noodle dishes, vegetables from Italian pasta dishes
Nuts and legumes	Mixed unsalted nuts, peanuts, peanut butter, tinned baked beans, tinned brown beans, tahoe soya curd
Whole grains	Brown bread, wholemeal bread, rye bread, gold-brown and wholemeal crispbread, Dutch wholemeal crispbakes, muesli, cooked breakfast cereal (Brinta), brown rice, multigrain pasta, wholemeal pasta
Low-fat dairy	20+/30+ cheese and cheese spread, semi-skimmed and skimmed milk (in porridge and to drink), buttermilk, buttermilk porridge, full fat, half fat and low fat yoghurt, full fat chocolate custard, full fat vanilla custard, full fat other flavoured custard, fromage frais Danoontje, low fat fromage frais with fruit, low fat fromage frais with fruit and artificial sweetener, full fat, half fat and low fat yoghurt with fruit, low fat yoghurt with fruit and artificial sweetener, full fat, semi-skimmed and skimmed chocolate-flavoured milk, chocolate-flavoured milk with artificial sweetener, yoghurt drink, yoghurt drink no sugar/artificial sweetener
Red and processed meats	Deli meats: liver pate, liver sausage, liver pate sausage, Berliner liver sausage, sausage luncheon meat, sausage with smoked bacon-bits, fried minced meat, cooked sausage, salami saveloy sausage, streaky bacon rasher, corned beef, boiled lean ham, boiled medium fat shoulder ham, boiled pork liver, smoke-dried beef, fried pork fricandeau, other processed meat products with <10 g fat excluding liver. Snacks: deep-fried frikandel sausage, deep-fried croquette meat, pork satay with peanut sauce, puff pastry sausage roll, dough pastry sausage roll with bread, tinned frankfurter sausage. Meats: breaded chicken burger, chicken nuggets prepared in frying fat, shallow fried minced beef/pork, minced beef/pork ball prepared with egg and crumbs, minced beef ball prepared without egg, veal prime rib, cooked smoked sausage, lean bacon, beef rump steak, beef roast, beef rib steak, streaked/marbled beef, beef stewing steak, beef steak tartare, sausage pork, pork fillet, pork fricandeau, pork chop, pork tenderloin, pork loin chop, pork liver, pork shoulder, filled kromesky meat, hamburger, pork rib chop, not breaded pork schnitzel, other meat products with <5 % or >5% fat excluding liver
Sweetened beverages	All fruit juices except for the freshly squeezed, sweetened soft drinks, sweetened chocolate-flavoured milks, sweetened yoghurt drinks, sweetened fruit juice concentrates, fruit juice concentrates used in dairy, sweetened tea

Supplementary Table 2: Baseline characteristics of children and parents according to children's CDQS at age 5-6 years

	CDQS			
	All	**Q1**	**Q2-4**	**Q5**
N 869	148	550	171	
Age (y)	5.1 ± 0.2	5.1 ± 0.2	5.1 ± 0.2	5.1 ± 0.2
Male (%)	52.0	49.3	52.4	53.2
CDQS	4.8 ± 1.1	3.0 ± 0.5	4.7 ± 0.5	6.4 ± 0.5
Total energy intake (kcal/d)	1520.9 ± 318.0	1367.8 ± 268.0	1523.7 ± 310.8	1644.4 ± 326.5
Energy intake per kg body weight (kcal/kg/d)	73.6 ± 17.1	66.9 ± 14.7	74.1 ± 17.2	77.9 ± 17.1
Height (cm)	116.5 ± 5.7	116.2 ± 5.6	116.5 ± 6.0	116.9 ±4.9
BMI (kg/m2)	15.39 ± 1.30	15.29 ± 1.21	15.35 ± 1.31	15.58 ± 1.31
Overweight (%)a	12.0	9.5	12.2	13.5
WC (cm)	52.3 ± 3.4	51.9 ± 3.3	52.3 ± 3.5	52.7 ± 3.1
Systolic BP (mm Hg)	98.9 ± 7.0	98.8 ± 7.4	99.1 ± 6.9	98.6 ± 6.7
Diastolic BP (mm Hg)	56.7 ± 6.0	57.3 ± 6.5	56.8 ± 5.7	56.1 ± 6.4
LDL-C (mmol/L)	2.34 ± 0.68	2.33 ± 0.60	2.36 ± 0.73	2.31 ± 0.60
HDL-C (mmol/L)	1.30 ± 0.30	1.29 ± 0.27	1.31 ± 0.31	1.30 ± 0.32
Total cholesterol (mmol/L)	4.05 ± 0.71	4.03 ± 0.64	4.05 ± 0.75	4.05 ± 0.63
Triglycerides (mmol/L)	0.65 ± 0.31	0.63 ± 0.27	0.67 ± 0.33	0.61 ± 0.24
Fasting glucose (mmol/L)	4.59 ± 0.51	4.65 ± 0.49	4.59 ± 0.51	4.53 ± 0.51
Screen time (min/d)	75.7 ± 48.6	88.4 ± 58.0	74.8 ± 46.4	67.7 ± 44.5
Ethnicity (%)				
Dutch	75.9	68.2	77.6	77.2
Surinamese	4.1	6.1	4.5	1.2
Turkish	1.0	3.4	0.7	0
Moroccan	3.3	2.7	2.9	5.3
Other Western	11.6	12.8	10.9	12.9
Other non-Western	3.9	6.8	3.3	3.5
Maternal educational level (%)				
Low	6.9	14.9	5.9	3.5
Middle	19.9	27.7	19.9	12.9
High	73.2	57.4	74.2	83.6
Parent weight status (%)				
Normal weight	50.7	42.7	53.5	48.5
One overweight parent	37.1	42.7	35.8	36.7
Two overweight parents	12.1	14.7	10.7	14.8
Family risk factors for CVD (%)				
None affected	41.5	36.5	41.4	46.2
One parent affected	39.9	41.2	40.0	38.6
Two parents affected	18.6	22.3	18.6	15.2

Values are means with standard deviations for continuous variables and percentages for categorical variables. Abbreviations: Q, quintile; N, number; BMI, body mass index; WC, waist circumference; BP, blood pressure; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; CVD, cardiovascular

Supplementary Table 3: Mean intake per DASH component and per quintile of the DASH component

	Total intake (g/day)	Quintile 1 (g/day)	Quintile 2 (g/day)	Quintile 3 (g/day)	Quintile 4 (g/day)	Quintile 5 (g/day)
Fruits	200.2 ± 116.6	82.2 ± 28.7	127.6 ± 10.7	180.2 ± 19.2	240.5 ± 17.8	383.1 ± 100.8
Vegetables	92.3 ± 50.7	32.9 ± 12.7	61.7 ± 6.4	83.5 ± 6.4	111.6 ± 10.1	171.6 ± 36.2
Nuts and legumes	15.0 ± 15.1	1.1 ± 1.1	6.1 ± 1.4	11.4 ± 1.5	18.3 ± 2.5	37.9 ± 17.6
Whole grains	99.3 ± 44.4	40.8 ± 22.6	78.0 ± 7.8	99.9 ± 3.6	122.1 ± 8.0	160.4 ± 24.0
Low-fat dairy	295.6 ± 159.3	89.0 ± 44.6	198.6 ± 26.1	286.9 ± 26.0	374.9 ± 27.6	528.9 ± 100.3
Red and processed meats	55.1 ± 33.8	107.2 ± 27.7	67.4 ± 5.8	49.7 ± 4.3	34.7 ± 4.3	16.3 ± 7.9
Sweetened beverages	171.9 ± 152.8	412.5 ± 153.2	213.5 ± 29.6	135.3 ± 19.6	74.5 ± 16.2	25.4 ± 13.7

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Part II

Existing tools and requirements from youth healthcare practice

Chapter 5

Lifestyle screening tools for children in the community setting: a systematic review

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Abstract

Screening of children's lifestyle, including nutrition, may contribute to the prevention of lifestyle-related conditions in childhood and later in life. Screening tools can evaluate a wide variety of lifestyle factors, resulting in different (risk) scores and prospects of action. This systematic review aimed to summarise the design, psychometric properties and implementation of lifestyle screening tools for children in community settings. We searched the electronic databases of Embase, Medline (PubMed) and CINAHL to identify articles published between 2004 and July 2020 addressing lifestyle screening tools for children aged 0–18 years in the community setting. Independent screening and selection by two reviewers was followed by data extraction and the qualitative analysis of findings. We identified 41 unique lifestyle screening tools, with the majority addressing dietary and/or lifestyle behaviours and habits related to overweight and obesity. The domains mostly covered were nutrition, physical activity and sedentary behaviour/screen time. Tool validation was limited, and deliberate implementation features, such as the availability of clear prospects of actions following tool outcomes, were lacking. Despite the multitude of existing lifestyle screening tools for children in the community setting, there is a need for a validated easy-to-administer tool that enables risk classification and offers specific prospects of action to prevent children from adverse health outcomes.

Introduction

A healthy lifestyle is essential for optimal growth and development as well as for later-life health of children [1,2]. The World Health Organization proposed the concept of a healthy lifestyle to be 'a way of living that lowers the risk of being seriously ill or dying early' [3]. A large number of factors can be considered as lifestyle. In children, nutrition, physical activity (PA), sedentary behaviour and sleep are lifestyle factors that were found to be associated with health outcomes [4–7]. Overweight, obesity and other cardiovascular risk factors are common consequences of an unhealthy lifestyle and may already appear during childhood [4]. The adequate evaluation of children's lifestyle can contribute to preventive actions that combat the increasing prevalence of lifestyle-related conditions.

To evaluate the lifestyle of children, including nutrition, various tools can be used. Two groups of lifestyle tools can be distinguished: lifestyle assessment tools and lifestyle screening tools [8]. Lifestyle assessment tools, such as food frequency questionnaires, 3-day food diaries and physical activity trackers, are used to examine the child's behaviour and/or characteristics in detail. To be of service to youth healthcare, which has a preventive function but limited consultation time, this paper focuses on lifestyle screening tools that identify risk (factors) on an individual level. Lifestyle screening tools usually comprise more general items than lifestyle assessment tools, are used for quick evaluation and assign a certain value to the lifestyle behaviour and/or characteristics of the child. In practice, a commonly used method for this is a short questionnaire. Outcomes of lifestyle screening tools may vary; they can, for example, result in an overall lifestyle score or high-light areas for improvement ('red flags'). Given the rapid value judgment, lifestyle screening tools can be helpful in clinical practice or community screening. Here, they can serve as a basis to enter into dialogue with the parents or provide advice for further actions, for instance, referral to a dietitian or starting an intervention. Next to the design characteristics of lifestyle screening tools (such as the number of items, covered topics and intended target group), the psychometric properties (i.e., reliability and validity) and implementation methods (such as the manner in which the outcomes or advice for further action are formulated (prospects of action)), practical application and tool format (online, on paper, etc.) are likely to affect the usability and effectiveness of such screening tools.

Reviews specifically on nutrition screening tools for children have mainly focused on tools developed for hospital settings [9–13]. A recently published systematic review by Becker et al. targeted the reliability and validity of nutrition screening tools for children up to 18 years of age, including tools for the community setting [14]. The community health care setting, represented by preventive and primary health care services, is the perfect place for the usage of lifestyle screening tools. This is because most children with a suboptimal lifestyle reside in the community setting and will not be admitted to a hospital. A thorough overview of existing lifestyle screening tools for children aged 0–18 years in the community setting, not limited to nutrition, is yet lacking.

Therefore, our systematic review aims to comprehensively describe lifestyle screening tools for children in the community setting. The present study is embedded in a Dutch governmental project that intends to develop a lifestyle screening tool for children aged 0–4 years. This screening tool will ultimately lead to timely measures to prevent children from negative lifestyle-related health outcomes. The specific questions to be addressed within our review are:

(1) What lifestyle screening tools for children in the community setting are available?
(2) What are the main features of these lifestyle screening tools regarding design, psychometric properties (i.e., reliability and validity) and implementation?

Materials and methods

This systematic review is reported as indicated in the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guideline [15]. An a priori systematic review protocol was developed (available upon request).

Search Strategy

We performed systematic searches in the electronic databases of Embase, Medline (PubMed) and CINAHL to identify articles addressing lifestyle screening tools for children in the community setting, published between January 2004 and July 2020. Based on the study objectives, the PICO model [16] was used to further specify the search strategy. The population (P) was defined as children up to 18 years of age in the community setting, the intervention/exposure (I) as lifestyle screening tools and the outcomes of interest (O) as indicators of an unhealthy lifestyle. We did not include a comparison to a control group (C) as we did not study an intervention effect. Search strings were developed with assistance from a librarian. Search terms were divided into the categories ‘child’, ‘screening’ and ‘lifestyle’, which were combined with ‘AND’. Emtree terms and MeSH terms were used to identify relevant articles (Supplementary file S1). Search filters to restrain the results to humans and English or Dutch language were applied. The search strategies were not limited to specific lifestyle factors.

As nutrition is such an eminent part of lifestyle, we performed additional literature searches focusing on nutrition screening tools. Hence, we updated the searches by Becker et al. and an exploratory systematic search that was conducted in 2019 (unpublished research, for details, see Supplementary file S1). Similar to the broader search on lifestyle screening tools, filters to limit the results to humans and English or Dutch language were applied.

Full details on the search strings are provided in Supplementary file S1. Search results were exported to EndNote X9 reference management software and deduplicated.

Eligibility Criteria

For the inclusion of an article, the following predefined criteria had to be met:

1. The study described a screening tool to identify lifestyle risk (factors) on an individual level for
2. children up to 18 years of age in
3. the community setting.
4. The tool had to be applied by a parent/caregiver, health professional (e.g., physician, nurse) or by the child him- or herself, and
5. the study was published in English or Dutch
6. between January 2004 and July 2020.

Exclusion criteria comprised:

1. Studies reporting on lifestyle questionnaires, with a purpose other than screening for lifestyle risk (factors) on an individual level (e.g., general questionnaires in national surveys);
2. studies on lifestyle assessment tools (e.g., (derivatives of) food frequency questionnaires, diet quality scores, anthropometry);
3. studies on a single specific lifestyle or nutrition factor (e.g., solely screen time or vegetable intake);
4. studies reporting prevalence rates of malnutrition or growth charts as a measure of nutrition risk;
5. tools to identify eating disorders;
6. tools developed for hospital settings or specific patient groups;
7. commentaries and conference abstracts.

Screening, Selection and Data Extraction

Applying the abovementioned inclusion and exclusion criteria, two reviewers (A.K. and S.t.B.) independently screened titles and abstracts of the obtained articles. Thereafter, they selected the relevant articles based on full texts according to the same inclusion and exclusion criteria. Additionally, articles included in the review of Becker et al. [14] and identified with the exploratory search on nutrition screening tools were checked for eligibility. Discrepancies in opinion on inclusion by the reviewers were resolved by discussion until consensus or in consultation with a third reviewer (L.E.). A.K. and S.t.B. then extracted the data from the included studies. Reported general information (reference, title), study characteristics (study objective, study year, country of origin, study design, sample size, age, outcome measures, results) and tool characteristics (tool name, tool aim, target population, person administered, administer duration, administer frequency, administer method, addressed domains, number of items, response format, tool outcome, prospect of action, strengths, limitations) were entered into a predesigned data extraction table. The usability of the data extraction table was tested beforehand by extracting data from 10% of the articles in duplicate by A.K. and S.t.B.. Articles reporting on the same tool were grouped. Articles covered in included reviews were also assessed for eligibility.

Data Analysis

By summarising the characteristics of the included studies and corresponding life-style screening tools, we performed an initial data synthesis. Subsequently, qualitative analysis was performed by tabulating and assorting by specific features, such as target age (toddlers, 1–3 years old; preschoolers, 3–5 years old; school age, 6–12 years old; adolescents, 13–18 years old), number of tool items and prospects of action. This enabled us to aggregate the data further and to explore similarities and differences between the identified screening tools.

Results

A total of 2698 articles were identified for screening (Figure 1). After the full-text re-view of 105 articles, 48 met the inclusion criteria and were included in the qualitative analysis. The most common reasons for exclusion were: not describing a screening tool or describing a general questionnaire instead of a screening tool. We included two systematic reviews [14,17], yielding no additional screening tools for inclusion. The other 46 articles [18–63] described 41 unique screening tools. The majority of the included articles reported on the development and validation of screening tools, whereas their implementation was rarely addressed. Studies were performed between 2001 and 2019 in sixteen different countries (both Western and non-Western), with nearly half conducted in the United States (n = 20).

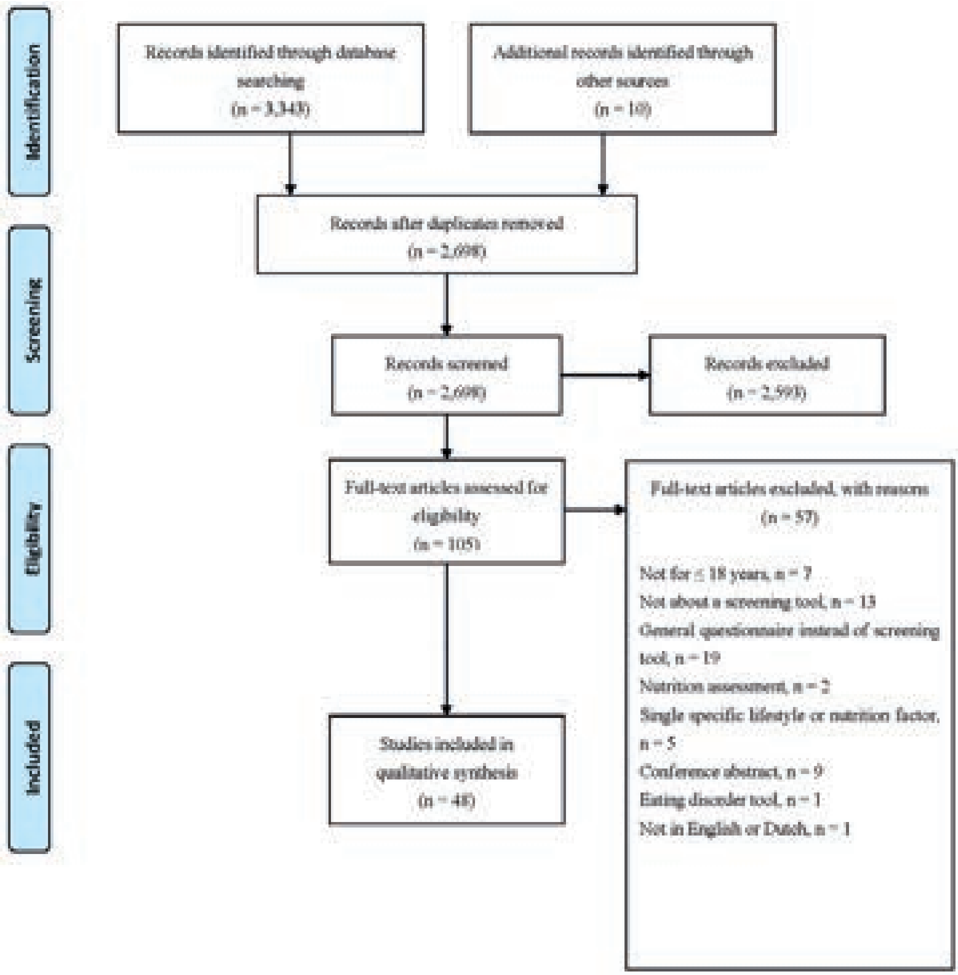

Figure 1. PRISMA flowchart of methodology.

Design of Screening Tools

Table 1 demonstrates various characteristics of the included lifestyle screening tools. The majority of tools were developed to screen lifestyle behaviour and habits. Although not always explicitly stated in the tool's aim, articles mostly described that the tool focused on factors associated with obesity risk. Ten screening tools were distinctively de-signed for toddlers (1–3 years old) or preschoolers (3–5 years old) [18–31] and another nine for school-aged children (6–12 y) [32–39]. Fourteen tools were described as either de-signed for children in general or did not specify the children's target age (0–18 y) [40–55]. Eight tools were specifically designed for adolescents (13–18 y) [56–63]. The tools aimed at toddlers and preschoolers were to be administered by parents or health care professionals. Children of school age reported themselves (n = 6) or their parents did (n = 3). One tool for children without specified age was divided into a part completed by the child and a part completed by the parents [55]. Tools for adolescents only were exclusively self-reported. Tools administered to parents could include proxy-reported items on the child but also self-reported items regarding parents themselves, such as self-efficacy for a healthy life-style or parental feeding practices. The number of items per tool ranged from 3 to 116, with a median of 22 items (interquartile range (IQR): 17, 34). No article described the rationale for the number of items. All tools used multiple choice questions (some combined with open questions), mainly on Likert-type scales. Two tools used visuals to increase comprehensibility [30,37]. These visuals included portion sizes and images to make the tool more appealing. The time needed to complete the tool was reported for only thirteen tools [18–20,30,31,34,37–40,47,52,60,63]. From those who reported the time, the time needed ranged from 3 [18–20] to 90 [37] minutes; six tools could be completed within 15 min [18–20,31,38,40,52].

Table 2 shows the encompassed lifestyle domains with specified items of the included screening tools. Specification of the nutrition items is demonstrated in Table 3. The domains covered most were nutrition (n = 39), PA (n = 25) and sedentary behaviour/screen time (n = 21) (Figure 2). The median of the number of covered domains was three. Tools for toddlers and preschoolers covered, with a median of two, fewer domains. All screening tools intended for toddlers and preschoolers covered nutrition. None of the screening tools specifically for toddlers included PA items, whereas, in other tools, PA was mainly evaluated by estimating the frequency and duration per week. Sedentary behaviour was not determined as such but evaluated with screen time as proxy. Sleep and hygiene were included in four and five tools, respectively, mainly as sleep duration (n = 2) and dental care (n = 4). Huang et al. included neighbourhood safety [55]; environmental factors in other tools were generally related to nutrition and PA (e.g., parental modelling). As for the items on nutrition, the intake of specific food groups, dietary habits and psychological factors were predominantly evaluated (Table 3). Of all the tools that evaluated the consumption of food groups (n = 27), most asked about vegetables (n = 25), fruits (n = 25), sugar-sweetened beverages (n = 16) and unhealthy snacks/fast food (n = 16). Commonly addressed eating habits were consuming breakfast (n = 9), eating at the table or while watching TV (n = 6) and eating with the family together (n = 5). Psychological factors mainly included (parental) beliefs and attitudes towards healthy eating. In addition, nutrition knowledge (n = 4) and food costs (n = 2) recurred in several tools.

Table 1. Characteristics of lifestyle screening tools for children in the community setting.

Tool Name	Tool Aim	Target Population	Adminis-tered by	Number of Items	Item Response Format	Tool Scoring	Prospect of Action
1. NutricheQ [18–20]	Assess dietary risk	Toddlers	Parent [b]	11 c	3-point Likert scale	Subsection score and total score; ranging from 0 to 22 Cut-offs for low, moderate and high risk are available per section	Tool identifies children who may need blood screening and nutritional intervention
2. Toddler Feeding Questionnaire (TFQ) [21]	Assess indulgent, authoritative and environmental feeding practices	Toddlers	Parent [a]	24	5-point Likert scale (never-always)	Subscale scores	NR
3. Toddler NutriSTEP [22]	Assess nutritional risk	Toddlers	Parent	17	Likert-type scale	Total score; ranging from 0 to 68 Cut-offs for low, moderate and high risk	Treat impaired state and refer to needed services
4. Toddler Dietary Questionnaire (TDQ) [23]	Assess dietary risk	Toddlers	Parent [b]	19	Likert-type scale	Total score; ranging from 0 to 100 Cut-offs for low, moderate, high and very high dietary risk	Health care professionals may refer to a dietitian based on identified risk

Table 1. ***Continued***

Tool Name	Tool Aim	Target Population	Adminis-tered by	Number of Items	Item Response Format	Tool Scoring	Prospect of Action
5. Child Eating Behavior Questionnaire (CEBQ) [24]	Assess eating behaviours	Preschoolers	Parent [b]	35	5-point Likert scale (never-always)	Subscale scores	NR
6. Nutrition Screening Tool for Every Preschooler (NutriSTEP) [25–27]	Assess nutritional risk	Preschoolers	Parent [b]	17	Likert-type scale (varying)	Total score; ranging from 0 to 68 Cut-offs for low, moderate and high risk	Parents receive results, customised feedback and resources such as links to credible health information websites
7. Preschooler Dietary Questionnaire (PDQ) [28]	Assess diet and provide a dietary risk score	Preschoolers	Parent [b]	19	Likert-type scale	Total score; ranging from 0 to 100 Cut-offs for low, moderate, high and very high dietary risk	Health care professionals may refer to a dietitian based on identified risk
8. Preschoolers Diet–Lifestyle Index (PDL-index) [29]	Assess adherence to diet–lifestyle recommendations	Preschoolers	Health care professional [b]	11	Likert-type scale (varying)	Total score; ranging from 0 to 44	Tool may guide health care professionals in counselling parents and policy makers in developing interventions

Table 1. *Continued*

Tool Name	Tool Aim	Target Population	Adminis-tered by	Number of Items	Item Response Format	Tool Scoring	Prospect of Action
9. Healthy Kids [30]	Assess diet, lifestyle and parenting domains to determine obesity risk	Children aged 2–5 y from low-income families	Parent [a,b]	19	Combination of closed and open questions	Total score; ranging from 19 to 95	Tool can be used to target counselling or nutrition education for families and to supplement physical examination
10. Tool by Das and Ghosh [31]	Assess nutrition knowledge	Children aged 3–6 y	Parent [a]	32	Closed questions	Total score; ranging 0–32	NR
11. Start the Conversation 4–12 (STC-4–12) [32]	Assess and counsel nutrition and PA barriers and behaviours	Children aged 4–12 y	Parent [a,b]	22	Likert-type scale (varying)	No score	The tool provides tips that serve as cues for action for parents and guide counselling by health care professionals
12. Healthy Families Survey [33]	Assess nutrition and PA behaviours	Elementary school children	Parent [a,b]	45	Combination of closed and open questions	Subscale scores	NR
13. Knowledge, Attitudes and Habits (KAH-) questionnaire [34]	Assess knowledge, attitudes and habits towards a healthy lifestyle	Elementary school children	Child [a]	48	3-point Likert scale	Subscale scores and total score; ranging from 0 to 96	NR

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Table 1. ***Continued***

Tool Name	Tool Aim	Target Population	Adminis-tered by	Number of Items	Item Response Format	Tool Scoring	Prospect of Action
14. Parental Self-efficacy Questionnaire [35]	Assess parental self-efficacy for enacting healthy diet and PA behaviours in their children	Children aged 6–11 y	Parent [a]	34	11-point Likert scale	Subscale scores and total score; ranging from 0 to 340	NR
15. Tool by Chacko and Ganesan [36]	Assess dietary gaps	School children aged 6–17 y	Child [a]	10	2-point Likert scales (yes–no)	Total score; ranging from 0 to 10	Parents and children can receive corrective counselling on the identified gaps
16. Food, Health and Choices questionnaire (FHC-Q) [37]	Assess energy balance behaviours and related theory-based psychosocial determinants	Upper elementary school children	Child [a]	116	Likert-type scale	Subscale scores	NR
17. Healthy Eating and Physical Activity Self-Efficacy Questionnaire for Children (HEPASEQ-C) [38]	Assess self-efficacy of healthy eating and PA	Upper elementary school children	Child [a]	9	3-point Likert scale (there is no way I can do this–I believe I can do this)	Total score; ranging from 9 to 27	NR
18. Healthy Eating and Physical Activity Behavior Recall Questionnaire for Children (HEPABRQ-C) [38]	Assess recall of healthy eating and PA	Upper elementary school children	Child [a]	10	Combination of closed and open questions	Total score; ranging from 0 to 21	NR
19. Eating Behavior Questionnaire for School Children [39]	Assess eating behaviours	School children	Child [a]	23	5-point Likert scale (never-always)	Subscore per domain	NR

Table 1. ***Continued***

Tool Name	Tool Aim	Target Population	Adminis-tered by	Number of Items	Item Response Format	Tool Scoring	Prospect of Action
20. Tool by Drouin and Winickoff [40]	Assess health-related behavioural risk factors	Children aged 0–18 y	Parent [b]	3	Closed questions	No score	Parents receive a handout with information about identified risk factors Health care professionals receive the survey results and an evidence-based suggested course of action
21. Child Nutrition and Physical Activity (CNPA) Screening Tool [41]	Assess behaviours that increase the risk of obesity	Children aged 2–18 y	Parent [a,b]	22	4-point Likert scale and open questions	Subscores for generated readiness to change and perception factors only	Tool provides health care professionals means to start the conversation about a healthy lifestyle with parents
22. Electronic Kids Dietary Index (E-KINDEX) [42]	Assess food habits, dietary beliefs and practices related to obesity	Children	Child [a] parent [b] or health care professional [b]	30	Likert-type scale (varying)	Subscale scores and total score; ranging from 1 to 87	In clinical practice, the score can be used as visual educational tool, provide continuous feedback and

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Table 1. *Continued*

Tool Name	Tool Aim	Target Population	Adminis-tered by	Number of Items	Item Response Format	Tool Scoring	Prospect of Action
							individual items may be used as specific goals for obesity status improvement
23. Family Health Behavior Scale (FHBS) [43]	Assess family eating and PA habits related to obesity	Children	Parent [a,b]	27	5-point Likert scale (never-nearly always)	Subscale scores and total score	NR
24. Family Nutrition and Physical Activity (FNPA) screening tool [44,45]	Assess risk factors for overweight/obesity in the home environment	Children	Parent [a,b]	20	4-point Likert scale (never-always)	Subscore per domain and total score	Korean version: based on scores, interventions such as counselling and education should be developed and provided
25. HABITS questionnaire [46]	Assess weight-related behaviours and intervention targets	Children	Child [a]	19	Likert-type scale (varying)	Subscale scores	Tool can establish a dialogue about weight-related lifestyle behaviours between health care professional and families

Table 1. ***Continued***

Tool Name	Tool Aim	Target Population	Adminis-tered by	Number of Items	Item Response Format	Tool Scoring	Prospect of Action
26. Healthy Living for Kids Survey (HLKS) [47]	Assess healthy lifestyle perceptions and behaviours	Children	Child [a]	59	Likert-type scale (varying)	Subscale scores and total score	Education of parents and children to redress inaccurate perceptions of a healthy lifestyle
27. HeartSmartKids (HSK) [48] (HeartSmartKids, LLC, Boulder, US)	Assess lifestyle habits to guide behaviour change counselling	Children	Child [a]	21	Likert-type scale (varying)	NR	Patient-specific education handouts with lifestyle recommenda-tions are generated
28. Home Self-Administered Tool for Environmental Assessment of Activity and Diet (HomeSTEAD) [49]	Assess home environment factors related to children's diet and PA	Children	Parent [a]	86	5-point Likert scale	Subscale scores	Promotion of healthy feeding practices
29. Lifestyle Behavior Checklist (LBC) [50,51]	Assess parental perceptions and self-efficacy in managing problems related child eating, activity and weight issues	Children with obesity	Parent [a]	25	Combination of closed and open questions	Subscale scores	NR
30. Pediatric Adapted Liking Survey (PALS) [52]	Assess dietary behaviours linked to caries and obesity risk	Children	Parent [b]	33	Horizontal visual 5-point Likert scale, (hates it–loves it)	Subscore per domain; ranging from −100 to +100	Tailored motivational diet-related messages for dental caries and obesity prevention

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Table 1. ***Continued***

Tool Name	Tool Aim	Target Population	Adminis-tered by	Number of Items	Item Response Format	Tool Scoring	Prospect of Action
31. Short-Form, Multicomponent Dietary Questionnaire (SF-FFQ4PolishChildren) [53]	Assess dietary and lifestyle behaviours	Children	Child [a] or parent [b]	44	Likert-type scale (varying)	Subscore per domain Cut-offs for low, moderate and high subscores	NR
32. Tool by Hendrie et al. [54]	Assess family activity environment	Children	Parent [a]	25	5-point Likert scales (strongly disagree–strongly agree)	NR	NR
33. Tool by Huang et al. [55]	Assess correlates of PA and screen time behaviours	Children	Child [a] and parent a,b	46	Likert-type scale (varying)	NR	NR
34. Adolescent Lifestyle Profile (ALP) [56,57]	Assess health-promoting behaviours	Adolescents	Child [a]	42	4-point Likert scale (never-routinely)	Total score; ranging from 42 to 168	NR
35. Childhood Family Mealtime Questionnaire (CFMQ) (reduced) [58]	Assess mealtime environment	Adolescents	Child [a]	22	5-point Likert scale (never–always)	NR	NR
36. Diet–Lifestyle Index [59]	Assess nutrition and lifestyle quality related to overweight and obesity	Adolescents	Child [a]	13	Likert-type scale (varying)	Total score; ranging from 11 to 57	NR
37. Shortened Health-Promoting Lifestyle Profile (HPLP) II [60]	Assess health-promoting behaviours	Adolescents	Child [a]	34	4-point Likert scale (never–routinely)	Subscale scores and total score	NR

Table 1. ***Continued***

Tool Name	Tool Aim	Target Population	Adminis-tered by	Number of Items	Item Response Format	Tool Scoring	Prospect of Action
38. Tool by Fernald et al. [61]	Assess health behaviour	Adolescents	Child [a]	16	NR	Total score; ranging from 0 to 3	NR
39. Tool by Hyun et al. [62]	Assess nutrition knowledge	Adolescents	Child [a]	20	2-point Likert scales (wrong–right)	Total score; ranging from 0 to 20	NR
40. Tool by Hyun et al. [62]	Assess dietary habits	Adolescents	Child [a]	9	5-point Likert scales (always–never)	Total score; ranging from 0 to 5	NR
41. VISA-TEEN [63]	Assess lifestyle	Adolescents	Child [a]	11	Combination of closed and open questions	Total score	NR

Note: Tools are sorted by target age. Abbreviations: NR, not reported; y, years. [a] Self-reported; [b] proxy-reported; [c] originally, 18 items were developed, but only 11 were validated.

Table 2. Addressed domains and items of lifestyle screening tools for children in the community setting.

Tool Name	Nutrition [a]	Physical Activity	Sedentary Behaviour/ Screen Time	Sleep	Hygiene	Environment	Other
1. NutricheQ [18–20]	√						
2. Toddler Feeding Questionnaire (TFQ) [b] [21]	√						
3. Toddler NutriSTEP [b] [22]	√		Duration of watching TV or using the computer				Growth adequacy, child's weight status
4. Toddler Dietary Questionnaire (TDQ) [23]	√						
5. Child Eating Behavior Questionnaire (CEBQ) [b] [24]	√						
6. Nutrition Screening Tool for Every Preschooler (NutriSTEP) [25–27]	√	Frequency of PA	Frequency and duration of watching TV, using computer and playing video games				Parental satisfaction of child's growth, child's weight status
7. Preschooler Dietary Questionnaire (PDQ) [b] [28]	√						
8. Preschoolers Diet–Lifestyle Index (PDL-index) [29]	√	Duration of moderate-to-vigorous PA	Duration of watching TV				
9. Healthy Kids [30]	√	Preference for playing over watching TV	Duration of watching TV and playing video or computer games	Bedtime			
10. Tool by Das and Ghosh [b] [31]	√						General knowledge on health and lifestyle

Table 2. *Continued*

Tool Name	Nutrition [a]	Physical Activity	Sedentary Behaviour/ Screen Time	Sleep	Hygiene	Environment	Other
11. Start the Conversation 4–12 (STC-4-12) [32]	√	Frequency and duration of sports, playing outside and being active, barriers and readiness to change regarding PA	Duration of screen time				
12. Healthy Families Survey [33]	√	Duration of PA, child sees parent being physically active	Duration of watching TV and using other screens, availability of TV in child's bedroom				
13. Knowledge, Attitudes and Habits (KAH-) questionnaire [34]	√	Frequency of playing active games, liking exercise, activities after school and during weekends, knowledge and attitudes towards PA	Activities after school and during weekends		Brushing teeth, washing hands, taking bath or shower		Knowledge, attitudes and habits regarding the human body and emotions
14. Parental Self-efficacy Questionnaire [35]	√	Confidence regarding child being physically active and playing outside	Confidence regarding limiting amount of screen time				
15. Tool by Chacko and Ganesan [36]	√						
16. Food, Health and Choices questionnaire (FHC-Q) [37]	√	Frequency of specific activities, medium PA and heavy PA	Frequency and duration of watching TV and playing video games				Self-determination, outcome expectations, self-efficacy, habit strength,

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Table 2. ***Continued***

Tool Name	Nutrition [a]	Physical Activity	Sedentary Behaviour/ Screen Time	Sleep	Hygiene	Environment	Other
							goal intention, knowledge and social desirability regarding a healthy lifestyle
17. Healthy Eating and Physical Activity Self-Efficacy Questionnaire for Children (HEPASEQ-C) [38]	√	Self-efficacy regarding PA					
18. Healthy Eating and Physical Activity Behavior Recall Questionnaire for Children (HEPABRQ-C) [38]	√	Duration of PA					
19. Eating Behavior Questionnaire for School Children [b] [39]	√				√ Not further specified	√ Not further specified	
20. Tool by Drouin and Winickoff [40]	√				Recent dental care visit		Tobacco smoke exposure
21. Child Nutrition and Physical Activity (CNPA) Screening Tool [41]	√	Frequency and duration of PA	Duration of media use, availability of media in child's bedroom				Perception, confidence and importance items on healthy choices
22. Electronic Kids Dietary Index (E-KINDEX) [42]	√						
23. Family Health Behavior Scale (FHBS) [43]	√	Duration of being physically active, PA with parents, playing					

Table 2. ***Continued***

Tool Name	Nutrition [a]	Physical Activity	Sedentary Behaviour/ Screen Time	Sleep	Hygiene	Environment	Other
		outside, doing sports, preferring indoor activities over outdoor activities, parental PA with child					
24. Family Nutrition and Physical Activity (FNPA) screening tool [b] [44,45]	√	Child's PA, family PA	Screen time behaviour and monitoring	Sleep duration		Healthy environment	
25. HABITS questionnaire [46]	√	Frequency of playing outside	Duration of watching TV				
26. Healthy Living for Kids Survey (HLKS) [b] [47]	√	Frequency and duration of 'hard', 'moderate' and 'mild' exercise, frequency of any activity to work up a sweat, self-efficacy for PA	Duration of screen time, number of TV shows/videos watched, self-efficacy for screen time				
27. HeartSmartKids (HSK) [b] [48] (HeartSmartKids, LLC, Boulder, US)	√	Duration of active play or sports	Duration of watching TV and using other screens	√ Not further specified			Anthropometric measures
28. Home Self-Administered Tool for Environmental Assessment of Activity and Diet (HomeSTEAD) [49]	√						
29. Lifestyle Behavior Checklist (LBC) [50,51]	√	Parental problems experiencing and confidence in dealing with child complaining about PA	Parental problem experience and confidence in dealing with child watching too much TV and playing				Parental problems experiencing and confidence in dealing

Table 2. ***Continued***

Tool Name	Nutri-tion [a]	Physical Activity	Sedentary Behaviour/ Screen Time	Sleep	Hygiene	Environment	Other
			too many computer games				with child complaining about problems related to obesity
30. Pediatric Adapted Liking Survey (PALS) [52]	√				Liking/ disliking of brushing teeth, taking a bath, getting dressed		
31. Short-Form, Multicomponent Dietary Questionnaire (SF-FFQ4PolishChildren) [b] [53]	√	Intensity of PA at school and leisure time	Duration of screen time				Family affluence, height, weight
32. Tool by Hendrie et al. [54]	√	Parental PA involvement, parental opportunity for PA role modelling, parental support of PA	Parental opportunity for screen time role modelling			See domain PA	
33. Tool by Huang et al. [55]	√	Child's self-efficacy regarding PA, home PA environment, sports facilities in neighbourhood, family and peer support for PA	Child's perceived enjoyment of screen-based behaviours with parents, parental role modelling regarding screen time, rules and guidance on screen-based behaviours, availability of electronic screens			Child's perceived neighbourhood safety, social environment in neighbourhood	

Table 2. ***Continued***

Tool Name	Nutrition [a]	Physical Activity	Sedentary Behaviour/ Screen Time	Sleep	Hygiene	Environment	Other
34. Adolescent Lifestyle Profile (ALP) [b] [56,57]	√	At least: frequency and duration of vigorous PA, playing active games with friends					Health responsibility, interpersonal relations, stress management, personal growth
35. Childhood Family Mealtime Questionnaire (CFMQ) (reduced) [58]	√						
36. Diet–Lifestyle Index [59]	√	Duration of extracurricular sport activities	Duration of watching TV and playing electronic games				Obesity status of parents
37. Shortened Health-Promoting Lifestyle Profile (HPLP) II [b] [60]	√	Not further specified					Health responsibility, stress management
38. Tool by Fernald et al. [61] [b]	√	At least: frequency and duration of PA	Duration of watching TV				Alcohol use, smoking
39. Tool by Hyun et al. [62]	√						
40. Tool by Hyun et al. [62]	√						
41. VISA-TEEN [63]	√	Duration of moderate and intense PA	Duration of using internet or gaming	Sleep duration	Frequency of brushing teeth and washing hands		Amount of cigarettes smoked, frequency of consuming alcohol and using drugs

Note: Tools are sorted by target age. [a] Details on nutrition items are demonstrated in Table 3; [b] Specific items of screening tool not fully described.

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Table 3. Addressed nutrition items of lifestyle screening tools for children in the community setting..

Tool Name	Consumption of Food Groups	Dietary Habits	Psychological Factors Associated with Nutrition	Other
1. NutricheQ [18–20]	Vegetables, fruits, milk, dairy products, sweetened beverages, fortified cereals, red meat instead of oily or dark fish, fast food, unhealthy snacks			Age moving to cow's milk, avoiding foods due to allergy or intolerance
2. Toddler Feeding Questionnaire (TFQ) a [21]		Parental indulgent and authoritative practices, not further specified		Food environment-related, not further specified
3. Toddler NutriSTEP a [22]	Vegetables and fruits, flavoured beverages, dairy and substitutes, grains, meat and alternatives, fast food	Eating while watching TV, eating episodes per day, child feeds him- or herself, drinking from bottle with a nipple		Food is expensive, problems with chewing or swallowing when eating, being hungry at mealtimes, child controls amount consumed
4. Toddler Dietary Questionnaire (TDQ) [23]	Vegetables, fruits, dairy, milk beverages, non-milk beverages, grains, white versus non-white bread, meat products, lean red meat, fish, hot potato products, snack products, sweet snacks, spreadable fats, vegemite-type spreads			
5. Child Eating Behavior Questionnaire (CEBQ) a [24]		Food fussiness, emotional overeating, emotional undereating, satiety responsiveness, slowness in eating, desire to drink, food responsiveness	Enjoyment of food	

Table 3. ***Continued***.

Tool Name	Consumption of Food Groups	Dietary Habits	Psychological Factors Associated with Nutrition	Other
6. Nutrition Screening Tool for Every Preschooler (NutriSTEP) [25–27]	Vegetables, fruits, dairy, grain products, meat or fish or poultry or alternatives, fast food, supplements	Eating while watching TV, eating episodes per day		Difficulty buying food because of costs, problems with chewing, swallowing, gagging or choking when eating, not hungry because of drinking all day, parental control of amount consumed
7. Preschooler Dietary Questionnaire (PDQ) [a] [28]	Vegetables, fruits, dairy, milk beverages, non-milk beverages, grains, white versus non-white bread, meat products, lean red meat, fish, hot potato products, snack products, sweet snacks, spreadable fats, vegemite-type spreads			
8. Preschoolers Diet–Lifestyle Index (PDL-index) [29]	Vegetables, fruits, sweets, dairy products, grains, red meat (products), white meat and legumes, fish and seafood, unsaturated fats			
9. Healthy Kids [30]	Vegetables, fruits, sugar-sweetened beverages, dairy, unhealthy snacks	Parent and child eating together, removing fat from meat		
10. Tool by Das and Ghosh [a] [31]				Knowledge on healthy dietary habits, nutrients and child nutrition practice
11. Start the Conversation 4–12 (STC-4-12) [32]	Vegetables and fruits, sugar-sweetened beverages, milk type, unhealthy snacks, fast food		Barriers and readiness to change regarding healthy eating	

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Table 3. ***Continued***.

Tool Name	Consumption of Food Groups	Dietary Habits	Psychological Factors Associated with Nutrition	Other
12. Healthy Families Survey [33]	Vegetables, fruits, sugar-sweetened beverages, healthy snacks, unhealthy snacks	Eating out, parent and child eating together, picky eating		Parental modelling and parent–child interactions regarding healthy eating, parental food resource management and shopping behaviours
13. Knowledge, Attitudes and Habits (KAH-) questionnaire [34]	Vegetables, fruits, pastries	Consuming breakfast, lunch and dinner, having mid-morning snack, trying new foods	Attitudes towards healthy and unhealthy eating	
14. Parental Self-efficacy Questionnaire [35]			Confidence regarding intake of vegetables, fruits, fruit juice, sugary drinks, sweets, dairy, grains, meat and alternatives, sodium, fats and eating out, eating together, child making healthy choices	Knowledge on healthy and unhealthy eating
15. Tool by Chacko and Ganesan [36]	Vegetables, green leafy vegetables, fruit, cereals, pulses and dahl and non-vegetarian food, milk and coffee and tea and flavoured milk and curd, junk food, food from street shops	Mid-morning and evening snack, meal skipping		
16. Food, Health and Choices questionnaire (FHC-Q) [37]	Vegetables, fruits, sugar-sweetened beverages, processed packaged snacks, fast food		Self-determination, outcome expectations, self-efficacy, habit strength, goal intention, knowledge and social desirability regarding a healthy diet	

Table 3. ***Continued***.

Tool Name	Consumption of Food Groups	Dietary Habits	Psychological Factors Associated with Nutrition	Other
17. Healthy Eating and Physical Activity Self-Efficacy Questionnaire for Children (HEPASEQ-C) [38]			Self-efficacy to adhere to recommendations and to choose the healthy option when in temptation	
18. Healthy Eating and Physical Activity Behavior Recall Questionnaire for Children (HEPABRQ-C) [38]	Vegetables, number of colours of vegetables, fruits, soda pop, dairy, healthy snacks	Choosing the healthy option when eating out		
19. Eating Behavior Questionnaire for School Children [a] [39]		Food responsiveness, meal timings, eating problems, meal preparation		
20. Tool by Drouin and Winickoff [40]	Sugar-sweetened beverages			
21. Child Nutrition and Physical Activity (CNPA) Screening Tool [41]	Vegetables, fruits, sugar-sweetened beverages, milk, milk type, fast food	Consuming breakfast, dinner eaten with adult	Perception, confidence and importance items on a healthy diet	
22. Electronic Kids Dietary Index (E-KINDEX) [42]	Vegetables, fruits and fruit juices, sweets and junk food, soft drinks, milk, bread, cereals and grain foods, meat, salted and smoked meat food, fish and seafood, legumes, fried food, grilled food	Consuming breakfast, number of main meals and snacks, eating in fast food restaurants or other eating places, eating with family, eating alone, eating of healthy food, eating meals in afternoon school, eating foods because they are advertised, eating whatever food is prepared at home, parental insistence to eat all	Beliefs and attitudes regarding an (un)healthy diet, weight, dieting	

Table 3. *Continued*.

Tool Name	Consumption of Food Groups	Dietary Habits	Psychological Factors Associated with Nutrition	Other
		the food, eating when not hungry		
23. Family Health Behavior Scale (FHBS) [43]		Consuming breakfast, eating three meals a day, eating at table, staying seated at the table, eating at a routine time, asking for unhealthy snacks, eating when bored, emotional eating, eating frequently, sneaking of food	Being influenced to eat or offered unhealthy foods by others	Choices and teaching on healthy foods by parents
24. Family Nutrition and Physical Activity (FNPA) screening tool [a] [44,45]	Food choices, beverage choices	Family eating patterns, family eating habits	Restriction/rewarding	
25. HABITS questionnaire [46]	Vegetables, fruits, fruit juice, sugar-sweetened beverages, milk, water, fast food meals, unhealthy snacks	Eating while watching TV, eating three meals a day, eating extra meals or snacks		
26. Healthy Living for Kids Survey (HLKS) a [47]	Vegetables, fruits, low fat milk, whole wheat bread		Self-efficacy and nutritional intention for healthy eating	
27. HeartSmartKids (HSK) a [48] (HeartSmartKids, LLC, Boulder, US)	At least: vegetables and fruits, sugar-sweetened beverages (incl. juice), milk, unhealthy snacks	At least: consuming breakfast, eating at restaurants, eating while watching TV		
28. Home Self-Administered Tool for Environmental Assessment of Activity and Diet (HomeSTEAD) [49]		Parent and child eating together at table, eating while TV is on	Parental autonomy support, atmosphere during meals	Parental control and limit setting, eating area decoration

Table 3. ***Continued***.

Tool Name	Consumption of Food Groups	Dietary Habits	Psychological Factors Associated with Nutrition	Other
29. Lifestyle Behavior Checklist (LBC) [50,51]			Parental problems experiencing and confidence in dealing with child's eating habits (e.g., eats too quickly, yells about food, hides food)	
30. Pediatric Adapted Liking Survey (PALS) [52]	[b] Vegetables, fruits, sugar-sweetened beverages, dairy, meat, fish, beans, peanut butter, unhealthy snacks (sweet, salty and fat)			
31. Short-Form, Multicomponent Dietary Questionnaire (SF-FFQ4PolishChildren) [a] [53]	Vegetables, fruits, sugar-sweetened beverages, energy drinks, juices, sweets, dairy, fish, fast food	Breakfast consumption, frequency of having two meals per day		Nutrition knowledge
34. Adolescent Lifestyle Profile (ALP) [a] [56,57]	At least: vegetables, fruits, sweets, low fat dairy, chicken or fish instead of beef	At least: consuming breakfast		
35. Childhood Family Mealtime Questionnaire (CFMQ) (reduced) [58]		Mealtime structure, mealtime communication	Family mealtime stress	Appearance weight control
36. Diet–Lifestyle Index [59]	Vegetables, fruits, sweets and added sugars, dairy type, wholegrain, breakfast cereals	Consuming breakfast, eating foods not prepared at home, eating episodes per day, removing visible fat from meat/poultry		
37. Shortened Health-Promoting Lifestyle Profile (HPLP) II a [60]	NR	NR	NR	NR
38. Tool by Fernald et al. [a] [61]	At least: vegetables, fruits			

Table 3. ***Continued*****.**

Tool Name	Consumption of Food Groups	Dietary Habits	Psychological Factors Associated with Nutrition	Other
39. Tool by Hyun et al. [62]				Nutrition knowledge, including general knowledge and knowledge regarding food composition, nutrients and diseases
40. Tool by Hyun et al. [62]	Vegetables, green and orange vegetables, seaweed, fruits, dairy, meat and fish and egg and beans	Consuming breakfast, eating adequate amounts, combining food groups at each meal		
41. VISA-TEEN [63]	Vegetables and fruit, soft drinks, dairy, grains and potatoes, red meats, chicken and fish and eggs, butter and sweets, liquid excluding soft drinks			

Notes: Tools are sorted by target age. We numbered the tools in Table 3 as in Table 1. As tool number 32 and 33 do not describe nutrition items, they have been omitted from Table 3. [a] Specific items of screening tool not fully described; [b] liking/disliking of food items is used as proxy for intake

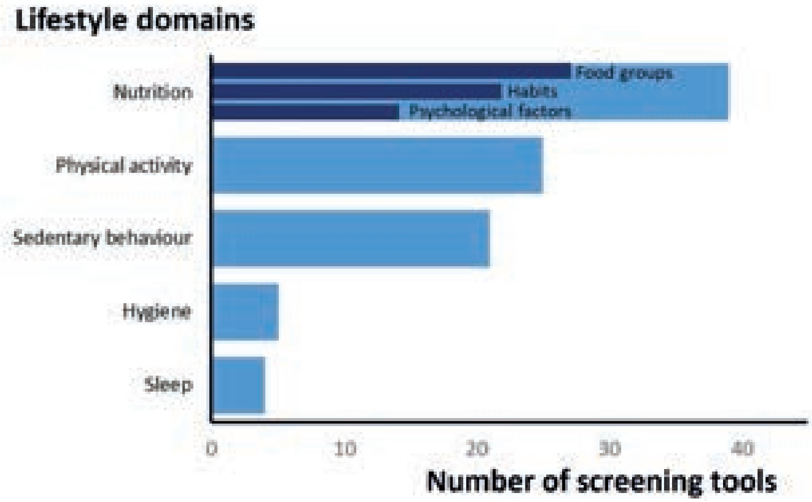

Figure 2. Prevalence of most frequently covered domains. N.B. The total number of covered do-mains exceeds the number of screening tools (n = 41) since most tools covered multiple do-mains.

Psychometric Properties

Table 4 demonstrates the validity and reliability outcomes of the included screening tools as illustrated by the different studies. For a total of 39 tools, psychometric properties were evaluated, whereas for two tools [36,61] they were not. The median sample size of the studies showing psychometric properties comprised 277 participants (IQR: 145, 486). Regarding reliability, Cronbach's β as a measure of internal consistency, and the intraclass correlation coefficient (ICC), considering test–retest reliability, were assessed for 24 and 11 tools, respectively. Other measures of test–retest reliability, such as Cohen's kappa (β n = 4), Pearson's correlation coefficient (r, n = 4) and Spearman's rho (β n = 2), were less evaluated. In general, internal consistency was moderate [64], but due to heterogeneity in the assessed concepts and tool aims, comparison between studies was not appropriate. Test–retest reliability was also highly variable, with eight tools clearly reaching cut-offs for 'sufficiency' based on ICC or β [22,23,25,26,28,31,52,55,63,65]. Regarding validity, features of criterion validity were determined mostly. Criterion validity included sensitivity and specificity (n = 6, e.g., to detect nutritional risk or obesity) as well as concurrent validity (n = 31, e.g., association of tool score with body mass index (BMI)). Predictive validity was not assessed for any tool. Specifically, the 'NutricheQ' was tested for sensitivity, specificity, associations with food group intake and nutrient intake based on a 4-day weighed food diary, and associations with BMI z-scores [18–20]. The other screening tools were validated less extensively, usually comprising only one dimension of validity.

Table 4. Psychometric properties of lifestyle screening tools for children in the community setting.

Tool Name	Country	Sample Size	Age	Reliability	Criterion Validity
1. NutricheQ	Ireland [18]	*N* = 371	1–3 y	Internal consistency, α = 0.50	Total score was associated with (4-day weighted food diary) intakes of fruits, vegetables, protein, dietary fibre, non-milk sugars, iron, vitamin D, zinc, calcium, riboflavin, niacin, folate, thiamine, phosphorous, potassium, carotene and retinol (r = −0.390–0.119, p < 0.05) A score > 4 (AUC = 76%) identified moderate risk with sensitivity = 83% and specificity = 48% A score > 8 (AUC = 85%) identified high risk with sensitivity = 70% and specificity =80%
	Italy [19]	*N* = 201	1–3 y	Internal consistency, α = 0.83 for Section 1 and α = 0.70 for Section 2 ICC = 0.73 (95% CI [0.40, 0.89], p = 0.0002) for Section 1 and ICC = 0.55 (95% CI [0.13, 0.81], p = 0.0074) for Section 2	In Section 1, a score ≥ 4 identified toddlers with a poor iron intake (AUC = 0.678, p = 0.001) and a score of ≥ 2 identified toddlers exceeding the En% protein intake (AUC = 0.6024, p = 0.009). In Section 2, a score of ≥ 3 identified toddlers with poor fibre intake (AUC = 0.7028, p < 0.0001)
	Lebanon [20]	*N* = 467	1–3 y		Total score was associated with age and BMI (r = 0.11, p = 0.021 (for both)), and with fat (**ρ** = 0.148, p = 0.039) and fibre (**ρ** = −0.137, p = 0.031) intake AUC = 0.457 for correctly classifying toddlers into the high risk group based on their BMI z-score

Table 4. ***Continued***

Tool Name	Country	Sample Size	Age	Reliability	Criterion Validity
2. Toddler Feeding Questionnaire (TFQ) [21]	United States	*N* = 629	3–5 y	Internal consistency, α = 0.66 for indulgent subscale, α = 0.65 for authoritative subscale, α = 0.48 for environmental subscale	Indulgent subscale scores were correlated with the HEI-2010 (ρ = −0.22, p < 0.001), kcal/d (ρ = 0.11, p = 0.011), grams of fat/day (ρ = 0.12, p = 0.008), servings of vegetables (ρ = −0.11, p = 0.01), servings of desserts (ρ = 0.13, p = 0.002) and servings of sugary drinks (ρ = 0.23, p < .001) Authoritative subscale scores were correlated with the HEI-2010 (ρ = 0.15, p < 0.001), servings of vegetables (ρ = 0.11, p = 0.011), servings of desserts (ρ = −0.15, p < 0.001) and servings of sugary drinks (ρ = − 0.09, p < 0.039) Environmental subscale scores were correlated with HEI-2010 (ρ = − 0.12, p = 0.004), kcals/day (ρ = 0.12, p = 0.007), grams of fat/day (ρ = 0.14, p = 0.001), servings of desserts (ρ = 0.13, p = 0.003) and servings of sugary drinks (ρ = 0.22, p < .001)
3. Toddler NutriSTEP [22]	Canada	*N* = 200	18–35 m	ICC = 0.951 (p < 0.001)	Total score was associated with dietician risk score (ρ = 0.67, p < 0.000) A score ≥ 21 identified moderate risk with sensitivity = 86% and specificity = 61% A score ≥ 26 identified high risk with sensitivity = 95% and specificity = 63%
4. Toddler Dietary Questionnaire (TDQ) [23]	Australia	*N* = 111	12–36 m	Total score ICC = 0.90 (p < 0.001) All children were classified into the same (n = 83, 75 %) or adjacent (n = 28, 25	Total score and food frequency questionnaire risk score were associated (r = 0.71, p < 0.001) Classification analysis between

Table 4. ***Continued***

Tool Name	Country	Sample Size	Age	Reliability	Criterion Validity
				%) dietary risk category during each administration Test–retest reliability for individual items, κ_w = 0.40–0.78	the TDQ and food frequency questionnaire revealed that all the participants were classified into the same (n = 88, 79 %) or adjacent (n = 23, 21 %) dietary risk category
5. Child Eating Behavior Questionnaire (CEBQ) [24]	Sweden	*N* = 1271	3–8 y	Internal consistency: α = 0.73	NR
6. Nutrition Screening Tool for Every Preschooler (NutriSTEP)	Canada [25]	*N* = 269	3–5 y	Total score ICC = 0.89 (95% CI [0.85, 0.92], p < 0.001) Test–retest reliability for individual items, κ = 0.39–1.0	Total score was associated with dietician risk rating (r = 0.48, p = 0.01) A score > 20 identified moderate risk with sensitivity = 53% and specificity = 79% A score > 25 identified high risk with sensitivity = 84% and specificity = 46%
	Canada [26]	*N* = 63 for internet use *N* = 64 for onscreen use	3–5 y	Internet use total score ICC = 0.91 (95% CI [0.90, 0.96]) Onscreen use total score ICC = 0.91 (95% CI [0.85, 0.95]) Test–retest reliability among risk categories, κ = 0.58 (p = 0.000) for internet use and κ = 0.50 (p = 0.000) for onscreen use	NR
	Iran [27]	*N* = 192	4–6 y	Test–retest reliability, r = 0.68 (p < 0.001)	Total score was associated with nutritionist risk score (r = 0.23, p = 0.003) and with healthy eating index (r = −0.16, p = 0.03) A score > 27 identified moderate risk with sensitivity = 41.7% and specificity = 85.7% A score > 31 identified high risk with sensitivity = 38.9% and specificity = 84.4%

Table 4. ***Continued***

Tool Name	Country	Sample Size	Age	Reliability	Criterion Validity
7. Preschooler Dietary Questionnaire (PDQ) [28]	Australia	*N* = 74	3–5 y	Total score ICC = 0.87 (95% CI [0.07, 2.95], p = 0.040)	Total score and food frequency questionnaire risk score were associated (r = 0.85, p = 0.009) PDQ scores were associated with the number of people per household (ρ = −0.32, 95% CI [−6.69, −0.59], p = 0.020), but not BMI z-score (ρ = −0.09, 95% CI [−0.02, −0.04], p = 0.512)
8. Preschoolers Diet–Lifestyle Index (PDL-index) [29]	Greece	*N* = 2287	2–5 y	NR	A 1/44 unit score increase was associated with an OR for obesity of 0.95 (95% CI [0.92, 0.98]) and an OR of 0.97 (95% CI [0.95, 0.99]) for overweight/obesity Correct classification rate for obesity = 85%, for overweight/obesity = 67% Sensitivity for obesity = 60%, for overweight/obesity =55% Specificity for obesity and overweight/obesity = 52%
9. Healthy Kids [30]	United States	*N* = 133	2–5 y	Internal consistency, α = 0.76 Test–retest reliability coefficient = 0.74 (p ≤ 0.01)	The Healthy Kids scale score was inversely associated with BMI percentiles (p = 0.02)
10. Tool by Das and Ghosh [31]	India	*N* = 134	3–6 y	Internal consistency, α = 0.87 Total score ICC = 0.77 (p <0.01)	NR
11. Start the Conversation 4–12 (STC-4-12) [32]	United States	*N* = 115	4–12 y	NR	Three of five queried dietary barriers were found to be significantly associated with at least one healthy eating behaviour Four of five queried barriers to PA were significantly associated with at least one PA-related behaviour

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Table 4. ***Continued***

Tool Name	Country	Sample Size	Age	Reliability	Criterion Validity
12. Healthy Families Survey [33]	United States	*N* = 1376	6–11 y	Internal consistency for subscales, $\alpha = 0.51–0.77$	NR
13. Knowledge, Attitudes and Habits (KAH-) questionnaire [34]	Spain	*N* = 295	6–7 y	Internal consistency, $\alpha = 0.79$	NR
14. Parental Self-efficacy Questionnaire [35]	United States	*N* = 146	6–11 y	Internal consistency, $\alpha = 0.94$ Test–retest reliability, $r = 0.94$ ($p < 0.001$)	NR
15. Tool by Chacko and Ganesan [36]	India	NR	6–17 y	NR	NR
16. Food, Health and Choices questionnaire (FHC-Q) [37]	United States	*N* = 221	9–11 y	Internal consistency: $\alpha = 0.77–0.92$ for behaviour scales and $\alpha = 0.44–0.83$ for psychosocial scales ICC = 0.59–0.81 for behaviours ($p < 0.001$) and ICC = 0.51–0.68 for continuous psychosocial determinants ($p < 0.05$)	Correlation coefficients between the FHC-Q and reference questionnaires were all statistically significant ($p < 0.01$)
17. Healthy Eating and Physical Activity Self-Efficacy Questionnaire for Children (HEPASEQ-C) [38]	United States	*N* = 492	9–13 y	Internal consistency, $\alpha = 0.75$	HEPASEQ-C was significantly correlated with HEPABRQ-C, $r = 0.50$ ($p = 0.000$)
18. Healthy Eating and Physical Activity Behavior Recall Questionnaire for Children (HEPABRQ-C) [38]	United States	*N* = 492	9–13 y	NR	HEPABRQ-C was significantly correlated with HEPASEQ-C , $r = 0.50$ ($p = 0.000$)
19. Eating Behavior Questionnaire for School Children [39]	India	*N* = 462	10–12 y	NR	No correlation between tool subscores and anthropometric measures (exact numerical data NR)

Table 4. ***Continued***

Tool Name	Country	Sample Size	Age	Reliability	Criterion Validity
20. Tool by Drouin and Winickoff [40]	United States	*N* = 626	0–18 y	NR	Parents receiving the tool were not more likely to receive counselling or service delivery by clinicians than participants not screened No statistical difference in the proportion of parents reporting having taken steps towards correcting the behaviour in the parents that received the screening after one month follow-up
21. Child Nutrition and Physical Activity (CNPA) Screening Tool [41]	United States	*N* = 2230	2–18 y	Internal consistency: α = 'low', exact value NR	Both generated readiness to change and perception subscores were associated with weight status categories ($p < 0.001$)
22. Electronic Kids Dietary Index (E-KINDEX) [42]	Greece	*N* = 622	9–13 y	Internal consistency: α = 0.60	Each 1 SD (i.e., 7.81 points) score increase was associated with a 2.31 ± 0.23 kg/m2 decrease in BMI ($p < 0.001$), a 2.23 ± 0.35 decrease in calculated % body fat ($p < 0.001$) and a 2.16 ± 0.61 cm decrease in waist circumference ($p < 0.001$) Correct classification rate for excess body fat was 84% (95% CI [0.74, 0.94]) Sensitivity for overweight/obesity versus normal weight = 74%, for obesity versus normal weight/ overweight = 61% Specificity for overweight/obesity versus normal weight = 46%, for obesity versus normal weight/ overweight = 79%

Table 4. ***Continued***

Tool Name	Country	Sample Size	Age	Reliability	Criterion Validity
23. Family Health Behavior Scale (FHBS) [43]	United States	*N* = 233	5–12 y	Internal consistency: $\alpha = 0.86$ Test-retest reliability coefficient = 0.85	FHBS was inversely associated with zBMI ($r = -0.28$, $p < 0.01$) Every unit increase was associated with an OR of 0.96 (95% CI [0.95, 0.99] for overweight/obesity ($p < 0.01$) Correct classification rate for weight classification = 63%
24. Family Nutrition and Physical Activity (FNPA) screening tool	United States [44]	*N* = 349	1st and 10th grade	NR	At both ages, the FNPA score was not significantly correlated with BMI% Only in first graders, scores in the lowest tertile were associated with higher odds for overweight/obesity compared to the highest tertile (OR = 2.49, 95% [CI 1.17, 5.31])
	United States [45]	*N* = 19	2–5 y	NR	NR
25. HABITS questionnaire [46]	United States	*N* = 35	7–16 y	Internal consistency, $\alpha = 0.61$ for dietary subscale and $\alpha = 0.59$ for PA/sedentary behaviour subscale Test-retest reliability, $\kappa = 0.27–0.78$ for individual items of dietary subscale and $\kappa = 0.29–0.48$ for PA/sedentary behaviour subscale As a whole, the dietary subscale and PA/sedentary behaviour subscales had test-retest reliabilities of $r = 0.94$ and $r = 0.87$, respectively	NR
26. Healthy Living for Kids Survey (HLKS) [47]	United States	*N* = 88	9–12 y	Internal consistency for subscales, $\alpha = 0.63–0.80$ Test-retest reliability for subscales: $r = 0.37–0.78$	NR

Table 4. ***Continued***

Tool Name	Country	Sample Size	Age	Reliability	Criterion Validity
27. HeartSmartKids (HSK) [48] (HeartSmartKids, LLC, Boulder, US)	United States	*N* = 103	9–14 y	Test-retest reliability, ρ = 0.38–0.78	Each item of the HSK was significantly correlated with the HABITS, ρ= 0.21–0.65 (p <0.05)
28. Home Self-Administered Tool for Environmental Assessment of Activity and Diet (HomeSTEAD) [49]	United States	*N* = 129	3–12 y	Internal consistency for subscales, α = 0.62–0.93 Subscale ICC = 0.57–0.89	No statistically significant correlation between factor composite scores and child BMI z-scores
29. Lifestyle Behavior Checklist (LBC)	Australia [50]	*N* = 182	4–11 y	Internal consistency, α = 0.97 for Problem scale and α = 0.92 for Confidence scale Test-retest reliability, ρ = 0.87 (p < 0.001) for Problem scale and ρ = 0.66 (p < 0.001) for Confidence scale	Correct classification rate for obesity was 91%
	The Netherlands [51]	*N* = 273	3–13 y	Internal consistency, α = 0.92 for Problem scale and α = 0.98 for Confidence scale Test-retest reliability, ρ = 0.74 (p < 0.001) for Problem scale and ρ = 0.70 (p < 0.001) for Confidence scale	Parents with healthy weight children scored lower on the Problem scale, F = 16.94 (p < 0.001), compared to those with overweight children The Problem scale was associated with nurturance (ρ = −0.23, p < 0.01), restrictiveness (ρ = 0.14, p < 0.05), psychological control (ρ = 0.19, p < 0.01) and BMI of child (ρ = 0.21, p < 0.01), mother (ρ = 0.23, p < 0.01) and father (ρ = 0.14, p < 0.05) The Confidence scale was associated with nurturance (ρ = 0.14, p < 0.05) and psychological control (ρ = −0.22, p < 0.01)
30. Pediatric Adapted Liking Survey (PALS) [52]	United States	*N* = 144	5–17 y	Internal consistency for subscales, α = 0.40–0.72 ICC for individual items = 0.79–0.91	In girls, higher BMI was associated with greater preference for fat/sweet/salty foods (ρ = 0.32, 95% CI [0.14, 1.15], p < 0.05)

Table 4. ***Continued***

Tool Name	Country	Sample Size	Age	Reliability	Criterion Validity
31. Short-Form, Multicomponent Dietary Questionnaire (SF-FFQ4PolishChildren) [53]	Poland	N = 437 children N = 630 adolescents	6–10 y 11–15 y	Test–retest reliability for consumption of food items and meals, κ = 0.46–0.81 in children, κ = 0.30–0.54 in adolescent's test–retest, and κ = 0.27–0.56 in adolescent's test and parent's retest Across study groups, test–retest reliability, κ = 0.31–0.72 for active/sedentary lifestyle items, κ = 0.55–0.93 for components of the Family Affluence Scale , κ = 0.64–0.67 for BMI categories, κ = 0.36 for the nutrition knowledge of adolescents and κ = 0.62 for the nutrition knowledge of children's parents	NR
32. Tool by Hendrie et al. [54]	Australia	N = 106	5–11 y	Internal consistency, α = 0.83	The family activity environment was associated with children's fruit and vegetable intake assessed with a 24-h recall ($r = 0.34$, $p < 0.01$), PA assessed by the Children's Leisure Activity Study Survey ($r = 0.27$, $p < 0.01$) and screen time ($r = -0.24$, $p < 0.05$) assessed by a survey
33. Tool by Huang et al. [55]	China	N = 303	9–14 y	Internal consistency for identified factors, α = 0.50–0.86 Identified factor ICC = 0.82–0.89	Self-efficacy ($r = 0.25$, $p < 0.05$), home physical activity environment ($r = 0.14$, $p < 0.05$) and peer support ($r = 0.25$, $p < 0.05$) were associated with child-reported moderate-to-vigorous PA Family support for PA was associated

Table 4. ***Continued***

Tool Name	Country	Sample Size	Age	Reliability	Criterion Validity
34. Adolescent Lifestyle Profile (ALP)	United States [56]	*N* = 207	10–15 y	Internal consistency: α = 0.91	with screen time (r = −0.22, p < 0.05) ALP correlated with hope (r = 0.60, p = 0.001), self-efficacy (r = 0.47, p = 0.001) and self-esteem (r = 0.35, p = 0.001) scores
	Portugal [57]	*N* = 236	12–18 y	Internal consistency: α = 0.87	NR
35. Childhood Family Mealtime Questionnaire (CFMQ) (reduced) [58]	United States	*N* = 280	11–15 y	Internal consistency for identified factors, α = 0.76–0.82	Childhood mealtime communication was associated with physically active days (ρ = 0.20, 95% CI [0.07, 0.32], p < 0.01), fruits and vegetable intake (ρ = 0.29, 95% CI [0.15, 0.45], p < 0.001) and added sugar intake (ρ = 0.23, 95% CI [0.09, 0.37], p < 0.001) Childhood mealtime stress was associated with fruits and vegetable intake (ρ = 0.26, 95% CI [0.08, 0.45], p < .01) and added sugar intake (ρ= 0.38, 95% CI [0.21, 0.57], p < 0.001)
36. Diet–Lifestyle Index [59]	Greece	*N* = 2008	12–17 y	NR	The Diet–Lifestyle Index was inversely associated with BMI in boys (ρ = −0.169, p < 0.001) and girls (ρ= −0.143, p < 0.001) An 11/57 unit score increase was associated with an OR of 0.93 (95% CI [0.90, 0.96]) for overweight/obesity (p < 0.001) Correct classification rate for BMI category = 83% Sensitivity for overweight/obesity = 66%, specificity = 50%
37. Shortened Health-Promoting Lifestyle Profile (HPLP) II [60]	Iran	*N* = 495	14–18 y	Internal consistency, α = 0.86	Total HPLP-II was associated with quality of life (r = 0.24, p< 0.001), self-efficacy (r = 0.48, p < 0.001) and demographic variables (data NR)

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Table 4. ***Continued***

Tool Name	Country	Sample Size	Age	Reliability	Criterion Validity
38. Tool by Fernald et al. [61]	United States	*N* = 227	Average 15 y	NR	NR
39. Tool by Hyun et al. [62]	Korea and China	*N* = 406	15–18 y	NR	Nutrition knowledge was associated with body shape satisfaction in Korean boys ($r = 0.208$, $p < 0.01$), not in Chinese boys
40. Tool by Hyun et al. [62]	Korea and China	*N* = 406	15–18 y	NR	Healthy dietary habits were associated with body shape satisfaction in Chinese boys ($r = 0.210$, $p < 0.01$), not in Korean boys
41. VISA-TEEN [63]	Spain	*N* = 419	13–19 y	Internal consistency, $\alpha = 0.66$ Total score ICC = 0.86 (95% CI [0.82, 0.89])	Total VISA-TEEN score was associated with KIDSCREEN-10 ($r = 0.21$, $p < 0.001$) and self-rated health ($p < 0.001$)

Note: Tools are sorted by target age. Abbreviations: y, years; ICC, intraclass correlation coefficient; NR, not reported; HEI-2010, Healthy Eating Index 2010.

Implementation

A total of 35 tools calculated a subscore and/or total score. Six tools defined score cut-offs for the identification of risk [18–20,22,23,25–28,53]. Eighteen tools provided some form of a prospect of action following the answers given. Two of these tools [32,40] based their prospects of action on highlighted topics, whereas the other sixteen based prospects of action on tool scores. None of the tools for adolescents provided a prospect of action. The prospects of action could be intended for the health care professional, child or parent. It included counselling, education, a combination of these two, initiating the conversation about a healthy lifestyle or referring to a specialist for further examination, and/or treatment. Articles on the 'NutriSTEP', 'Start the Conversation 4–12β 'tool by Drouin and Winickoff', 'HeartSmartKids' (HeartSmartKids, LLC, Boulder, US) and 'Pediatric Adapted Liking Survey' described that their prospects of action are tailored to the answers given, but details on them were lacking [25–27,32,40,48,52]. The 'NutricheQ' was advised to be administered during regular growth check-ups [18–20]. Other tools did not describe recommendations for administering occasion or frequency. Despite being developed for out-of-hospital use, the intended target location of administering the tools was merely suggested. When administration methods were reported, it involved paper (n = 15) or online (n = 10) formats. The 'NutriSTEP' paper version was expanded by an internet and onscreen version in response to the interest of health care professionals [26] and the 'Food, Health and Choices questionnaire' used an audience response system to decrease administer burden [37]. Others did not describe their motivation for the choice of administration methods.

5

Discussion

The 41 lifestyle screening tools for children included in this review varied widely in their design, but items on nutrition, PA and sedentary behaviour/screen time were commonly addressed. Nutrition items predominantly covered the intake of specific food groups, dietary habits and psychological factors, such as (parental) beliefs and attitudes towards a healthy lifestyle. For most tools, one or more aspects of reliability and/or validity had been studied with varying results. Nearly half of the screening tools offered prospects of action, but none described the exact follow-up actions based on tool outcomes. Moreover, other features of implementation were sparse.

Most tools evaluated lifestyle determinants related to overweight and obesity. Considering overweight, domains related to energy balance, i.e., nutrition, PA and sedentary behaviour, were frequently evaluated. Compared to PA and sedentary behaviour/screen time, which mainly concerned frequency and duration, there was more variety in nutrition items, which reflects the versatility of this topic. The tools not only addressed the in-take of foods directly related to energy intake, such as sugar-sweetened beverages and un-healthy snacks/fast food but also foods and dietary habits that might be more indirectly associated with weight status, such as fruits and vegetables, having breakfast and eating together at the table [66–68]. The concept of a balanced diet, characterised by adequate amounts and proportions of nutrients required for good health, is broader than energy balance alone. The 'NutricheQ' aimed to evaluate the risk of dietary imbalances in toddlers, with a particular focus on iron and vitamin D [18–20]. Next to iron and vitamin D, the total score of the 'NutricheQ' was associated with the intake of fruits, vegetables, protein, dietary fibre, non-milk sugars and other specific micronutrients [18], and its 18-item version score was also associated with BMI z-scores [20], indicating extensive dietary exploration. It could be proposed that screening tools addressing both dietary and energy balance may be most effective in screening for the risk of overall health problems, including overweight. This could for instance be conducted through the assessment of children's adherence to age-specific recommendations for commonly consumed food groups.

While there is emerging evidence on the importance of sleep on weight status and overall health [69,70], only four tools covered sleep. This finding accords with the results of Byrne et al., who conducted a systematic review on brief tools measuring obesity-related behaviours for children under five years of age [17]. Only two out of their twelve appraised tools covered sleep, indicating paucity [17]. Regarding the specific items on sleep, sleep duration was the most common in our results. A systematic review on sleep and childhood obesity supports the relevance of sleep duration on weight status but stated that associations with other dimensions, such as sleep quality and bedtime, need to be studied further [69]. The previous findings that shorter sleep duration in children is associated with unhealthy dietary habits and lower PA suggest a pathway from sleep deficiency to obesity and indicate that certain lifestyle behaviours might cluster in individuals [71,72].

The ten screening tools specifically developed for toddlers and preschoolers covered fewer domains than the tools for the other age groups; yet, all comprised nutrition. The early years of life form a critical window of opportunity for growth and development, in which proper nutrition is fundamental [1]. However, other lifestyle factors, such as PA, sedentary behaviour and sleep, have also been shown to affect health in toddlers and pre-schoolers [5–7]. An explanation for the lack of these domains in tools for toddlers and preschoolers might be that guidelines on these topics for this age group are not universally available. Howbeit, none of the reviewed articles clearly justified their choice of the exact items included. Depending on the aim of the lifestyle screening tool, it could be useful to base tool domains on clustering lifestyle behaviours in the target population to provide integrated follow-up advice. In addition, it might be valuable to study accurate indicators of an unhealthy lifestyle in advance. Furthermore, the accuracy of the questions should be optimized to obtain the desired information (e.g., the exact question to evaluate general vegetable intake).

In addition to lifestyle behaviours and habits, the included screening tools evaluated psychological factors related to lifestyle. Psychological factors, such as parental attitudes towards healthy eating and self-efficacy to adhere to recommendations, are important

[73]. On the one hand, these perceptions can imply certain behaviours. On the other, they can map motivation and perceived barriers for behaviour change. As children's lifestyle behaviour is highly reliant on parental support behaviours [74], it is helpful to evaluate parental perceptions regarding lifestyle. When health care professionals gain an insight into parental indicators of behaviour change, they obtain cues for motivational interviewing to help parents and children shifting towards a healthier lifestyle.

Although 39 out of 41 screening tools had undergone some form of psychometric testing, the results were inconclusive and hardly comparable due to high heterogeneity in tool aim and study design. However, a number of tools, such as the 'NutricheQ', 'NutriSTEP' and Lifestyle Behavior Checklist [18–20,25–27,50,51], have been researched more thoroughly than others and may therefore have a more solid foundation for use in practice. Becker et al. [14] concluded in their review that no nutrition screening tool for children in the community setting provided enough evidence for moderate to high validity and reliability [14]. As the reliability and validity influence the effectiveness of screening tools, assessing these psychometric properties is crucial. Nevertheless, the interpretation of group-level validity and reliability for individual counselling should be performed with prudence [75]. Proper psychometric assessment should also take into account differences in socioeconomic status and language and fill the current gap in testing predictive validity. The lack of a gold standard for screening children's lifestyle impairs the validity testing of new lifestyle screening tools. Nonetheless, studying the association of validated dietary assessment methods and activity trackers with items of lifestyle screening tools could assess criterion validity. In addition, longitudinal studies addressing a common outcome of an unhealthy lifestyle, such as overweight, and applying identical intervention strategies could study the effectiveness of a new tool over another one or over a health care professional's clinical view.

Eighteen tools provided recommendations for actions to be taken based on the answers given. Overall, these recommendations for both children and parents were as general as 'receiving tips' or health care professionals 'offering counselling' or 'referring to a specialist', and are therefore open to interpretation. Neither of the tools that identified cut-offs for particular risk classifications defined clear follow-up actions according to the classification. This is in contrast with established nutrition screening tools for hospitalised children, which offer specific action points per identified risk group [76–79]. Defining risk score cut-offs corresponding with unambiguous follow-up steps, such as 'no action required', 'discuss lifestyle with parents and repeat screening in X weeks' and 'initiate further examination by a specialist', might strengthen the effectiveness of lifestyle screening tools. Considering the various domains of lifestyle, integrating subscores and cut-offs for different domains could pinpoint the areas that need attention and guide health care professionals to address these specifically.

With this review, we have created a hitherto lacking overview of the literature. Searching for screening tools encompassing lifestyle in the broadest sense of the term made our search strategy comprehensive and enabled the inclusion of tools that evaluate a broad variety of lifestyle determinants. Our additional focus explicitly on nutrition highlighted the importance of this topic within children's lifestyle.

Not preselecting specific lifestyle factors (except nutrition) in our search strategy could also be considered a limitation, as we may have missed articles on screening tools that only denote specific determinants (e.g., PA and screen time), without framing them in the context of lifestyle in general. Moreover, we might have missed certain screening tools due to publication bias. Another important concern was the definition of screening tools, which we predefined in our protocol as tools that assign a certain value to behaviour and/or characteristics and/or offer prospects of action to an individual. The ascertainment of screening tools was performed in duplicate and independently, but the lack of a universal definition may have hampered the robustness of our methods. As this review was conducted to provide an overview of all recent literature on lifestyle screening tools for children in the community setting, regardless of methodological quality and tool outcome, we did not include a quality or risk of bias assessment. However, we expect that the limitations of this review have not altered the main conclusions and that we gained clear in-sights into existing lifestyle screening tools for children.

Ideally, a balance exists between the set of items retrieving as much information as possible and convenience by the person completing the tool. Considering the association between questionnaire length and response burden [80], future studies should target the optimal number of items relative to the aim of the screening tool. Moreover, addressing aspects of implementation of a screening tool might contribute to fulfilling the potential of its usage. For example, studies that explore the most effective administration method (e.g., paper format, online or mobile application), setting (e.g., at home or at a clinic) and target group of health care professionals handling the results of the screening tool could detect vital features in making the screening tool advantageous. Finally, it is crucial to validate current and new lifestyle screening tools to identify children at risk as early as possible.

Conclusions

This systematic review shows that a fair variety exists in lifestyle screening tools for children in the community setting. The majority addressed dietary and/or lifestyle behaviours and habits related to overweight and obesity. Domains that were mostly covered included nutrition, PA and sedentary behaviour/screen time. Tool validation was, however, limited, and the availability of unambiguous prospects of actions following tool outcomes was lacking. Considering the importance of a healthy lifestyle during childhood, there is a need for an easy-to-administer lifestyle screening tool for children with distinct follow-up actions in order to improve a child's lifestyle at an early age.

Supplemental Material

Supplementary File S1: Search strategy

All searches were performed on July 27, 2020.

Searches Lifestyle Tools

PubMed:

Search	Search terms	Number of hits
#1	"child"[mh] OR "infant"[mh] OR "adolescent"[mh] OR "pediatrics"[mh] OR child*[ti] OR infant*[ti] OR adolescent*[ti] OR pediatric*[ti] OR paediatric*[ti] OR toddler*[ti] OR preschool*[ti] OR youth*[ti]	3,777,091
#2	"Surveys and Questionnaires"[mj] OR "Mass Screening"[mj] OR screening[ti]	330,386
#3	"life style"[mj] OR lifestyle*[ti] OR life-style*[ti]	45,048
#4	#1 AND #2 AND #3	552
#5	#1 AND #2 AND #3 Filters: Humans, Dutch, English, from 2004 - 2020	404

Cinahl:

Search	Search terms	Number of hits
#1	MH "Child+" OR MH "Infant+" OR MH "Adolescence+" OR MH "Pediatrics+" OR TI(child* OR infant* OR adolescent* OR pediatric* OR paediatric* OR toddler* OR preschool* OR youth*)	1,090,303
#2	MM "Questionnaires+" OR MM "Surveys+" OR MM "Health Screening+" OR TI(screening)	97,764
#3	MM "Life Style+" OR TI(Lifestyle* OR Life-style*)	122,915
#4	#1 AND #2 AND #3	540
#5	#1 AND #2 AND #3 Filters: Humans, from 2004-2020	372

Embase:

Search	Search terms	Number of hits
#1	'child'/exp OR 'infant'/exp OR 'adolescent'/exp OR 'pediatrics'/exp OR child*:ti OR infant*:ti OR adolescent*:ti OR pediatric*:ti OR paediatric*:ti OR toddler*:ti OR preschool*:ti OR youth*:ti	4,022,363
#2	'questionnaire'/exp/mj OR 'health survey'/exp/mj OR 'survey'/exp/mj OR 'screening'/exp/mj OR screening:ti	377,246
#3	'lifestyle'/exp/mj OR lifestyle*:ti OR life-style*:ti	33,889
#4	#1 AND #2 AND #3	176
#5	#1 AND #2 AND #3 Filters: Humans, Dutch, English, from 2004 - 2020	123

5

Updates Becker et al. [13]

PubMed

Search	Search terms	Number of hits
#1	"nutritional risk"[Title/Abstract] OR "malnutrition risk"[Title/Abstract] OR "nutrient poor"[Title/Abstract] OR "dietary risk"[Title/Abstract] OR "child nutrition disorders/etiology"[MeSH Terms] OR "feeding and eating disorders of childhood/diagnosis"[MeSH Terms] OR "feeding and eating disorders of childhood/etiology"[MeSH Terms] OR "malnutrition/diagnosis"[MeSH Terms] OR "Nutrition Assessment"[MeSH Terms] OR "child nutrition disorders/diagnosis"[MeSH Terms] OR "Nutrition Assessment"[Title/Abstract] OR "nutrition diagnostic"[Title/Abstract] OR "nutrition diagnosis"[Title/Abstract] OR "nutrition screening"[Title/Abstract] OR "malnutrition assessment"[Title/Abstract] OR "malnutrition-inflammation score"[Title/Abstract] OR "Malnutrition/diagnosis"[Title/Abstract] OR "malnutrition diagnostic"[Title/Abstract] OR "malnutrition screening"[Title/Abstract] OR "nutritional assessment"[Title/Abstract] OR "nutritional diagnosis"[Title/Abstract] OR "nutritional screening"[Title/Abstract]	36,983
#2	"Child"[MeSH Terms] OR "Adolescent"[MeSH Terms] OR "Pediatrics"[MeSH Terms] OR "Child"[Title/Abstract] OR "children"[Title/Abstract] OR "Adolescent"[Title/Abstract] OR "adolescents"[Title/Abstract] OR "pediatric"[Title/Abstract] OR "paediatric"[Title/Abstract] OR "paediatrics"[Title/Abstract] OR "Pediatrics"[Title/Abstract] OR "infant"[Title/Abstract] OR "infants"[Title/Abstract]	3,737,556
#3	"reliability"[Title/Abstract] OR "sensitive"[Title/Abstract] OR "sensitivity"[Title/Abstract] OR "specific"[Title/Abstract] OR "specificity"[Title/Abstract] OR "validated"[Title/Abstract] OR "validation"[Title/Abstract] OR "validity"[Title/Abstract] OR "Sensitivity and Specificity"[MeSH Terms] OR "Reproducibility of Results"[MeSH Terms] OR "Reference Values"[MeSH Terms] OR "overall agreement"[Title/Abstract] OR "detected"[Title/Abstract] OR "correlated"[Title/Abstract]	6,062,749
#4	#1 AND #2 AND #3 NOT (animals[mh] NOT humans[mh]) AND English[la] AND 2017/01/01:2020/07/27[pdat]	558

Cinahl

Search	Search terms	Number of hits
#1	MH "Child Nutrition Disorders+" OR MH "Infant Nutrition Disorders/DI/ET" OR MH "Feeding and Eating Disorders of Childhood/DI/ET" OR MH "Malnutrition/DI/ET" OR MH "Nutritional Assessment"	18,495
#2	TI ((nutrition* or malnutrition or dietary) n1 (risk* or diagnos* or screen* or assessment*))	3,252
#3	TI (Nutrient* n1 poor)	28
#4	TI "malnutrition-inflammation score"	23
#5	AB ((nutrition* or malnutrition or dietary) n1 (risk* or diagnos* or screen* or assessment*))	7,003
#6	AB (Nutrient* n1 poor)	278
#7	AB "malnutrition-inflammation score"	75
#8	MH "Child+" OR MH "Infant+"	670,219
#9	TI (Child* OR adolescen* OR pediatric* OR paediatric* OR infant*)	467,626
#10	AB (Child* OR adolescen* OR pediatric* OR paediatric* OR infant*)	509,052
#11	MH "Reference Values" OR MH "Reproducibility of Results" OR MH "External Validity" OR MH "Reliability+" OR MH "Reliability and Validity+"	308,452
#12	TI (reliability OR sensitive OR sensitivity OR specific OR specificity OR validated OR validation OR validity)	99,472
#13	AB (reliability OR sensitive OR sensitivity OR specific OR specificity OR validated OR validation OR validity)	546,007
#14	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7	23,730
#15	#8 OR #9 OR #10	953,415
#16	#11 OR #12 OR #13	772,646
#17	#14 AND #15 AND #16 Filter: published between 2017-2020	381

Embase

Search	Search terms	Number of hits
#1	'child'/exp OR 'adolescent'/exp OR 'infant'/exp	3,724,335
#2	child*:ti,ab OR adolescen*:ti,ab OR pediatric*:ti,ab OR paediatric*:ti,ab OR infant*:ti,ab	2,568,360
#3	'sensitivity and specificity'/exp OR 'reproducibility'/exp OR 'reference value'/exp OR 'validity'/exp OR 'reliability'/exp	876,173
#4	reliability:ti,ab OR sensitive:ti,ab OR sensitivity:ti,ab OR specific:ti,ab OR specificity:ti,ab OR validated:ti,ab OR validation:ti,ab OR validity:ti,ab	5,340,083
#5	((nutrition* OR malnutrition OR dietary) NEAR/1 (risk* OR diagnos* OR screen* OR assessment*)):ti,ab	18,600
#6	(nutrient* NEAR/1 poor):ti,ab	1,769
#7	'malnutrition-inflammation score':ti,ab	325
#8	'nutritional assessment'/exp	30,493
#9	'nutritional status'/exp	67,730
#10	#1 OR #2	4,411,762
#11	#3 OR #4	5,691,695
#12	#5 OR #6 OR #7 OR #8 OR #9	98,617
#13	#10 AND #11 AND #12	5,197
#14	#13 AND [English]/lim AND [2017-2020]/py	1,425

Update Exploratory Systematic Search

PubMed

Search	Search terms	Number of hits
#1	"infant"[mh] OR "child"[mh] OR "adolescent"[mh] OR infant[tiab] OR infants[tiab] OR infanthood[tiab] OR preschool[tiab] OR preschooler[tiab] OR toddler[tiab] OR toddlers[tiab] OR toddlerhood[tiab] OR child[tiab] OR children[tiab] OR childhood[tiab] OR adolescent[tiab] OR adolescents[tiab] OR adolescent[tiab] OR adolescents[tiab] OR adolescence[tiab] OR teen[tiab] OR teens[tiab] OR teenager[tiab] OR teenagers[tiab] OR youth[tiab] OR youths[tiab]	4,003,592
#2	"malnutrition"[mh:noexp] OR "overnutrition"[mh:noexp] OR malnutrition[tiab] OR malnourished[tiab] OR malnourishment[tiab] OR malnutrition risk[tiab] OR undernutrition[tiab] OR overnutrition[tiab] OR dietary imbalance[tiab] OR dietary imbalances[tiab] OR nutrition imbalance[tiab] OR nutritional imbalance[tiab] OR nutrition imbalances[tiab] OR nutritional imbalances[tiab] OR nutrition risk[tiab] OR nutritional risk[tiab]	58,551
#3	"mass screening"[mh:noexp] OR "nutrition assessment"[mh] OR screening tool[tiab] OR screening tools[tiab] OR screening instrument[tiab] OR screening instruments[tiab] OR nutrition questionnaire[tiab] OR nutritional questionnaire[tiab] OR nutrition screening[tiab] OR nutritional screening[tiab] OR nutrition risk screening[tiab] OR nutritional risk screening[tiab] OR malnutrition risk screening [tiab] OR nutrition assessment[tiab] OR nutritional assessment[tiab] OR dietary assessment[tiab]	145,375
#4	#1 AND #2 AND #3 AND 2019/01/01:2020/07/27[pdat] Filters: Dutch, English, Humans	80

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Chapter 6

Perceived stress, family impact, and changes in physical and social daily life activities of children with chronic somatic conditions during the COVID-19 pandemic

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Abstract

Background: The COVID-19 pandemic has inevitably affected children and their families. This study examines the impact of the COVID-19 measures in children with chronic somatic conditions (CSC) and their parents and compares them with a Dutch general population sample.

Methods: We included a sample of children with CSC (0-18 years, n=326) and compared them with children (8-18 years, n=1,287) from the Dutch general population. Perceived stress, coping, social interaction with friends and family, physical activity, eating behavior, family support, parenting perception, and financial situation were assessed once with the self-reported and parent-reported COVID-19 child check questionnaire, between November 2020 and May 2021. Comparisons between the two samples were made by using t-tests and chi square tests.

Results: The proportion of children who reported being less physically active and having less social interaction with friends since the COVID-19 pandemic was higher in children with CSC than in children from the general population. Children with CSC and their parents experienced less stress than children and parents from the general population. Moreover, parents of children with CSC aged 0-7 years and parents of children aged 8-18 years from the general population experienced less support and more financial deterioration than parents of children with CSC aged 8-18 years. In the parents from the general population only, this deteriorated financial situation was associated with more stress, worse family interaction and parenting perception, and less received support.

Conclusions: The impact of COVID-19 on children with CSC and their parents differed from those in the general population. Addressing the collateral damage of COVID-19 measures in children and their families may give direction to policy and potentially prevent lifelong impact.

Background

Early 2020, coronavirus disease 2019 (COVID-19) evolved from a local outbreak in Wuhan into a global pandemic. Despite children generally having milder forms of COVID-19, the COVID-19 pandemic likely had a significant impact on daily life of children and their families [1]. To prevent the spread of COVID-19 and the collapse of health care systems, imposed measures, such as social distancing and closure of schools and sports clubs, restricted the everyday life of children. These restrictions have presumably affected children's behavior and well-being as well as their parents' [2].

For children with chronic somatic conditions (CSC), defined as a diagnosis based on medical scientific knowledge, highly resistant to treatment, and lasting longer than three months [3], the impact of the COVID-19 measures might be different than in healthy children. Prior to COVID-19, children with CSC were already at higher risk of having impaired psychological wellbeing. Due to the often unexpected, uncontrollable, and functionally impairing nature of chronic conditions they are, for example, more vulnerable to experience stress [4]. In addition to the psychological impact, children with CSC may be faced with other disadvantages. Depending on the severity and degree of disability of their condition, children may be absent from school more often, for example due to frequent hospitalizations or outpatient visits. Regarding lifestyle, it was found that children with a somatic or psychiatric chronic disease had a poorer diet, engaged less in physical activity, spent more time watching television, and had less social interactions with friends than their healthy peers [5]. In the family context, the matter of a child with CSC may also have a detrimental impact. Parental stress is a common phenomenon and parental overprotection might hamper the development of the chronically ill child. The financial status might also be worse due to added caregiving demands and income loss [6]. A clear understanding of the impact of the COVID-19 pandemic in this vulnerable group may enable healthcare professionals to adequately support children with CSC and their parents.

Studies in children and adolescents from the general population have demonstrated that the COVID-19 pandemic had significant impact on psychological wellbeing, particularly resulting in more symptoms of stress, anxiety, and depression [2, 7-10]. Various factors may be underlying these psychological complaints, including disruption in school and physical activity routines, not being able to play outdoors, the lack of in-person contact with friends and extracurricular activities and boredom [8, 10]. Regarding daily activities, Dutch studies showed that children missed contact with their friends, were less physically active and spent more time using electronic screens during the COVID-19 pandemic than before [8, 11]. The psychological impact of COVID-19 in children with chronic conditions were found to be two-sided: i.e. leading to challenges as well as opportunities [12]. Challenges are heightened health anxiety, stress of disrupted routines and school closure, but also an increased risk of family stress and reduced access to support. Whereas opportunities can include increased time with family, reduced academic stress, the opportunity to build resilience, reduced access to substances, and more access to healthcare technology [12]. To date, few studies have compared the psychological impact of the COVID-19 pandemic in children with CSC and their parents to the impact in healthy children and their parents. In children with lung diseases -who are therefore more vulnerable to COVID-19- one study found more anxiety in children and parents than in healthy controls [13], whereas another study could only confirm this result in mothers, as they showed that healthy children experienced more anxiety [14]. Studies that compared children with CSC in general to healthy controls also found conflicting results [15-17]. Moreover, little is known about changes in daily life activities due to COVID-19 in children with CSC. To explore whether children with CSC and their families should be supported different than healthy controls, studies with larger sample sizes and a variety of chronic conditions are needed.

Therefore, the objectives of our study were 1) to compare the impact of the Dutch COVID-19 measures on perceived stress, coping, social interaction with friends, physical activity, and eating behavior in children aged 8-18 years with CSC and from the general population, 2) to assess the impact of the Dutch COVID-19 measures on perceived stress, family interaction, parenting perception, family support and financial situation in parents of children with CSC aged 0-18 years, 3) to compare the impact of the Dutch COVID-19 measures in parents of children with CSC aged 0-7 years to parents of children with CSC aged 8-18 years, and 4) to compare the impact of the Dutch COVID-19 measures on parents of children aged 8-18 years with CSC and from the general population.

Methods

The COVID-19 Regulation Timeline in the Netherlands

From October 14th to December 14th 2020, the second partial COVID-19 lockdown came into effect in the Netherlands [18]. In addition to the basic rules of hygiene, social distancing, wearing a face mask in public indoor spaces, working and staying at home as much as possible, all bars and restaurants were closed, shops had to close at 8 pm and it was allowed only to receive three guests at home. Starting December 14th 2020, a hard lockdown was in effect, which included closure of schools, out-of-school care and daycare (except for socially vulnerable children and children with parents having an essential profession), non-essential shops and leisure facilities. Sports clubs were also closed, but children up to 17 years were allowed to play sports outside individually and in teams [18]. A curfew was effective from January 23rd to April 28th 2021. On February 8th 2021, primary schools and daycares reopened, and from March 1st, secondary school students were allowed to have physical lessons again one day a week. On April 28th, non-essential shops and terraces reopened and on May 19th, it was again possible to visit leisure facilities, such as swimming pools and animal parks [18].

Participants

In this cross-sectional study, two independent participant samples were included. The main study sample comprised children with a CSC who received treatment at an academic Dutch hospital. The control sample involved children from the Dutch general population.

Children with CSC Sample

Between December 3rd 2020 and May 2nd 2021 (hard lockdown including curfew), parents (of children aged 0-18 years) and children (aged 8-18 years) receiving long-term care at four academic Dutch hospitals (Emma Children's Hospital, Amsterdam UMC; Sophia Children's Hospital, Erasmus MC; Beatrix Children's Hospital, UMC Groningen; Wilhelmina Children's Hospital, UMC Utrecht) were invited to complete the COVID-19 child check questionnaire at home. This questionnaire was administered once for the current study, as part of the Patient Reported Outcome Measures (PROMs). PROMs are included in the standard care through the KLIK PROM portal (www.hetklikt.nu), which is an online portal to systematically monitor outcomes in children with various chronic diseases and their parents over time [19]. Parents and children of 8 years and older are asked to complete PROMs about health-related quality of life and psychosocial functioning prior to the outpatient consultation with the pediatrician or other healthcare professional. Answers on the PROMs are converted into a KLIK ePROfile and discussed during the consultation. KLIK is implemented in daily clinical practice since 2011 in >30 Dutch hospitals for many different patient groups.

Healthcare professionals were asked to add the COVID-19 child check questionnaire to the already administered PROMs of their patients and to discuss the answers during the outpatient visit. For this study, we only used data of children and parents who gave online informed consent for use of their KLIK data for scientific purposes (83%).

General Population Sample

Between November 6th and 30th 2020 (partial lockdown), research agency 'Panel Inzicht' invited parents with children aged 8-18 years from existing panels representative of the Dutch general population to complete the COVID-19 child check questionnaire. This procedure was part of other studies [8, 17]; we merely used the participants as a control group. The parents asked their children to complete the child-reported questions. The questionnaires were filled out on the research website of the KLIK portal. Data collection continued until a representative sample (within 2.5% variation on age and gender) of about 1,000 children was attained. The general population sample (8-18 years) included 1,214 children, with a mean age of 13.8 years and 48% boys.

COVID-19 Child Check Questionnaire

To detect the consequences of the COVID-19 pandemic for children and families at an early stage, a group of experts (pediatricians and psychologists, including KJ, KD and BdJvK) developed the COVID-19 child check questionnaire(Additional file 1), which was based on the CoRonavIruS health Impact Survey (CRISIS) [20]. The COVID-19 child check is intended as a tool for healthcare professionals to facilitate the conversation with children and parents about the impact of the COVID-19 pandemic they are experiencing.

Parents were asked to complete 5 questions about themselves and their family and 5 regarding their child. Children 8 years and older completed 4 questions about themselves. The questions regarding the parents themselves and the family concerned perceived stress (10-point Likert, from 1 (no stress) to 10 (extreme stress)) and change in family interaction, parenting perception, support, and financial situation (3 closed-ended responses and 1 open text option) since the start of the COVID-19 pandemic. Parents and children completed the same questions regarding the child's perceived stress (10-point Likert, from 1 (no stress) to 10 (extreme stress)), coping with COVID-19 measures, and changes in time spent with friends and physical activity (3 closed-ended responses and 1 open text option) since the start of the COVID-19 pandemic. Parents completed an additional question about change in eating behavior of the child (closed-ended responses with open text option). Parent-reported support and financial situation were compressed into two response categories to meet the assumption of chi square tests that the expected value of cells should be 5 or greater in at least 80% of cells. That is, less support from others (such as family and friends) was combined with less support from care providers and the subdivision in being able or unable to make ends meet was combined into a group with deteriorated financial situation.

Statistical Analyses

Characteristics of children from both samples were described in means and percentages. For this study, the perceived stress item responses and the closed-ended responses of the COVID-19 child check questionnaire were analyzed. Child-reported outcomes of the two samples (8-18 years) were compared with t-tests and chi square tests, along with the parent-reported outcomes concerning the child (8-18 years). The parent-reported outcomes regarding themselves and the family were described for the complete CSC sample (0-18 years). As children 8 years and older filled out the COVID-19 child check themselves, we used this age as a cut-off. T-tests and chi square tests were used to compare parents of young children (0-7 years) with parents of older children (8-18 years) from the CSC sample and to compare parents from the CSC sample with parents from the general population (all having children aged 8-18 years). Additional t-tests and chi square tests were used to further explore associations with deteriorated financial situation. The association between the child's perceived stress and parental perceived stress was examined with the Pearson's correlation coefficient in both samples (8-18 years). SPSS software (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) was used for all statistical analyses.

Results

Sample Characteristics

The total CSC sample (0-18 years) included 326 children: mean age 10.9 years and 49% boys (Table 1). Participating children were recruited from academic hospitals in the North-Western part of the Netherlands from a variety of pediatric patient groups. Hematology (20%), rheumatology (18%) and congenital anomalies (12%) were the most frequent chronic diseases. Parents from the CSC sample had a mean age of 42.1 years and 78% were mothers. As for the sample of children aged 8-18 years in the CSC sample (n= 229), it comprised more girls than the general population sample aged 8-18 years (56% vs 48%, β(1)=4.39, p=0.036), the mean age was not statistically different (13.6 y (SD 3.1) vs 13.8 y (SD 3.1), t(1135)=-0.62, p=0.53).

Table 1: Characteristics of children and their parents (CSC sample, 0-18 years)

Child characteristics[a]	**Outcome**
Age, mean (SD)	10.9 (5.1)
Boys, %	49
Patient group, %	
Hematology	20
Rheumatology	18
Congenital anomalies	12
Gastroenterology	11
Endocrinology	6
Marfan syndrome	6
Dermatology	6
Other[b]	21
Parent characteristics	
Age, mean (SD)	42.1 (8.4)
Mothers/female guardian, %	78

[a]N=326, [b]Including muscle diseases, viral infections, menstrual disorders, kidney transplantation, cystic fibrosis and ophthalmology.

Impact of the COVID-19 Measures on the Children

Children (8-18 years) with CSC reported significantly lower stress levels (3.5 (SD 2.4) vs 4.9 (SD 2.6), t(1338)=-7.06, p<0.001; stress scale: 1 (no stress) to 10 (extreme stress)) (Figure 1), less social interaction with friends (59% vs 45%, β(2)=13.38, p=0.001), and being less physically active (47% vs 30%, β(2)=25.46, p<0.001) than the general population children (Table 2). Parents of the children with CSC (8-18 years) also reported less stress

(3.9 (SD 2.3) vs 4.8 (SD2.5), $t(1474)=-5.14$, $p<0.001$; stress scale: 1 (no stress) to 10 (extreme stress)), less social interaction with friends (55% vs 42%, $\beta(2)=15.24$, $p<0.001$), and less physical activity (48% vs 26%, $\beta(2)=38.01$, $p<0.001$) in their children compared with parents from the general population sample. More than 80% of the parents in both groups reported an unchanged eating behavior in their child, no difference between groups was found ($\beta(2)=0.55$, $p=0.76$). Coping was not statistically different between the groups (child-reported $\beta(2)=0.57$, $p=0.75$, parent-reported $\beta(2)=2.58$, $p=0.28$), with about 60% of the children reacting neutrally towards the COVID-19 measures.

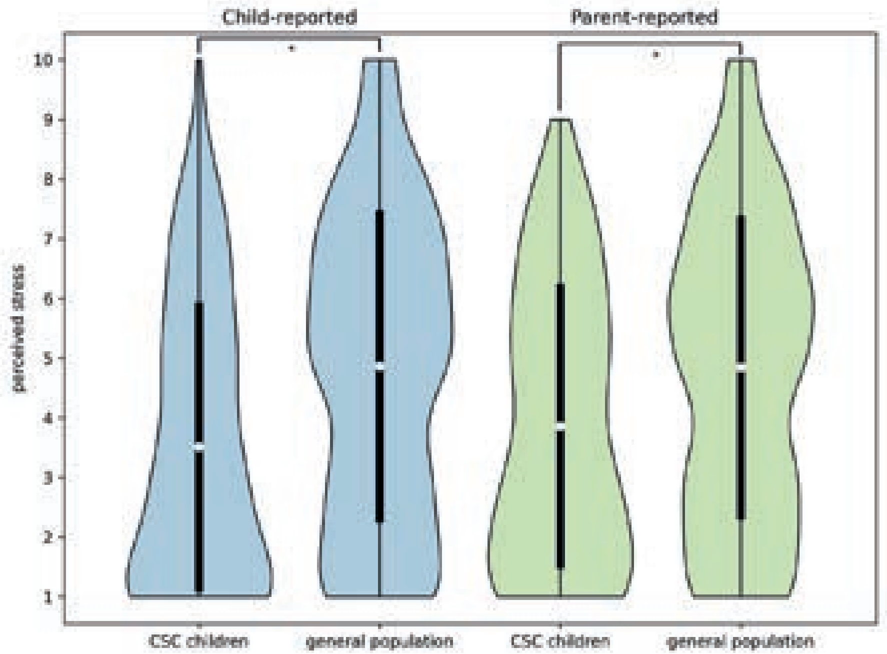

Figure 1: Distribution of child-reported and parent-reported perceived stress in Dutch children during COVID-19

The white dots demonstrate the mean and the black bars the associated standard deviations.

Table 2: Impact of the Dutch measures against COVID-19 on children aged 8-18 years

	Child-reported					Parent-reported				
	CSC children		General population			CSC children		General population		
	N	Outcome	N	Outcome	p-value	N	Outcome	N	Outcome	p-value
Perceived stress[a], mean (SD)	*207*	3.5 (2.4)	*1,133*	4.9 (2.6)	<0.001	*189*	3.9 (2.3)	*1,287*	4.8 (2.5)	<0.001
Coping, %	*174*		*1,075*		0.75	*173*		*1,240*		0.28
Positive reaction		8		9			19		24	
Unchanged		64		62			62		57	
Negative reaction		28		29			18		18	
Social interaction with friends, %	*194*		*1,114*		0.001	*182*		*1,274*		<0.001
See and speak to friends more often		4		7			2		8	
Unchanged		38		48			42		50	
See and speak to friends less often		59		45			55		42	
Physical activity, %	*202*		*1,122*		<0.001	*183*		*1,277*		<0.001
More physically active		6		13			5		13	
Unchanged		47		58			48		61	
Less physically active		47		30			48		26	
Eating behaviour, %						175		*1,277*		0.76
Healthier							10		12	
Unchanged							83		81	
Less healthy							7		8	

Outcome values are means with standard deviations or percentages. [a]Assessed on a 10-point Likert scale (1 (no stress) to 10 (extreme stress)).

6

Impact of the COVID-19 Measures on the Parents

Parents of children aged 0-18 years in the CSC sample reported a mean stress score of 4.1 (SD 2.2) (stress scale: 1 (no stress) to 10 (extreme stress)) for themselves (Table 3). The majority of these parents experienced no change in family interaction (80%), parenting perception (72%), support from others and care providers (85%), and financial situation (88%).

When splitting the CSC sample by age, parents of children with CSC aged 0-7 years did not differ in stress score with parents of children with CSC aged 8-18 years (4.0 (SD 2.2) vs 4.1 (SD 2.2), t(284)=-0.18, p=0.86; stress scale: 1 (no stress) to 10 (extreme stress)), nor in parenting perception (β(2)=1.18 , p=0.56). Parents of children with CSC aged 0-7 years experienced less support (20% vs 11%, β(1)= 3.88, p=0.049) and more financial deterioration (18% vs 8%, β(1)=5.86, p=0.02) than parents of children with CSC aged 8-18 years.

Parents of CSC children aged 8-18 years reported significantly less stress than parents of children aged 8-18 years in the general population (4.1 (SD 2.2) vs 5.1 (SD 2.5), t(1474)=-5.23, p<0.001; stress scale: 1 (no stress) to 10 (extreme stress)) (Figure 2). Parents from the general population more often indicated parenting as less difficult (11% vs 5%, β(2)=6.43, p=0.04), received less support from others (24% vs 11%, β(1)=14.04, p<0.001), and encountered more financial deterioration (29% vs 8%, β(1)=34.78, p<0.001) than parents of CSC children. Additional analyses showed that a deteriorated financial situation among parents in the general population was associated with more parental stress (t(1258)=-6.32), worse family interaction (β(2)=36.06), worse parenting perception (β(2)=105.50), and less received support (β(1)=141.60), (all p<0.001). These associations were not found in parents of CSC children (aged 8-18 years, nor in ages 0-18 and 0-7 years).

Table 3: Impact of the Dutch measures against COVID-19 on parents

	CSC children 0-18 y		CSC children 0-7 y		CSC children 8-18 y		p-value CSC 0-7 y 8-18 y	General population vs 8-18 y		p-value CSC 8-18 y vs general population 8-18 y
	N	Outcome	N	Outcome	N	Outcome		N	Outcome	
Perceived stress[a], mean (SD)	*286*	4.1 (2.2)	*97*	4.0 (2.2)	*189*	4.1 (2.2)	0.86	*1,287*	5.1 (2.5)	<0.001
Family interaction, %	*272*		*91*		*181*		0.82	*1,273*		0.11
More positive	*32*	12		12		12			15	
Unchanged	*217*	80		78		81			73	
More negative	*23*	8		10		8			11	
Parenting perception, %	*268*		*89*		*179*		0.56	*1,266*		0.04
Less difficult	*11*	4		2		5			11	
Unchanged	*194*	72		74		72			67	
More difficult	*63*	24		24		23			22	
Support, %	*267*		*93*		*174*		0.049	*1,270*		<0.001
Unchanged	*228*	85		80		89			76	
Less support from others and care providers	*39*	15		20		11			24	
Financial situation, %	*276*		*94*		*182*		0.02	*1,260*		<0.001
Unchanged	*244*	88		82		92			71	
Deteriorated, able or unable to make ends meet	*32*	12		18		8			29	

Outcome values are means with standard deviations or percentages. [a]Assessed on a 10-point Likert scale (1 (no stress) to 10 (extreme stress)).

6

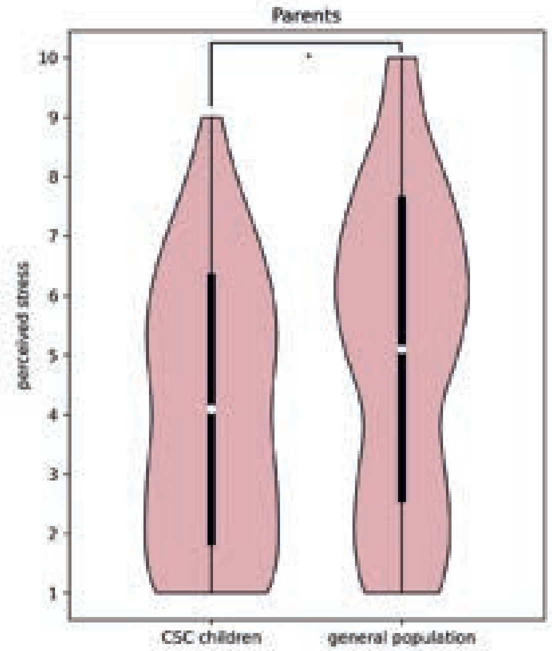

Figure 2: Distribution of perceived stress in Dutch parents during COVID-19

The white dots demonstrate the mean and the black bars the associated standard deviations

In the general population, the association between the perceived stress reported by the child and the perceived stress reported by the parents themselves (r= 0.64, $p<0.001$) was stronger compared with the child-parent stress association in the CSC sample (r=0.37, $p<0.001$) (z-observed = -4.39).

Discussion

Our study aimed to describe the impact of the Dutch COVID-19 measures on children with CSC and their parents and to compare them with a control group of children and parents from the general population. The impact of COVID-19 measures on perceived stress and physical and social daily life activities of children with CSC and their parents differed from those in the general population. Children in the CSC sample engaged less in physical activity and had less social interaction with their friends during the COVID-19 measures compared with children from the general population sample. On the other hand, both children and their parents in the CSC sample reported less stress compared with those in the general population sample. There was a difference depending on the age of the child within the CSC sample, parents of children aged 0-7 years experienced less support and more financial deterioration than parents of children aged 8-18 years. Surprisingly, this deteriorated financial situation was not associated with perceived stress or daily life impact whereas in the general population these associations were significant in parents of children 8-18 years.

We expect that the different impact of COVID-19 measures on perceived stress and daily life in children with CSC and their parents compared with those in the general population could not be explained by the different inclusion periods in the COVID regulation timeline in the Netherlands. The Dutch COVID-19 restrictions were more tightened during the inclusion of the CSC sample with temporarily school closures and a curfew. Therefore, it could be presumed that the impact on children from the general population and the differences between the CSC and general population samples might even be underestimated in our results.

We found lower perceived stress in children with CSC and their parents compared with those in the general population. This finding is in line with a Dutch study that demonstrated less mental health problems among children with pre-existing somatic conditions compared with children from the general population and compared with children having pre-existing psychiatric conditions (all aged 8-18 years) during the Dutch COVID-19 lockdown in April-May 2020 [17]. In contrast, a study in the US found lower stress levels among parents with healthy children than among parents of children with chronic somatic or mental conditions [15]. This difference may be explained by the fact that we explicitly addressed somatic conditions, potential differences in healthcare access, differences in the assessment of stress, and by assessing different populations of children. Our study used a 10-point Likert scale to explore stress during the COVID-19 pandemic among parents, whereas the US study used the Perceived Stress Scale (PSS). According to the PSS, the stress levels among the parent groups in the US study (healthy children, children with chronic conditions) were both denoted as 'moderate', which could indicate that despite the differences in perceived stress, the clinical relevance of these differences, however, might be limited. Disease-specific studies also showed varying results regarding psychological impact. Children with chronic lung diseases and their parents in Turkey had more anxiety than healthy controls during COVID-19 [13]. This finding is comprehensible with COVID-19 generally being known as a lung disease. In children with cystic fibrosis, however, COVID-19 had no effect on anxiety levels, but anxiety in their mothers was raised [14]. Dutch children with cancer and their parents reported lower stress during COVID-19 than before COVID-19 [21]. One could argue that children with chronic diseases are used to a certain amount of stress and might have developed coping strategies, for example related to school absence or being distant from friends, which allow them to cope effectively with any additional stress due to COVID-19 regulations [22-24]. Moreover, the COVID-19 measures might have reduced prior everyday demands that normally caused stress. It could also be argued that stress in children with CSC is lower because COVID-19 measures impose the avoidance of certain activities and they do not have to decide for themselves whether they participate or that their parents may be more shielding [25]. We recommend analyses considering disease type and severity in future research to examine this hypotheses. Besides, qualitative research may provide more insight into underlying reasons of given stress levels and help to further develop the COVID-19 child check questionnaire.

As to financial changes since COVID-19, both parents of younger (0-7 years) children with CSC and parents from the general population experienced more deterioration during COVID-19 measures than parents of 8-18 year old CSC children. This could be explained by adaptation practices. Depending on the type of disease, financial and time caregiving burden in children with CSC are generally higher than for healthy children [26, 27]. Consequently, families of older children (8-18 years) have adapted to this situation over time, for instance with adjusted career choices, financial aid and support, and altered expenditure patterns [27, 28]. The same is likely regarding support, as parents of (older) children with CSC may already have built up a sustainable network on which they rely [28]. The absence of an association between financial deterioration and parental stress or other family impact in the CSC sample could also be attributed to earlier adaptation. Since financial deterioration was associated with more perceived stress and negative family impact in the general population sample, one could argue that these families have not yet adapted and therefore faced more family life disruptions due to COVID-19.

As to physical and social daily activities, it is known that children with chronic conditions exercise less and have less social interaction with friends compared with healthy children [5]. Our findings demonstrated that these behaviors in children with CSC were also more negatively influenced by the COVID-19 measures, with a striking 59% of children that saw and spoke to friends less often and 47% that was less physically active than before COVID-19. Although physical activity remained the same in the majority of children from the general population, more than a quarter stated to have been less physically active during COVID-19 measures. This is in line with other literature that found a reduction of physical activity among children during COVID-19 restrictions, along with increased screen time behavior [29-32]. Our findings urge for attention to physical activity and social interaction with friends for all children both during and after COVID-19 measures. Although children with CSC reported less stress, their less engagement in physical activity and social interaction with friends are worrisome. Given the disadvantages children with CSC already had before the COVID-19 pandemic in these areas, and the fact that participation in sports and non-digital social interactions also benefits their wellbeing and development [33, 34], interventions targeting physical and social activity on the long term is of great importance and beneficial specifically in this population of children.

The weak association between child and parental stress during COVID-19 measures in the CSC sample might be another sign of adaptation. Stress in children and parents from the general population was associated more strongly. This observed difference in stress association between children and parents could be attributed to specific characteristics of both samples or different coping mechanisms.

Strengths and Limitations

The strengths of this study are a broad spectrum of child and family outcomes and the inclusion of a large control group from the general population. The CSC sample was relatively small which impaired sub-analyses among different patient groups, besides there was no information available on disease severity. Due to the cross-sectional design of the study, results on a possible temporal relation between COVID-19 measures and the outcomes were hampered and causal conclusions could not be drawn. Lastly, the (psychometric) validity and reliability of the COVID-19 child check questionnaire have not been investigated yet. However, since the questionnaire primarily serves as a signaling tool and does not measure one specific construct, validation may be difficult.

Conclusions

This study provides evidence of positive as well as negative consequences of the Dutch COVID-19 measures in children with CSC and their parents. While children with CSC experienced less stress, they had less social interaction with friends and engaged less in physical activity during Dutch COVID-19 measures than children in the general population. As to clinical implications, it is recommended to monitor whether they resume these activities in the long run. Children and parents from the general population reported more stress, more often had a deteriorated financial situation, and experienced less support than the children with CSC and their parents. As long as COVID-19 prohibits return to normal daily life, questionnaires such as the COVID-19 child check could assist healthcare professionals in discussing problems. By revealing the collateral damage of COVID-19 measures among children and their families, the COVID-19 child check might also guide policy when considering new measures or supporting children, for example in reducing stress or promoting physical activity.

Acknowledgements

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Supplemental Material

Additional File 1: COVID-19 child check questionnaire

Parent Part

The following questions are about changes in your family and with your child during the Corona period, from March 2020 up to now.

Questions about You and Your Family

1. How much stress do you experience in the current Corona period?

   1 2 3 4 5 6 7 8 9 10

   No stress ... Extreme stress

2. Do your family members interact differently during the Corona period?
   a.) My family members interact more positively.
   b.) My family members interact the same as always.
   c.) My family members interact more negatively, for example, there is more arguing or irritation.
   d.) Other: ....

3. How do you experience parenting during the Corona period?
   a.) I do not experience any change in parenting.
   b.) I find parenting less difficult than before the Corona period.
   c.) I find parenting more difficult than before the Corona period.
   d.) Other: ....

4. Has the support you receive from others, such as family, friends or care providers, changed during the Corona period?
   a.) I get as much support from others as always.
   b.) I get less support from others, such as family and friends.
   c.) I get less support from care providers.
   d.) Other: ....

5. Has the financial situation of your family changed during the Corona period?
   a.) Nothing has changed in our financial situation.
   b.) Our financial situation has deteriorated, but we are able to make ends meet.
   c.) Our financial situation has deteriorated; we have trouble making ends meet.
   d.) Other: ....

Questions about Your Child

6. How much stress does your child experience in the current Corona period?

1	2	3	4	5	6	7	8	9	10
No stress									Extreme stress

7. How does your child react to the measures during the Corona period?
   a.) My child reacts positively to the measures.
   b.) My child reacts neutrally to the measures.
   c.) My child reacts angry, sad or frustrated to the measures.
   d.) Other: ....

8. Has anything changed in your child's eating behavior during the Corona period?
   a.) My child has been eating healthier.
   b.) Nothing has changed in my child's eating behavior.
   c.) My child has been eating less healthy.
   d.) Other: ....

9. Has anything changed in the amount of physical activity of your child during the Corona period, for example, in playing outside, sports and cycling?
   a.) My child has been more physically active.
   b.) Nothing changed in how much my child has been physically active.
   c.) My child has been less physically active.
   d.) Other: ....

10. Has Corona changed anything in how often your child sees or speaks to friends?
   a.) My child sees or speaks to friends more often.
   b.) Nothing has changed in how often my child sees or speaks to friends.
   c.) My child sees or speaks to friends less often.
   d.) Other: ....

Child Part

1. How much stress do you experience due to Corona?

1	2	3	4	5	6	7	8	9	10
No stress									Extreme stress

2. How do you feel because of the Corona measures?
   a.) I experience positive feelings because of the measures.
   b.) The measures do not affect how I feel.
   c.) I experience negative feelings, such as sadness or anger, because of the measures.
   d.) Other: ....

3. Has Corona changed anything in how often you see or speak to your friends?
   a.) I see or speak to my friends more often.
   b.) Nothing has changed in how often I see or speak to my friends.
   c.) I see or speak to my friends less often.
   d.) Other: ....

4. Has anything changed in the amount of physical activity during this Corona period, for example in playing outside and sports?
   a.) I have been more physically active.
   b.) Nothing has changed in how much I am physically active.
   c.) I have been less physically active.
   d.) Other: ....

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Chapter 7

A lifestyle screening tool for young children in the community: needs and wishes of parents and youth healthcare professionals

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Submitted

Abstract

Background: Youth healthcare has an important role in promoting a healthy lifestyle in young children in order to prevent lifestyle-related health problems. To aid youth healthcare in this task, a new lifestyle screening tool will be developed. The aim of this study was to explore how youth healthcare professionals (YHCP) could best support parents in improving their children's lifestyle using a new lifestyle screening tool for young children.

Methods: We conducted four and seven focus groups among parents (N=25) and YHCP (N=25), respectively. Two main topics were addressed: the experiences with current practice of youth healthcare regarding lifestyle in young children, and the requirements for the lifestyle screening tool to be developed. The focus groups were recorded, transcribed verbatim and analysed using an inductive approach.

Results: Both parents and YHCP indicated that young children's lifestyles are often discussed during youth healthcare appointments. While parents felt that this discussion could be more in-depth, YHCP mainly needed clues to continue the discussion. According to parents and YHCP, a new lifestyle screening tool for young children should be easy to use, take little time and provide courses of action. Moreover, it should be attractive to complete and align with the family concerned.

Conclusions: According to parents and YHCP, a new lifestyle screening tool for young children could be useful to discuss specific lifestyle topics in more detail and to provide targeted advice.

Background

In early childhood (0-4 years), unhealthy lifestyle behaviours, such as poor dietary intake, limited physical activity, excessive screen time and insufficient sleep, have been associated with adverse health outcomes [1-3]. Overweight and obesity are among the most prominent manifestations of these unhealthy behaviours [4]. According to the WHO, 5.1% of all children under five were overweight or obese in 2020, highlighting the magnitude of the problem [5]. In the Netherlands, the prevalence of overweight (including obesity) in children aged 2-9 years was 15.5% in 2021; the prevalence of obesity was 4.8% [6]. As lifestyle habits are formed early in life and may persist over time, lifestyle interventions in the early years hold the greatest potential for long-term health benefits [7].

In the Netherlands, preventive youth healthcare is a free service that aims to promote, protect and secure the health, growth and development of children up to the age of 18 [8]. From birth onwards, all children and their parents are offered regular consultations, vaccinations and counselling at local child health clinics. Youth healthcare professionals (YHCP) work in multidisciplinary teams and can refer to specialized care when needed. Among the core activities of YHCP is screening, for example for unhealthy lifestyle behaviour. By identifying unhealthy lifestyle behaviour in children, YHCP can provide targeted advice to parents to help them improve their children's lifestyles. In practice, lifestyle screening in young children appears to be complex and time-consuming, and no unambiguous screening tool is available. However, as up to 95% of young children are reached by Dutch youth healthcare, the regular consultations provide an excellent setting for the use of a lifestyle screening tool [9].

In 2018, the Dutch Ministry of Health, Welfare and Sport published the National Prevention Agreement, which describes policies to tackle overweight, smoking and problematic alcohol use [10]. This agreement called for the development of a screening tool that would provide insight into the lifestyle of children aged 0-4 years and give parents practical support in mitigating the long-term risks of an unhealthy lifestyle. As part of this project, we previously reviewed existing lifestyle screening tools for children and identified food consumption and clusters of lifestyle behaviours in Dutch toddlers [11-13].

To ensure successful implementation of a new lifestyle screening tool within youth healthcare, the tool should fit current youth healthcare working practices and reflect the preferences of parents and YHCP. The aim of this paper is to describe 1) current practice of youth healthcare regarding lifestyle in young children, and 2) the requirements for the lifestyle screening tool under development, according to parents and YHCP.

Methods

Study Design

We conducted focus groups among parents of children aged 0-6 years and YHCP working in Dutch youth healthcare. The use of focus groups allows for interaction between participants, which may lead to additional insight into the topics discussed [14]. Prior to the focus groups, participants completed a questionnaire assessing general characteristics. For the parents, this concerned their age, sex, education level, country of birth, number of children and age of their children. From YHCP, their profession (youth physician or youth nurse) and the healthcare centre they were appointed at were obtained. This study is reported as indicated by the COREQ (COnsolidated criteria for REporting Qualitative Research) Checklist [15].

Participants

Participants were recruited using convenience and purposive sampling between April and October 2021. Parents were able to sign up via a previously conducted survey that served as a first exploration of the topic of lifestyle among parents of young children. In addition, parent recruitment leaflets were posted at youth healthcare centres, nurseries and the Erasmus University Medical Centre. Personal networks of members of the research team were also contacted and snowball recruitment occurred through parents who had signed up. The inclusion criteria for parents were: 1) having at least one child between the ages of 6 months and 6 years, and 2) being able to provide informed consent. There were no exclusion criteria. As data collection took place, we noticed that parents with lower educational attainment and parents with a migrant background were under-represented. A final recruitment attempt was therefore made through 'parent contact persons' at schools in Rotterdam, the Netherlands, with a relatively large population of low-educated families and families with a migration background.

YHCP (both youth physicians and youth nurses) working with children between the ages of 6 months and 6 years were eligible for inclusion. They were recruited through the research team's professional network and through *JGZ Life!*, an online current affairs program for professionals within youth healthcare.

Data Collection

Data collection was performed in Dutch between June and November 2021 and took place for parents and YHCP separately. Participants could indicate their availability on predefined time slots. We tried to have between four and eight participants per focus group, but twice we accepted that there would be two participants in a focus group and once three. Due to COVID-19 measures, the first focus groups were held online via MS Teams. However, at the end of 2021, COVID-19 measures were loosened and we were able to conduct the focus groups with lower-educated parents and parents with a migration background in dedicated parent rooms at their children's schools. In addition to the information letter and written informed consent, the focus group moderator briefly explained the study aims and participants verbally reconfirmed their consent to audio recording, at the beginning of each focus group. During the focus groups, at least two members of the research team (CL (MD, PhD), MdW (PhD), LSG (PhD), and AK (MD), all female researchers) were present and field notes were taken. We developed separate topic guides for parents and YHCP. The key questions for both parents and YHCP in this topic guide concerned: 1) the current practice of youth healthcare regarding young children's lifestyle, and 2) the requirements for the lifestyle screening tool under development. Prior to topic two, the moderator summarized the main idea of the new lifestyle screening tool (i.e. asking parents questions regarding their children's lifestyle preceding a youth healthcare visit, leading to tailored advice). The lifestyle screening tool had not been mentioned to the participants before, in order to avoid narrowed data collection for the first topic. All participating parents received a gift card as a token of appreciation; YHCP received an attendance fee.

Data Analysis

All audio recordings were transcribed verbatim. The transcripts were coded using NVivo software (QSR International Pty Ltd. (2022) Nvivo (Release 1.7)) and analysed using an inductive thematic approach [16]. First, two researchers (AK and KK) openly coded two transcripts independently, one from parents and one from YHCP. These preliminary coding schemes were compared, refined and discussed with LSG until consensus about the axial coding framework was reached. Next, AK and KK coded the remaining transcripts. In consultation, new codes were added to the coding scheme and AK and KK checked the consistency of all coded transcripts. AK and LSG agreed that data saturation was achieved. Through a process of discussion, agreement was reached on overarching themes and key findings of the data. Descriptive characteristics of the study samples were summarized using Microsoft Excel 2016.

Results

Participant Characteristics

Seven focus groups were held among parents and four among YHCP. The average durations were 58 and 56 minutes for parents and YHCP, respectively. The characteristics of participating parents and YHCP are given in Table 1. The average age of parents was 38.0 years (SD 4.4, range 31-46) and the majority were female (96%). The mean number of children per parent was 2.6 (SD 1.7, range 1-7). Most of the parents had been born in the Netherlands (64%) and had received a middle level of education (45%). Participating YHCP were predominantly female (96%). Most of them were working as a youth physician (68%) and the largest portion in the Western part of the Netherlands (48%).

Table 1: Characteristics of participating parents and YHCP

	Parents (N = 25)
Age (years)a	38.0 (31-46)
Gender (%)	
Female	96
Male	4
Number of children	2.6 (1-7)
Country of birth (%)	
The Netherlands	64
Morocco	32
Tunisia	4
Educational level (%)	
Low	20
Middle	45
High	44
	Youth healthcare professionals (N = 25)
Gender (%)	
Female	96
Male	4
Profession (%)	
Youth physician	68
Youth nurse	32
Region in the Netherlands (%)	
North	4
East	28
South	20
West	48

Values are mean and range or percentages. [a]One missing on age.

Current Practice of Youth Healthcare Regarding Young Children's Lifestyle

Parents

Regarding the current practice of youth healthcare regarding young children's lifestyles, the themes that arose were: 1) screening and discussing lifestyle, and 2) advising and informing. Parents stated that their child's lifestyle is often discussed during youth healthcare appointments and that they appreciate this. The emphasis is usually on nutrition, but physical activity and sleep are also commonly addressed. Parents value the open-ended, non-judgmental questions asked by YHCP to start the conversation. However, when asked to clarify their preferences, parents expressed that YHCP could also ask more in-depth questions, such as to examine how much the child exactly eats or how the vegetable intake is. According to the parents, this may provide YHCP with a better overview to give specific advice, as well as break down barriers that might prevent parents from sharing their issues when only open-ended questions are posed.

"If a child is growing well and following the curve, then it's basically done. But you could also zoom in on what they actually eat and what the fruit and vegetable intake is like." Parent #5

Moreover, parents indicated that the conversation could be more in line with their needs and family situation. Obstacles in the conversation about lifestyle according to parents are the relatively few standard appointments within youth healthcare and time constraints. Some parents put forward that not all YHCP were equally open to alternative ways of eating or upbringing.

Parents reported that they had received advice and information about their child's nutrition, physical activity and screen use. In general, parents were satisfied with the advice received. Nevertheless, the advice was also repeatedly experienced as not very extensive and not giving enough direction in what is healthy. As facilitators in informing about lifestyle by YHCP, parents reported explaining guidelines and advice and offering information material to take home.

With regard to the way of informing, parents prefer a coaching, non-strict conversation with a holistic perspective. A major impeding factor in adhering to the lifestyle advice for their young children is the presence of older children in the family. In the focus groups with parents with lower levels of education and migrant backgrounds, the grandparents' views on a healthy lifestyle and a healthy weight were also noted as disturbing factor.

"When I go on holiday to my family, they say: 'Oh he is cute, but skinny, so sad'." Parent #13

YHCP

For YHCP, the themes on the current practice of youth healthcare regarding young children's lifestyles that arose: 1) screening and discussing lifestyle, and 2) advising and informing. YHCP indicated that the subject of lifestyle is discussed in the majority of appointments. Exceptions include appointments on indication, for example when vision or motor skills are examined only. When children are younger than one year old, lifestyle, particularly nutrition, is often addressed at the parent's initiative. Parents may have questions themselves, and also expect talking about their child's nutrition. After the first year of life, parents typically bring up the topic of nutrition only when they experience problems, such as the child not eating well or being a picky eater. YHCP stated that if parents do no mention lifestyle themselves, they will inquire about it as openly as possible.

"Well, I basically just ask at every consultation: 'How is the diet?'. And then we talk about that." YHCP #5

In addition to nutrition, YHCP may discuss with parents their children's physical activity, screen time, sleep, as well as family stressors, parenting and parental lifestyle. Sometimes this conversation is initiated on the basis of a child's growth curve or specific items in the electronic health record, such as supplemental vitamin D intake. Several YHCP also mentioned that tools, such as a waiting room poster that displays the number of sugar cubes in various sugar-sweetened beverages, frequently spark discussion. However, the demand-driven way of working within Dutch youth healthcare and time constraints make it sometimes challenging to discuss lifestyle with parents, especially when YHCP feel there are no "starting points", such as unhealthy weight, for the conversation.

> *"So, when I ask 'How is the diet?', and the answer is 'Good', yes, then it gets difficult. Because indeed, how much further should you ask? If I see a child having overweight or obesity, then I really have a starting point for a conversation, but when I see a child with a healthy weight who is developing well, yes... Then I'll let it go, then I won't ask any further questions. So, I'm probably missing a lot of things." YHCP #7*

> *"You have several things to do and this [discussing lifestyle] is just a small part of it. In that respect, I believe I absolutely miss children who may have an unhealthy diet but are otherwise healthy-weighted. But because you just have 20 minutes and there are so many things you need to give attention to, that goes wrong sometimes." YHCP #14*

Nevertheless, when YHCP notice "red flags", such as abnormal growth or overweight, they probe further. While it is easier to start the conversation about lifestyle in this case, YHCP find it more difficult to continue this conversation. Reasons for this are mainly parent-related: some parents may find the topic of lifestyle too sensitive, they may not be open to a conversation about it, or are unaware of the lifestyle recommendations for a specific age.

With regard to advising and informing parents about lifestyle of their children, YHCP indicated a list of facilitators and barriers. Above all, it was stated that advice or information given should be tailored to the family concerned. To facilitate this, YHCP reported that provided advice and information should be in line with the parents' knowledge, skills, financial resources, environment, and culture. Additionally, using existing tools and information sources, such as flyers from the Dutch Nutrition Centre, and offering feasible advice was considered helpful. Most barriers were related to these facilitators. In addition, the resistance of parents to advice was also raised as a major concern.

> *"But here again, if parents notice that their child is overweight but refuse to do anything about it, it is better to ask parents again when they begin to worry about it. (..) However, it gives me mixed feelings, because the child has no choice. (..) So, I still find that very difficult." YHCP #16*

Requirements for a New Lifestyle Screening Tool

Parents

The requirements that emerged from the parents were divided into requirements for themselves and for their children (Table 2). Six themes were identified in terms of requirements for the parents themselves: 1) usability, 2) time investment, 3) alignment with family, 4) visual attractiveness, 5) effectiveness, and 6) child privacy. Usability mainly concerned completing the tool at a suitable place (e.g. at home or waiting room) and in a practical way (digitally or on paper). Although opinions varied on the best place and method, parents agreed that the time investment should be minimal and certainly no longer than ten minutes. To align the lifestyle screening tool with the family, parents requested that the tool be tailored to the family's needs and values in terms of socio-economic status, skills and family culture. Parents preferred a visually appealing tool that provides an overview of a child's lifestyle.

> *"And that's why I thought of a spider web, because then you can show the relationship between the different elements, and as professional you can also say: 'Hey, I'm noticing something here'." Parent #2*

As for effectiveness, major concerns for parents were that the purpose of the tool should be clear to them and that YHCP act upon the answers parents provide. Moreover, the tool should mainly facilitate and support the conversation with the YHCP and not be strict and patronizing. While the higher-educated parents emphasized the importance of using the tool holistically and without judgment, the parents with a lower education and/or migration background indicated that they would prefer outcomes with more direction. The use of a traffic light system, for example, in which healthy behavior is marked green and less healthy behavior orange or red, would give them guidance and motivation to improve.

> *"Of course! When I get a warning like 'your child can do much better' (...), you just do your best!" Parent #14*

Some parents mentioned that a tool would have been helpful before the age of one, whereas others stated that they had more questions during toddlerhood and such a tool would therefore be more effective from the age of 12 months and older. Finally, parents considered it critical to ensure the safety of the data they would provide with the tool.

The requirement for the child comprised including relevant topics in the tool. The parents suggested nutrition, physical activity and sleep as the most relevant topics. Screen time was not mentioned.

YHCP

YHCP devised requirements for the new lifestyle screening tool for themselves, for the parents, and for the children (Table 2). As for requirements for YHCP themselves, three themes were identified: 1) usability, 2) time investment, and 3) courses of action. Usability referred to several factors, including using the tool as a conversation aid, embedding it into the current working method and electronic health record, and utilizing existing tools and resources for providing advice and information. Regarding time investment, the most frequently mentioned concern for YHCP themselves was that the instrument should not lead to time loss during the appointment. Lastly, the YHCP mentioned that the tool should offer them courses for action, for example by providing a score, offering cues for the conversation or contributing to counselling.

> *"Could it be a starting point for the conversation you are already having anyway, but in a certain way, from that starting point?" YHCP #2*

According to the YHCP, the requirements for the parents were subdivided into: 1) usability, 2) alignment with family, 3) attractiveness, and 4) effectiveness. YHCP expressed that the tool should have high usability for parents too, for example by enabling quick and digital completion. In addition, the YHCP above all felt that a new lifestyle screening tool should align with the family, particularly in terms of the parents' needs, socio-economic status, skills, and culture. Other requirements for parents for the tool included it being attractive, i.e. visually appealing and not too strict or patronizing, as well as being effective, for example by increasing parents' knowledge and awareness of their child's lifestyle.

> *"That is of course always important to keep in mind: 'is this parent even able to change anything about this?'. Preferably, you take them along. Like 'What could you do now?', or 'What would help you now?'. If there is no money for a sports club, for example, many municipalities have funds available for that." YHCP #2*

The overarching theme of the requirements for the children according to YHCP was effectiveness. YHCP mentioned that a new lifestyle screening tool would be effective for children if it covers relevant topics and is used at appropriate ages. Healthy and unhealthy dietary intake and physical activity were most frequently mentioned as relevant topics, but screen time, sleep and smoking also emerged. YHCP agreed that a lifestyle screening tool should be applied before lifestyle patterns become ingrained, so for example at the age of one year, or even earlier.

Table 2: Summarized requirements for a new lifestyle screening tool according to parents and YHCP

	Parents' views		YHCP' views	
Target group	**Themes**	**Requirements**	**Themes**	**Requirements**
Parents	• Usability	Tool completion at home or in waiting room; digitally or on paper	• Usability	Quick and digital tool completion
	• Time investment	Completion takes no longer than ten minutes		
	• Alignment with family	Tool takes into account parental needs, socio-economic status, skills and culture	• Alignment with family	Tool takes into account parental needs, socio-economic status, skills and culture
	• Visual attractiveness	Visually appealing tool that provides an overview	• Attractiveness	Visually appealing tool that is not strict or pedantic
	• Effectiveness	Tool purpose should be clear; YHCP should act upon answers given; tool should support an open conversation; tool application from age of one year	• Effectiveness	Tool should increase parents' knowledge and awareness
	• Child privacy	Data security should be ensured		
Children	• Relevant topics	Nutrition, physical activity, sleep	• Effectiveness	Topics: healthy and unhealthy dietary intake, physical activity, screen time, sleep, smoking; tool application from age of one year or earlier
YHCP			• Usability	Tool should support conversation, be embedded in current working method and electronic health record and use existing resources for providing advice and information
			• Time investment	Tool usage should not lead to time loss during appointment
			• Courses of action	Tool should offer a score or cues for the conversation or counselling

7

Discussion

This study describes the experiences of current practice in Dutch youth healthcare regarding lifestyle in young children and the requirements for a new lifestyle screening tool according to parents and YHCP. A new lifestyle screening tool was considered desirable by both groups.

Parents reported that they were generally satisfied with the current practice in youth healthcare regarding the lifestyle of young children. They appreciated the open start to the lifestyle conversation, but required a more in-depth approach from the YHCP, both in continuing the conversation and in providing advice and information. This finding is in line with Swedish research in which parents indicated the desire to receive more information and advice regardless of their identified needs [17]. Parents in our study felt that this could be overcome by further questioning on specific lifestyle topics, and also by providing more explanation and background to the guidelines and advice, or by offering information materials to take home. Asking specifically about the habitual quantity of fruit consumption or hours of screen time, for example, may not be in line with the demand-driven approach used in Dutch youth healthcare. A common conversation technique within this demand-driven methodology starts from the parents' concerns in order to actively engage them in the conversation [18]. This technique is based on the idea that care can then be tailored to parents' needs and that parents will be more motivated to make changes if they themselves perceive certain issues as problems. YHCP also experienced that sometimes they want to continue a conversation about lifestyle with the parent, but they lack "starting points" or tools to do so. In their view, the demand-driven approach then conflicts with the need to work preventively. A lifestyle screening tool could address this concern by first asking an open-ended question about the parent's perspective and then eliciting more specific information about certain lifestyle topics. In this way, both the parent and the YHCP are given a helping hand to guide and deepen the conversation, discuss topics that might not otherwise be covered, and allow the parent to get specific advice.

Although the nuance of the themes was slightly different for parents and YHCP, we found considerable of overlap between the requirements of both groups. Above all, for parents as well as YHCP, a new lifestyle screening tool for young children should be easy to use, take little time, and provide concrete courses of action. Furthermore, for parents, tool usage should align to the family in question and be (visually) attractive to use. In our view, these requirements may also be relevant to other innovations within youth healthcare. Support that matches personal experiences, preferences and practices that is culturally sensitive was also expressed as a need in a Dutch study that examined parents' perspectives regarding youth health care in the first two years [19]. For the lifestyle screening tool, for example, this could mean that the advice given by the YHCP takes into account the family's food culture and financial resources. In another Dutch study on psychosocial and lifestyle assessment of childhood obesity, care professionals also stated that visual materials are helpful in conversations with parents [20].

Higher-educated parents and YHCP felt that screening tool outcomes should not be too judgmental, whereas parents from less educated or migrant backgrounds needed more clarity in the answers given and were open to a more directive approach. As children of parents with lower education levels or migrant backgrounds are more likely to have unhealthy lifestyles, there is more to be gained especially there [21, 22]. A 'traffic light' system indicating healthy and unhealthier behavior, as suggested by these parents, may therefore be a useful, clarifying and effective feature of the new lifestyle screening tool.

Strengths and Limitations

Strengths of this study include conducting focus groups with both stakeholder groups, namely parents and YHCP. This qualitative approach allowed for the collection of enhanced opinions and data from person-to-person interactions, as well as comparison of the two groups [14]. Our efforts to reach more parents with a lower education level and non-Dutch background increased the transferability of our findings. Credibility was raised by the data being coded independently by two researchers. The use of convenience sampling in parent recruitment is a study limitation, which was partly due to COVID-19 regulations in place at the time. COVID-19 regulations also required most of the focus groups to take place online. While this may not have affected the data quality, face-to-face interviews may be preferable when discussing socially sensitive topics, such as lifestyle [23]. As most of the parents in our study had several children, we should be aware that the results may be different for first-time parents. Lastly, the limited involvement of fathers and lack in diversity of cultural backgrounds should be considered when interpreting the results in the context of the Netherlands as a whole.

Conclusions

Young children's lifestyles are often discussed during youth healthcare appointments. However, parents sometimes require more depth in these conversations and YHCP need more leads to continue the lifestyle dialogue. A lifestyle screening tool may support this. According to parents and YHCP, this screening tool should be easy to use, take little time and offer courses of action. For parents in particular, the tool should be attractive to complete and align with the family in terms of parental needs, socio-economic status, skills and culture. To reach the group that would benefit most from lifestyle improvements, i.e. families from lower socio-economic backgrounds, it may be crucial to meet their needs.

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Part III

Development and evaluation of FLY-Kids

Chapter 8

Development and evaluation study of FLY-Kids: a new lifestyle screening tool for young children

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Submitted

Abstract

Purpose: Evaluating, discussing and advising on young children's lifestyles may contribute to timely modification of unhealthy behaviour and prevention of adverse health consequences. We aimed to develop and evaluate a new lifestyle screening tool for children aged 1-3 years.

Methods: The lifestyle screening tool "FLY-Kids" was developed using data from lifestyle behaviour patterns of Dutch toddlers, age-specific lifestyle recommendations, target group analyses, and a Delphi process. Through 10 items, FLY-Kids generates a dashboard with an overview of the child's lifestyle that can be used as conversation aid. FLY-Kids was completed by parents of children aged 1-3 years attending a regular youth healthcare appointment. Youth healthcare professionals (YHCP) then used the FLY-Kids dashboard to discuss lifestyle with the parents, and provided tailored advice. Parents as well as YHCP evaluated the tool after use. Descriptive and correlation statistics were used to determine the usability, feasibility, and preliminary effect of FLY-Kids.

Results: Parents (N=201) scored an average of 3.2 (out of 9, SD 1.6) unfavourable lifestyle behaviours in their children, while 3.0% complied with all recommendations. Most unfavourable behaviours were reported in unhealthy food intake and electronic screen time behaviour. Parents and YHCP regarded FLY-Kids as usable and feasible. The number of items identified by FLY-Kids as requiring attention was associated with the number of items discussed during the appointment ($r=0.47$, $p<0.001$).

Conclusions: FLY-Kids can be used to identify unhealthy lifestyle behaviour in young children and guide the conversation about lifestyle in preventive healthcare settings. End-users rated FLY-Kids as helpful and user-friendly.

Introduction

Despite the importance of a healthy lifestyle for children's optimal growth and development, many parents do not comply with lifestyle recommendations for their offspring [1]. Unfavourable lifestyle behaviour, such as inadequate dietary intake, lack of physical activity, high amounts of screen time as well as insufficient sleep, have been associated with adverse health outcomes already in early childhood [2-5]. Overweight and obesity are among the most prominent health implications, with a global prevalence of 5.7% in children under the age of five [6]. In addition to the increased risk of certain (chronic) diseases due to being overweight, common consequences of an unhealthy lifestyle in children include tooth decay, myopia, impaired motor skills and delayed cognitive development [7-9]. Given that lifestyle habits formed during childhood tend to persevere, as does overweight, the early years provide the perfect opportunity for sustained healthy behaviour and its associated health benefits throughout life [10-12].

Since young children (aged 1-3 years) represent a vulnerable group with high potential, promoting a healthy lifestyle in them should be prioritized. To timely tackle unfavourable lifestyle behaviour of young children, a screening tool may be helpful. Such a tool, completed by parents (or caregivers, also referred to as parents in this paper), would allow young children's lifestyle habits to be mapped quickly and easily. While using a lifestyle screening tool could create awareness among parents, on the one hand, such tools could also offer healthcare professionals prompts to start a conversation about lifestyle with parents. Consequently, suboptimal lifestyle behaviours could be discussed, and tailored advice can be given to support the parents in improving their child's lifestyle behaviour.

8

A few lifestyle screening tools exist for community-living children aged 1-3 years. The Toddler Dietary Questionnaire, NutricheQ and Toddler NutriSTEP are short screening tools that identify nutritional risk [13-15]. The Toddler Dietary Questionnaire addresses the intake of specific food groups [13]. The NutricheQ and Toddler NutriSTEP additionally encompass aspects such as feeding practices and parent feeding styles (NutricheQ), and growth and daily sedentary activity (Toddler NutriSTEP) [14, 15]. Nevertheless, the outcome of these tools is still limited to nutrition. Another concern in the application of lifestyle screening tools in young children is the feedback and support to parents. While completing a screening tool could lead to awareness, a response to the outcome and advice tailored to the family concerned may increase the chance of actual behavioural change [16]. Furthermore, for successful implementation, healthcare professionals have to be guided in discussing screening tool outcomes and be given specific courses of action. Currently, there is no screening tool that covers lifestyle in the broadest sense of the term with specific action protocols that can be used in preventive healthcare for children aged 1-3 years.

To enable adequate, rapid and feasible lifestyle evaluation in young children, to provide parents and youth healthcare professionals (YHCP) guidance in discussing and improving children's lifestyle behaviour, and ultimately to prevent children from adverse lifestyle-related health consequences, we developed a screening tool called "Features of Lifestyle in Young Kids" (FLY-Kids). The aim of this paper is to 1) describe the development of FLY-Kids and 2) report on its usability, feasibility, and preliminary effect based on the evaluation study.

Methods

FLY-Kids is a 10-item parent-administered lifestyle screening tool for children aged 1-3 years (Online Resource 1). The first item determines parental satisfaction with their child's lifestyle; the other items are divided into four themes and consist of questions that are evaluated against age-specific recommendations: healthy food intake (vegetables and fruits), unhealthy food intake (sugar-sweetened beverages and snacks), eating habits (mealtime practice and food parenting practice), and other lifestyle habits (physical activity, screen time, and sleep). Parents grade their satisfaction on a scale from 1 (very unsatisfied) to 10 (very satisfied). The other questions comprise three or four response options. After completion, these multiple choice items are scored "green", "orange", or "red", with an additional "yellow" in case of four response options, indicating the extent to which the recommendation is met [17, 18]. Since the recommendations for screen time and sleep vary slightly by age, there are three FLY-Kids versions for ages 1, 2 and 3 years, respectively (Online Resource 1). FLY-Kids is intended to be completed prior to a youth healthcare visit and provides healthcare professionals with a dashboard showing which lifestyle aspects may require attention. Healthcare professionals can use this dashboard and enclosed courses of action (potential underlying reasons to explore further, as well as advice and information resources for parents) to enter into dialogue with parents and support them in improving the lifestyle of their child. The outline of the development and evaluation process of FLY-Kids is demonstrated in Figure 1. A detailed description of the development process of FLY-Kids is provided in Online Resource 2.

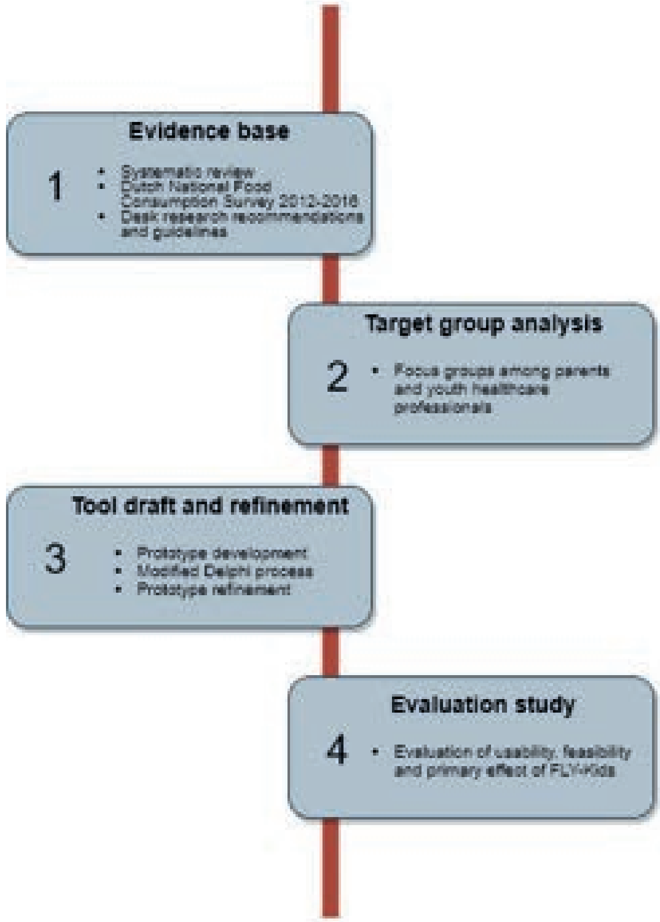


Figure 1: Overview of the development and evaluation process of FLY-Kids

Evaluation Study of FLY-Kids

Study Design and Population

Between June and November 2022, FLY-Kids was evaluated at four youth healthcare centres in different municipalities in the Netherlands (Goes, Utrecht, Hardenberg, Almere). These centres were recruited by advertising in the Dutch Knowledge Centre for Youth Health newsletter and direct communication. We included parents and their children aged 1-3 years attending a regular youth healthcare appointment. Exclusion criteria were: 1) parents not having sufficient command of the Dutch language to complete the tool, 2) parents or children considered not eligible according to the YHCP (e.g. due to psychosocial problems within the family, psychomotor retardation, or a specific diet), or 3) no time to fill out the questionnaire before the appointment. The consulting YHCP (physicians and nurses) were included as a separate participant group.

Data Collection

A detailed description of the data collection of the evaluation study is described in Online Resource 3. In brief, parents were invited to participate by a researcher in the waiting room after their child's anthropometric measurements were taken. Parents who agreed to participate completed a paper version of FLY-Kids and provided written informed consent. The researcher passed the scored dashboard on to the YHCP. Parents and YHCP discussed the dashboard during the consultation and advice and more information was provided accordingly. Afterwards, parents filled out a short questionnaire on background characteristics, and both parents and YHCP completed an evaluation form regarding FLY-Kids' usability and feasibility on a scale of 1 (strongly disagree) to 5 (strongly agree), with the option to provide additional open text input.

Statistical Analyses

Characteristics of participating children and parents were described in means (SD) and percentages. The mean value of the FLY-Kids item on parental satisfaction was calculated. For the other FLY-Kids items, the proportion of parents who had given the "green", "yellow", "orange" or "red" response option were expressed. Associations of scores on FLY-Kids with parental satisfaction, age of the child, weight SD score, and items discussed during the consultation were examined with Pearson's correlation coefficient. Likert scale responses on the usability and feasibility questions of parents and YHCP were summarized by means of descriptive statistics. Open text answers were organized by theme and analysed accordingly. SPSS software (IBM SPSS Statistics for Windows, Version 28.0.1.0 NY: IBM Corp.) was used for all quantitative analyses.

Results

Sample Characteristics

Of the 210 invited parents, 208 agreed to participate. After excluding incomplete and unconsented questionnaires, 201 were included for analysis. The sample of children comprised 105 1-year-olds (52%), 73 2-year-olds (36%) and 23 3-year-olds (11%), of which 49% were boys (Table 1). Mean SD scores for weight-for-height and height-for-age for all enrolled children were, -0.08 (SD 1.08), and 0.18 (1.26), respectively. As for weight classification, 7% of children were underweight, 81% had a normal weight, 11% had overweight, and 2% were affected with obesity [19, 20]. Participating parents were mostly mothers (75%) and had a mean age of 34.9 y (SD 6.1). In addition, the majority of them were born in the Netherlands (82%) and had attained a high level of education (62%). The evaluation study involved 18 YHCP, of whom 15 completed the evaluation form. Among the latter were 6 (40%) physicians and 9 (60%) nurses.

Table 1: Characteristics of children and parents in the evaluation study of FLY-Kids

	All	1 year	2 and 3 years
Number of participants	**201**	**105**	**96**
Child characteristics			
Age (m)	22 (8.5)	15 (2.8)	30 (6.1)
Sex, m:v (%)	49:51	49:51	49:51
Weight-for-height SD score	-0.08 (1.08)	-0.09 (1.09)	-0.08 (1.07)
Height-for-age SD score	0.18 (1.26)	0.19 (1.36)	0.18 (1.15)
Weight classification (%)			
Underweight	7	7	7
Normal weight	81	81	80
Overweight	11	12	11
Obesity	2	1	2
Parent characteristics			
Relationship with child (%)			
Mother	75	78	71
Father	23	19	27
Other	2	3	2
Age (y)	34.9 (6.1)	34.3 (6.4)	35.6 (5.8)
Country of birth (%)			
The Netherlands	82	82	81
Other Western country	4	6	3
Non-Western country	14	12	16
Education level (%)			
Low	10	7	14
Middle	28	34	22
High	62	59	64

Values are means with standard deviations or percentages.

FLY-Kids Scores

Parents reported a mean satisfaction level of 8.4 (SD 1.0, range 6-10) with regard to their child's overall lifestyle. The scores on the other FLY-Kids items are demonstrated in Figure 2. A proportion of 72% of children scored "green" on the item vegetables, meaning they complied with the age-specific recommendation. For fruit, this was 89%, for sugar-sweetened beverages 43%, and for snacks 19%. Parents reported the most favourable response option in 96% and 63% of cases on mealtime practice and food parenting practice items, respectively. Regarding physical activity, screen time, and sleep, parents indicated that their child met the recommendation, respectively, in 74%, 53%, and 73% of cases. A total of 6 children (3.0%) scored "green" on all items. On average, children scored 3.2 items (SD 1.6, range 0-9, median 3) that did not meet the recommendation (indicated as "yellow", "orange", or "red"), and 2.3 items (SD 1.7, range 0-8, median 2) that required further exploration according to the work instruction (indicated as "orange" or "red").

Parents who scored high on the satisfaction scale indicated fewer items not meeting the recommendation ($r= -0.32$, $p<0.001$). The age of the children was also associated with the number of items not meeting the recommendation ($r=0.30$, $p<0.001$), with younger

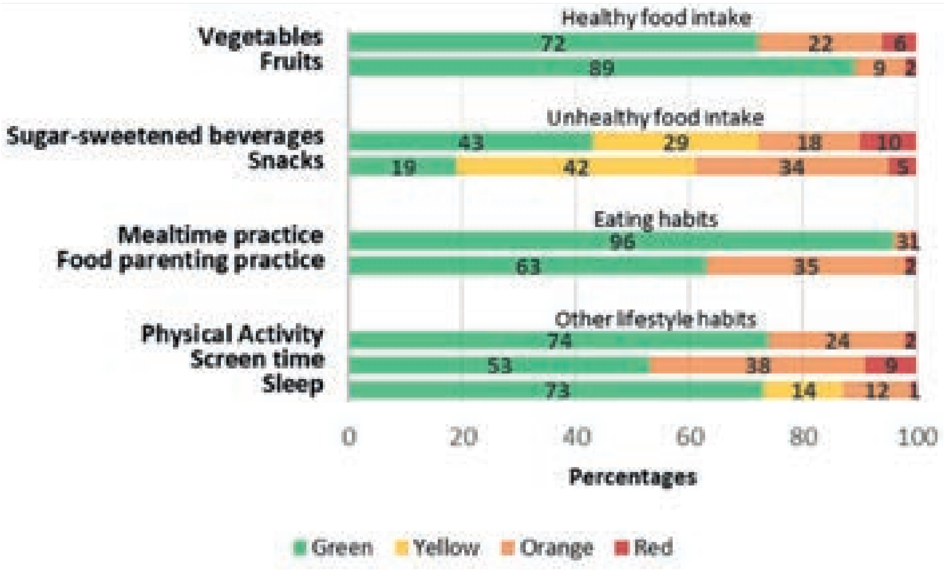


Figure 2: FLY-Kids scores (as compared to national recommendations)

children having fewer unfavourable scored items. We found no association between the number of items that did not meet the recommendation and the weight-for-height SD score of the children (r=-0.03, p=0.72).

Usability and Feasibility of FLY-Kids

Parents

As to usability of FLY-Kids, parents rated the completion ease with a mean of 4.8 (SD 0.4) (Table 2). The mean rating on clarity of the questions was 4.8 (SD 0.4). Helpfulness of FLY-Kids in the conversation with the YHCP and helpfulness of FLY-Kids-related tips and advice received were scored with an average of 4.4 (SD 0.8) and 4.5 (SD 0.7), respectively. Regarding feasibility, parents rated the completion time with a mean of 4.9 (SD 0.4) and willingness to complete FLY-Kids regularly with a mean of 4.0 (SD 1.1). A total of 36 parents provided an additional open text response. The themes "overall experience", "snacks", "digitalization", "free text option", "language", and "miscellaneous" were used to categorize these responses, which mainly concerned tips for further implementation.

YHCP

Concerning usability of FLY-Kids, YHCP scored the overall user-friendliness with an average of 4.6 (SD 0.7) and the clarity of how to use the screening tool with a mean of 4.8 (SD 0.4) (Table 2). Helpfulness of the dashboard in providing an overview of the child's lifestyle and helpfulness of FLY-Kids in the conversation were rated with mean values of 4.5 (SD

0.6) and 4.5 (SD 0.6), respectively. As to feasibility, practicality of using FLY-Kids during the consultation scored a mean of 4.1 (SD 0.9). YHCP rated the compatibility with regular working practice and possibility of integration within the consultation time constraints with means of 4.1 (SD 0.7) and 3.7 (SD 1.1), respectively. In addition, they scored the satisfaction of parents when using FLY-Kids with a mean of 4.1 (SD 0.8) and the workability of the courses of action with a mean of 4.3 (SD 0.8). Open text responses by YHCP were classified in the themes "digitalization", "nuance within responses", and "concerns for implementation".

Table 2: Usability and feasibility of FLY-Kids according to parents and YHCP

Parents			
Usability		**Feasibility**	
Item	**Rating, mean (SD)**	**Item**	**Rating, mean (SD)**
Completion ease	4.8 (0.4)	Completion duration	4.9 (0.4)
Clarity of questions	4.8 (0.4)	Willingness regular completion	4.0 (1.1)
Helpfulness in conversation	4.4 (0.8)		
Helpfulness of tips and advice	4.5 (0.7)		
YHCP			
Usability		**Feasibility**	
Item	**Rating, mean (SD)**	**Item**	**Rating, mean (SD)**
User-friendliness	4.6 (0.7)	Practicality during consultation	4.1 (0.9)
Clarity of utilisation	4.8 (0.4)	Compatibility with working practice	4.1 (0.7)
Helpfulness of dashboard	4.5 (0.6)	Possibility integration within consultation time	3.7 (1.1)
Helpfulness in conversation	4.5 (0.6)	Satisfaction of parents	4.1 (0.8)
		Workability of courses of action	4.3 (0.8)

8

Preliminary Effects of FLY-Kids

A majority of parents (96%) reported having discussed their child's lifestyle with the YHCP during the consultation. The YHCP reported an average of 2.9 FLY-Kids items (SD 2.4, range 0-9, median 2) discussed. The number of items scored "orange" or "red" was associated with the number of items discussed during the consultation ($r=0.47$, $p<0.001$).

Discussion

This paper describes the development and first evaluation study of FLY-Kids, a lifestyle screening tool for children aged 1-3 years. Following the development process, we showed that most parents were willing to complete FLY-Kids and considered it helpful and easy to use. YHCP confirmed this usefulness and discussed with parents items marked as requiring further exploration.

Parents scored an average of 3.2 (out of 9) unfavourable lifestyle behaviours in their children, and only 3.0% of children complied with all recommendations. These findings suggest that FLY-Kids is able to identify unhealthy behaviour and that young children may benefit from lifestyle screening through FLY-Kids, via targeted advice for lifestyle improvement by their parents. Most unfavourable lifestyle behaviours were reported in unhealthy food intake (sugar-sweetened beverages and snacks) and electronic screen time behaviour. These results are in accordance with previous population studies that demonstrated that young children regularly consume sugar-sweetened beverages and snacks that are high in salt, sugar and saturated fats [21]. Concerning usage of electronic screens, our results also concur with former studies that concluded that a major proportion of young children does not meet screen time guidelines [22].

Interestingly, parents who scored high on the satisfaction scale scored more items meeting the recommendation. It cannot be inferred from our results whether following more recommendations increased parents' satisfaction with their child's lifestyle or the other way around. However, in line with the potential benefits of motivational interviewing for lifestyle behaviour change, we consider determining parental satisfaction a relevant component of FLY-Kids [23].

Overall, we discovered end-user support for the use of FLY-Kids within youth healthcare, a crucial condition for successful implementation. Regarding the usability, parents and YHCP reported that the screening tool was simple and easy to use. Furthermore, we observed that both parents and YHCP regarded FLY-Kids to be helpful in the conversation. As this user experience matches the goal of FLY-Kids, i.e. to screen young children's lifestyle in order to support a conversation about lifestyle between parents and YHCP, this is an encouraging finding. Moreover, YHCP felt they were given a good overview of children's lifestyle and parents valued the tips and advice they received. FLY-Kids' feasibility for use in youth healthcare was also rated fairly high, albeit lower than its usability. For YHCP, this was mainly due to the limited consultation time. As also mentioned by several parents, digitalization of FLY-Kids may increase its usability. In addition, a digital version may enhance integration with the electronic health record, saving time and increasing feasibility, and enable longitudinal measurements.

In 96% of cases, parents reported they had discussed their child's lifestyle with the YHCP during the consultation. While parents scored an average of 2.3 items that needed further exploration according to the work instruction, an average of 2.9 FLY-Kids items was discussed during the consultation. Furthermore, we found a strong association of the number of items requiring further exploration with the number of items discussed. These results suggest that FLY-Kids promotes a conversation about lifestyle that is not limited to aspects that may require attention.

However, the crucial step in improving children's lifestyle lies in incorporating the information and advice and actual lifestyle behaviour change. Ultimately, this would lead to positive health outcomes, such as maintaining a healthy weight. In the evaluation study, we could not determine an association between the number of items that did not meet the recommendation and the weight-to-height SD score of the children. Such outcome validation would provide evidence that FLY-Kids is a valuable tool in identifying children at the highest risk for lifestyle-related health problems. Longitudinal research is needed to determine whether the use of FLY-Kids contributes to positive lifestyle behaviour change and associated health benefits.

Strengths and Limitations

FLY-Kids was created through an extensive development process. By first evaluating parental satisfaction and provision of specific courses of action, YHCP are assisted in engaging into an open dialogue with the parent and tailoring advice to fit the family concerned. We consider these features to be major strengths of the tool. The high response rate of the evaluation study suggests that FLY-Kids is undemanding and can be used in preventive healthcare settings with limited consultation time.

As discussing lifestyle is incorporated in standard care and we did not include a control group, it could not be inferred from our findings whether FLY-Kids ensures more frequent lifestyle dialogues. In addition, the presence of the researcher may have resulted in more awareness and prompts to talk about lifestyle, and more socially desirable responses. Although the evaluation study was carried out in areas with varying degrees of urbanization, only a small percentage of parents had a low education level and/or migration background. Given that these families may have higher odds for having an unhealthy lifestyle, we consider this another study limitation [24, 25]. Lastly, some locations also offered telephone instead of in-person consultations to 2- and 3-year-olds, leading to a lower number of evaluated children within these age groups.

Conclusions

FLY-Kids is a screening tool designed to rapidly evaluate multiple dimensions of lifestyle in children aged 1-3 years. It allows YHCP to use a dashboard with outcomes as a conversation tool to provide parents with tailored support towards behaviour change. FLY-Kids' usability and feasibility were highly rated by parents and YHCP. In addition, during the preventive healthcare consultation, parents and YHCP were able to discuss lifestyle items identified by FLY-Kids as requiring attention. Longitudinal research is needed to determine whether the use of FLY-Kids contributes to positive lifestyle behaviour change and associated health benefits.

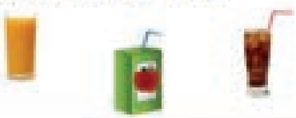
Acknowledgements

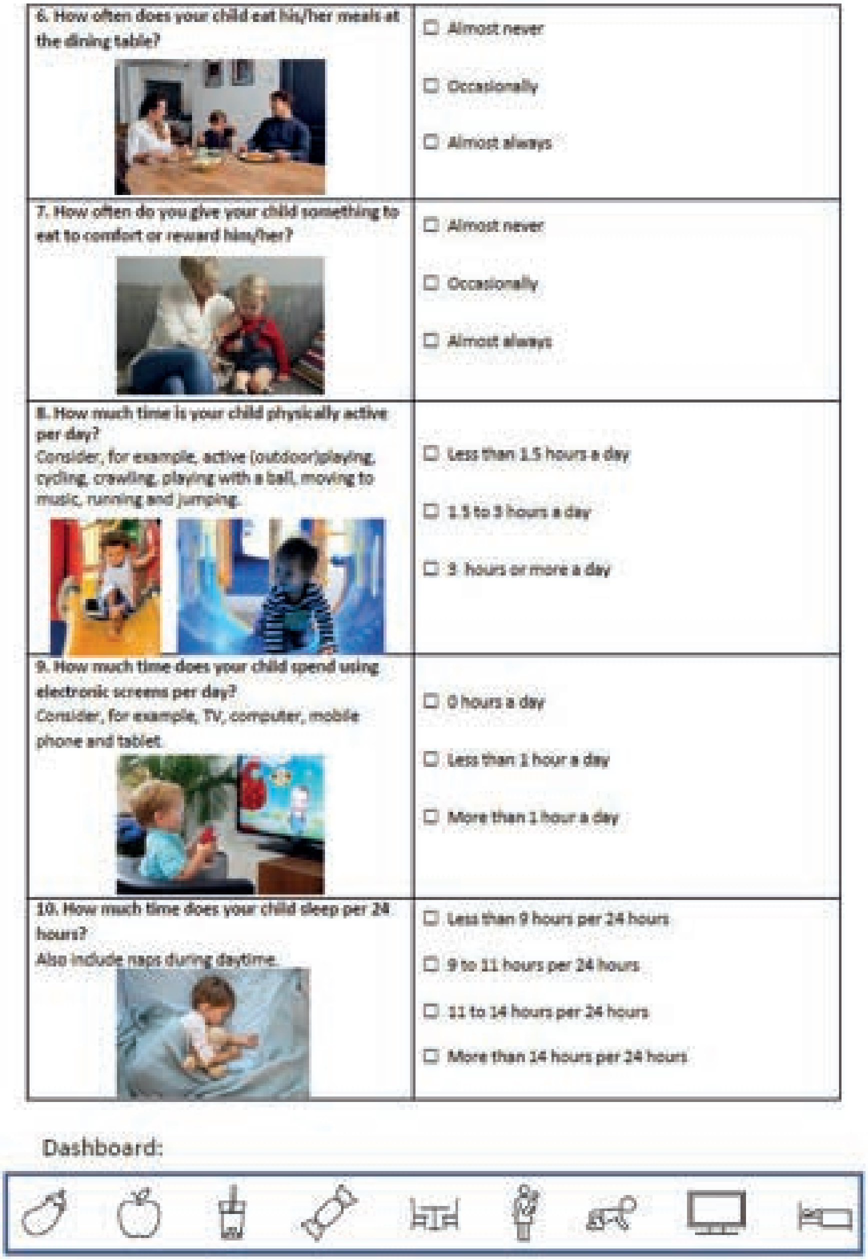
The authors thank all participating families and youth healthcare professionals involved. We thank Ashley Smit, Diana Capello, Lianne Wieldraaijer, and Demi Tabak for their help with the recruitment and execution of the evaluation study, and all partners from the Platform Healthy Nutrition 0-4 years for their expert opinion.

Supplemental Material

Online Resource 1

FLY-Kids **Please tick the box of your choice for each question**

1. How satisfied are you with your child's lifestyle (diet, physical activity, screen time, sleep)? Circle a number between 1 and 10	Satisfaction  1 2 3 4 5 6 7 8 9 10
2. How many vegetables does your child eat per day? Consider all vegetables your child consumes, including, for example, cucumber in between meals.  Examples of 1 serving spoon of vegetables	☐ Less than half a serving spoon a day ☐ Half to 1 serving spoon a day ☐ 1 serving spoon or more a day
3. How many days a week does your child eat fruit? 	☐ Less than 4 days a week ☐ 4 to 6 days a week ☐ Every day
4. How many sugar-sweetened beverages does your child drink per day? Consider, for example, soft drinks, fruit juice, thick juice, lemonade, and milk drinks with sugar, such as chocolate milk and yoghurt drink. 	☐ None ☐ Less than 1 glass or juice box a day ☐ 1 glass or juice box a day ☐ 2 glasses or juice boxes or more a day
5. How many snacks does your child eat per day? Consider, for example, cookies, candy, crisps, and cake. 	☐ None ☐ Less than 1 snack a day ☐ 1 snack a day ☐ 2 snacks or more a day



6. How often does your child eat his/her meals at the dining table?	☐ Almost never ☐ Occasionally ☐ Almost always
7. How often do you give your child something to eat to comfort or reward him/her?	☐ Almost never ☐ Occasionally ☐ Almost always
8. How much time is your child physically active per day? Consider, for example, active (outdoor)playing, cycling, crawling, playing with a ball, moving to music, running and jumping.	☐ Less than 1.5 hours a day ☐ 1.5 to 3 hours a day ☐ 3 hours or more a day
9. How much time does your child spend using electronic screens per day? Consider, for example, TV, computer, mobile phone and tablet.	☐ 0 hours a day ☐ Less than 1 hour a day ☐ More than 1 hour a day
10. How much time does your child sleep per 24 hours? Also include naps during daytime.	☐ Less than 9 hours per 24 hours ☐ 9 to 11 hours per 24 hours ☐ 11 to 14 hours per 24 hours ☐ More than 14 hours per 24 hours

Supplementary Figure 1: FLY-Kids tool for children aged 1 year (translated and back translated from and to Dutch)

Note: Response options for **screen time** for children aged 2 and 3 years are: 0 to 1 hour a day, 1 to 2 hours a day, and 2 hours or more a day. Response options for **sleep** for children aged 3 years are: less than 8 hours per 24 hours, 8 to 10 hours per 24 hours, 10 to 13 hours per 24 hours, and more than 13 hours per 24 hours

Online Resource 2

Supplementary Text File 1: Detailed description of the development of the lifestyle screening tool FLY-Kids

A consortium of directly involved parties was established at the start. Throughout the project, this consortium met every few months for updates and discussion. In addition, once a year, a larger group of experts united in the Dutch "Platform Healthy Nutrition 0-4 years" [1] held a meeting about the project.

In phase 1, we established the scientific background of the screening tool under development. A systematic review was conducted to identify existing lifestyle screening tools for children in the community setting and to gain insight into their features of design, psychometric properties and implementation [2]. The Dutch National Food Consumption Survey 2012-2016 was also used in the development of FLY-Kids. Observed dietary intakes and derived lifestyle clusters of children aged 1-3 years provided information on potential nutritional challenges and underlying patterns, respectively [3, 4]. In addition, we performed desk research into age-specific lifestyle recommendations and guidelines for healthcare professionals and associated advice and information resources for parents to outline lifestyle topics with available courses of action [5-7].

Phase 2 involved target group analysis (results not presented). We conducted an online survey among parents of young children and focus group discussions among parents (N=25) and YHCP (N=25) to identify the needs and wishes for the lifestyle screening tool under development. Using a topic guide, we consecutively addressed: 1) the role of youth healthcare in young children's lifestyle, and 2) the requirements for the lifestyle screening tool under development.

A prototype of FLY-Kids was developed in phase 3. To support YHCP in aligning with parents' perceptions during the healthcare visit, the first item was constructed to address the parental perspective on their child's lifestyle. For the other items in the tool, we restricted the list of potential topics emerging from phases 1 and 2 to topics concerning modifiable lifestyle behaviour of the child. Topics selected for the prototype had to be associated with health outcomes in children. Moreover, age-specific recommendations and courses of action had to be available in the case of unfavourable behaviour. Items were formulated at Dutch language level B1. For each lifestyle item in the prototype, potential courses of action were compiled based on the desk research. Then, using a modified Delphi process, the content of the 10-item prototype and courses of action were evaluated by a group of experts (paediatricians, youth healthcare physicians, dietitians, nutrition scientists, and policy officers) in two online survey rounds [8]. In round 1, participants were to express their opinion on the FLY-Kids items (questions and response options), choosing from: "Fine, keep in present form", "Small modification, namely:...", "Other question with this topic, namely:...". A free text field was included for suggestions and recommendations. In addition, participants were asked to add to the lists of courses of action. Round 1 was completed by 30 participants, with agreement ranging from 23-80%. Revision of the prototype was based on agreement and free text input. In round 2, participants had to indicate whether they agreed with the modified items and lists of courses of action ("Yes, I agree", "No, I do not agree"). Again a free text field was included. A total of 25 participants completed round 2. Agreement for the FLY-kids items ranged from 76-100%. For the courses of action, an agreement between 88-100% was reached. A meeting with the Platform Healthy Nutrition 0-4 years was organised to discuss final modifications and to agree upon the final content of FLY-Kids. Finally, FLY-Kids was provided with supporting images to assist parents in completing the screening tool (Online Resource 1).

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Online Resource 3

Supplementary Text File 2: Detailed description of the data collection within the evaluation study of FLY-Kids

Parents were informed about the aim of the study, invited to participate and asked to provide written informed consent by a researcher. Only parents who provided informed consent were included in the study. Upon arrival in the waiting room and as part of standard care, anthropometric measurements of the children were performed according to standardised protocols. A doctor's assistant or trained researcher weighed children (wearing no or light underclothes) to the nearest 100 grams using a calibrated mechanical or digital scale. An infantometer and stadiometer were used to measure the height of children below and above two years, respectively, to the nearest 1 millimetre. Parents who had agreed to participate completed the paper form of FLY-Kids and returned it to the researcher. The researcher scored the items and passed the form on to the YHCP. The YHCP then used FLY-Kids during the consultation to initiate the conversation about lifestyle. More specifically, parental satisfaction with their child's lifestyle and questions parents were addressed, and items scored "orange" or "red" were further explored. More information and advice were given accordingly. YHCP marked the discussed FLY-Kids items on the form. After the consultation, parents reported some characteristics about themselves and responded to statements about the usability and feasibility of FLY-Kids on a scale of 1 (strongly disagree) to 5 (strongly agree) and could give additional written feedback. The YHCP evaluated the usability and feasibility of FLY-Kids, also on a scale of 1 (strongly disagree) to 5 (strongly agree) via an online form following the evaluation period at the healthcare centre where they were employed.

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Chapter 9

General discussion

The overall aim of this thesis was to improve preventive youth healthcare for young children (aged 1-3 years) by developing and evaluating a lifestyle screening tool. The thesis emanates from the FLY-Kids (Features of Lifestyle in Young Kids) project 2020-2023, which was undertaken as part of the National Prevention Agreement and commissioned by the Dutch Ministry of Health, Welfare and Sport [1]. The National Prevention Agreement aims to offer all children a good start in life and keep adults healthy and active for as long as possible by reducing overweight, smoking, and problematic alcohol use. Regarding overweight, the key pillar of the FLY-Kids project, the ambition is to lower the prevalence of overweight and obesity to 1995 levels by 2040. Formative research (Parts I and II) was conducted to serve as input for the development and evaluation (Part III) of the lifestyle screening tool 'FLY-Kids'.

The main objectives of this thesis were:

Part I – Current lifestyle behaviour of children

7. To explore current lifestyle behaviour in children
8. To identify patterns in lifestyle behaviour of young children

Part II – Existing tools and requirements from youth healthcare practice

9. To summarize characteristics of existing lifestyle screening tools for children
10. To determine requirements for the lifestyle screening tool according to parents and youth healthcare professionals

Part III – Development and evaluation of FLY-Kids

11. To design and evaluate the lifestyle screening tool 'FLY-Kids'

In this general discussion, we comment on our main findings. In addition, we address methodological considerations of the FLY-Kids project, discuss future perspectives and provide a general conclusion.

A Healthy Lifestyle Early in Life

The National Prevention Agreement aims to give all children a 'good start' in life that will benefit them for the rest of their lives [1]. There is considerable evidence to support the hypothesis that adhering to a healthy lifestyle from an early age is crucial for adequate growth and development, as well as for overall health in early and later life [2-5]. Conversely, unhealthy lifestyle behaviours seems to be associated with adverse health outcomes, even in children [6-8]. In research, policy documents and other media, lifestyle is often referred to as specific behaviours, including dietary intake, physical activity, electronic screen time behaviour and sleep. It is known that the lifestyle patterns of young children can consist of both healthy and unhealthy behaviours [9, 10]. As lifestyle habits and patterns are established in early childhood and tend to persist over time, as do their consequences, optimising lifestyle behaviour in young children offers potential for the rest of life [11-15].

As described above, lifestyle improvement in young children is hypothesized to contribute to the prevention of health issues. Common lifestyle-related health issues in young children include overweight, underweight, micronutrient malnutrition (for example characterized by anaemia or low vitamin D status), constipation, myopia, and delayed motor development, but also psychological problems [16-22]. Overweight is among the most frequent and early presenting consequences of an unhealthy lifestyle and is often caused by a positive energy balance [16]. Moreover, overweight can be a precursor to other problems, such as cardiovascular morbidity at a young age and cardiovascular disease at a later age [16]. Figure 1 depicts the evolution of overweight prevalence among children aged 2-21 years from 1981 to 2009 in the Netherlands [23]. Although the rapidly increasing trends in childhood obesity over the past decades seem to have stabilized, more recent data have shown a prevalence of overweight in 15.5% of children aged 2 to 9 years in 2021, of whom 4.8% were severely overweight [24]. The National Prevention Agreement has established the objective of reducing the percentage of overweight and obesity in children aged 4-18 years from 13.5% to 9.1% or less and from 2.8% to 2.3% or less, respectively [1]. A similar commitment is set for children under 4 years. While the 'Guideline overweight and obesity' provide guidance in diagnostics, support and care for children who are already overweight or obese, many other sectors are currently taking action to prevent other children from becoming overweight [25]. Preventive youth healthcare is an important player in this, reaching almost all young children in the Netherlands [26]. Hence, strengthening their approach to positive lifestyle behaviour change has the potential to considerably lower the burden of overweight and other lifestyle-related health issues in the Netherlands.

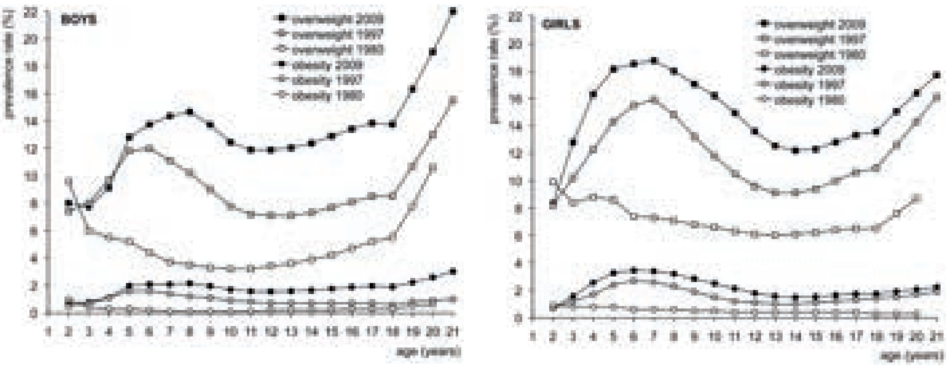

Figure 1: Prevalence of overweight and obesity in Dutch children aged 2-21 years from 1981 to 2009 (Source: Schönbeck et al. 2011 [23])

Part I – Current Lifestyle Behaviour of Children

In Part I of this thesis, we described the current lifestyle behaviour of Dutch children in order to identify opportunities for improvement and to determine starting points for the lifestyle screening tool under development. The Dutch National Food Consumption Survey 2012-2016 provided insight into habitual nutrient intake, food consumption, and lifestyle patterns of children aged 1-3 years in the Netherlands (Chapters 2 and 3). Although we were unable to provide a statement about all nutrients, the habitual intake of most nutrients seemed adequate (Chapter 2). The high intakes of saturated fatty acids, retinol, iodine, copper, zinc, and sodium found may have been an indicator of the high intakes of unhealthy food products among the children. Given that these unhealthy food products are generally energy dense and may thus be related to undesirable weight development, preventive measures, such as a lifestyle screening tool, could respond to this. Furthermore, these results support the objectives pursued by the National Prevention Agreement to inform consumers about the 'Wheel of Five' (i.e. the Dutch food-based dietary guidelines issued by the Netherlands Nutrition Centre [27]) and to encourage and entice them to eat accordingly [1]. Using cluster analyses, we identified three distinct patterns in the lifestyle behaviours of these 1-3-year-olds (Chapter 3). The 'relatively healthy cluster' was characterized by high intakes of fruit and vegetables, low intakes of sugar-sweetened beverages and unhealthy snacks, and low screen time. The 'active snacking cluster' demonstrated high unhealthy snack intake and high physical activity, and the 'sedentary sweet beverage cluster' differentiated itself by high intake of sugar-sweetened beverages and high screen time. As children aged 1 year were more likely to be allocated to the 'relatively healthy cluster' than children aged 2 and 3 years, we suggest that preventive efforts may focus more on maintaining healthy behaviour in 1-year-olds and on changing towards healthy behaviour in children aged 2 and 3 years. The observed association between a lower education level of the parents and a less healthy cluster of the child supports the notion that professionals should consider determinants in the distal layers of the social determinants of child health model (Pearce et al. [28], described in the Introduction of this thesis) when deploying interventions to improve children's lifestyles.

In addition to quantity, dietary intake can also be expressed as diet quality, for which various indices are available. To operationalize diet quality in Dutch children aged 5-6 years, we employed the Dietary Approaches to Stop Hypertension (DASH) score and the child diet quality score (CDQS) (Chapter 4) [17, 29]. The results showed that higher diet quality according to these indices at age 5-6 years was associated with lower body mass index, lower plasma triglycerides, and lower risk of dyslipidaemia after six years follow-up. These findings concur with previous research and highlight the importance of diet quality in school-age children [30]. Whether such associations between diet quality in children aged 1-3 years and later cardiovascular outcomes also exist, cannot be inferred from our findings. However, it is known that dietary patterns tend to persist over time, which implies that diet quality at age 5-6 years could have been established earlier and determining diet quality in children aged 1-3 years may be valuable [12]. Nevertheless, as the DASH score and CDQS are based on time-consuming food frequency questionnaires, we deemed them unsuitable for incorporation into the rapid lifestyle screening tool that was being developed during the thesis process.

Part II – Existing Tools and Requirements from Youth Healthcare Practice

Part II of this thesis focused more directly on the lifestyle screening tool under development. We conducted a systematic review to summarise the design, psychometric properties and implementation of existing lifestyle screening tools for children (0-18 years) in community settings (Chapter 5). The majority of the 41 tools identified addressed lifestyle behaviours related to overweight, including nutrition, physical activity and sedentary behaviour/screen time. Although research has shown an association between sleep with weight and overall health, only four tools addressed this topic [31, 32]. In addition, current tools for children aged 1-3 years were mostly limited to nutrition, with courses of action being either non-specific or absent. Parental completion of a screening tool may raise awareness, but it is more likely that courses of action following the answers given will increase the chances of behaviour change. For example, using the transtheoretical model of behaviour change, we may consider completing a tool and receiving feedback to be part of the contemplation phase, whereas the provision of advice may guide the parent more towards preparation of behaviour change [33]. To identify unfavourable lifestyle behaviour in children aged 1-3 years and protect them from adverse lifestyle-related health outcomes, we deemed it necessary to develop a new lifestyle screening tool that addresses lifestyle as a whole and includes specific courses of action.

The COVID-19 pandemic provided a unique opportunity for the development of novel screening tools. To identify children and families to whom the Dutch COVID-19 measures have led or may lead to problems in physical or mental health or safety, the COVID-19 child check questionnaire was created. According to the COVID-19 child check, the impact of COVID-19 measures appeared to be different in children with chronic somatic conditions (CSC) and their parents than in children and parents in the general population (Chapter 6). Children with CSC reported less stress, but they also spent less time with friends and were less physically active during COVID-19 measures than children from the general population. In addition to experiencing more stress, children and parents from the general population more frequently had deteriorated financial circumstances, and received less support than children with CSC and their parents. Screening tools such as the COVID-19 child check may aid healthcare professionals to discuss potential problems, but also devise interventions for specific target groups, such as efforts to promote physical activity in children with CSC.

Alignment among stakeholders may be critical to the ultimate success of an innovation

[34]. In order to tailor the screening tool to the requirements of its end-users, we explored the needs and wishes of parents and youth healthcare professionals regarding the new lifestyle screening tool (Chapter 7). To this end, we conducted focus groups. First, we assessed their experiences of current youth healthcare practice in relation to young children's lifestyles, and then we determined their perspectives on the tool under development. Both parents and youth healthcare professionals reported that young children's lifestyle is often discussed. While parents indicated that these conversations could be more in-depth, youth healthcare professionals felt that they needed more tools to continue the lifestyle discussion. Parents and youth healthcare professionals reported that a lifestyle screening tool should be user-friendly, take little time and offer courses of action. In addition, it should be attractive to complete and be tailored to the family, for example in terms of socio-economic and cultural background or skills. In designing the lifestyle screening tool, an effort was made to accommodate as many of these requirements as possible.

Part III – Development and Evaluation of FLY-Kids

Following the formative research in Part I and II, the lifestyle screening tool FLY-Kids was designed and subsequently evaluated in youth healthcare practice in Part III of this thesis. During the creation of FLY-Kids, it was decided that three fundamental conditions had to be met:

1. The lifestyle screening tool had to aid the conversation between parent and youth healthcare professional and be compatible with the demand-driven way of working as used within Dutch youth healthcare;
2. Items within the tool were to be restricted to topics concerning modifiable lifestyle behaviours of the child that may have health effects;
3. Age-specific courses of actions had to be available in the case of unfavourable behaviour.

The final version of FLY-Kids involved a 10-item parent-administered lifestyle screening tool intended to be completed by parents of children aged 1-3 years prior to a youth healthcare visit. FLY-Kids allows for an open conversation and opportunities to connect with the parents' needs by first determining parental satisfaction with their child's lifestyle. The other nine items, which cover the themes of healthy food intake, unhealthy food intake, eating habits, and other lifestyle habits, are evaluated against age-specific recommendations. The youth healthcare professional receives a dashboard with a colour score of these items to guide the conversation and courses of action to support parents changing their child's unfavourable lifestyle behaviours. The high response rate in the evaluation study indicated that parents were willing to complete FLY-Kids in the context of the study (Chapter 8). There was also a relatively high level of user satisfaction with FLY-Kids. Parents reported high scores for usability and feasibility. Youth healthcare professionals also rated FLY-Kids as usable and feasible, but raised some concerns about the implementation, which can be used to further improve procedures. In addition, the study showed an association between the number of items identified by FLY-Kids as requiring attention and the number of items discussed by youth healthcare professionals and parents during the appointment. This finding supports the hypothesis that FLY-Kids can be used to guide the conversation about lifestyle within youth healthcare.

Methodological Considerations of the FLY-Kids Project

A development process based on the Intervention Mapping approach has been used to develop FLY-Kids [35]. The involvement of parents and youth healthcare professionals in both development, first usage, and evaluation of FLY-Kids was essential, as they concern the intended end users. Besides, as we used a representative sample of Dutch 1-3 year olds from the Dutch National Food Consumption Survey, we were able to gain good insight into the lifestyle patterns and bottlenecks in this population. Lastly, by including all children aged 1-3 years attending a regular youth healthcare appointment in our evaluation study, we assessed the use of FLY-Kids in a 'real world setting' and reduced the risk of selection bias.

Despite these strengths, some limitations need to be discussed. Firstly, although we made an extra effort to address the needs and wishes of parents from lower socio-economic and migration backgrounds in the target group analyses, we were unable to determine whether FLY-Kids actually matches the needs of these populations due to their underrepresentation in the evaluation study. To fully support these families who are predisposed to an unhealthy lifestyle, it is critical to explore whether the tool itself (e.g. language use), as well as its use as conversation aid by the youth healthcare professional and the courses of action (e.g. applicability of advices) align with them. Secondly, because FLY-Kids is new in its kind, we could not compare the lifestyle behaviour results in the evaluation study to a 'gold standard' for lifestyle screening in children aged 1-3 years. However, existing validated methods such as repeated 24-hour dietary recalls and actigraphy could be used to compare results on specific FLY-Kids items. Thirdly, there was no follow-up on the courses of action that were given, nor on the children's weight course. Longitudinal research is needed to assess whether the courses of action are adhered to, sustained and ultimately lead to improved health outcomes for the child, such as maintaining a healthy weight.

Future Perspectives

This thesis aligns with the paradigm that early interventions to improve the lifestyles of young children may lead to lifelong health benefits [36]. Prioritising a healthy lifestyle in young children requires efforts from many perspectives and sectors of society, but youth healthcare has a unique position in this regard. Given the promising preliminary effectiveness evaluation, as well as the high usability and feasibility ratings, we propose to expand the use of the lifestyle screening tool FLY-Kids in Dutch youth healthcare practice and to conduct further research on its use. Together with the sounding board group of the FLY-Kids project, we have developed a proposal for an implementation and follow-up strategy, which is detailed below.

Implementation of FLY-Kids within Youth Healthcare

As more youth healthcare professionals become familiar with FLY-Kids and use it to evaluate and discuss young children's lifestyles with parents, the use and effects of the tool can be further explored. For health innovations to be successfully disseminated or implemented in practice, many conditions can be considered [37]. The screening tool should be easily accessible to parents and youth healthcare professionals. Besides, its use must be feasible and take into account the resources available, such as staff time and training, and (digital) infrastructure. And, not least of all, the tool should be user-friendly and align with current working practices. Digitisation of FLY-Kids would be a pragmatic first step toward increasing the instrument's accessibility, feasibility and usability. With a digital version of FLY-Kids, parents might fill out the questions prior to the youth healthcare appointment, for example, on their mobile phone. The items could be scored automatically and sent to the youth healthcare professional, who can open a FLY-Kids dashboard within the electronic health record. This dashboard should provide the youth healthcare professional with a clear overview of the child's lifestyle and guide the conversation between parents and youth healthcare professionals by indicating the items that require attention. Figure 2 depicts an example of such a dashboard.

Figure 2: Example of a FLY-Kids dashboard

After discussing the dashboard, the youth healthcare professional could record the topics discussed and advice given in the electronic health record for future reference using the 'log courses of action' button on the right-hand side of the dashboard. The 'browse courses of action' button can be used to view potential courses of action for each FLY-Kids item. The possibility of sending relevant lifestyle information to parents electronically (an option already available in some electronic health records), such as flyers from the Netherlands Nutrition Centre, could potentially facilitate the uptake of advice given. At the start of the digitisation process, an overview of the system requirements for the digital FLY-Kids needs to be established. A proposal for the functional requirements of the digital version of FLY-Kids with a description of the actions and context is given in Table 1.

Table 1: Functional requirements for the digital FLY-Kids version

Requirement	Description of actions	Context
Intake	Parent completes FLY-Kids digitally	At youth healthcare centre or at home
Data transfer	With the parent's consent, the youth healthcare professional receives the data entered	Youth healthcare centre
Decision support	Youth healthcare professional receives automatic decision support via a digital dashboard	Youth healthcare centre
Tailored advice	During the youth healthcare appointment, parent and youth healthcare professional discuss the dashboard Youth healthcare professional supports parent with advice tailored to the family concerned and decisions regarding follow-up are made jointly Courses of action are documented in a standardised way in the electronic health record	Youth healthcare centre
Monitoring	As the parent completes FLY-Kids annually, a longitudinal lifestyle overview is obtained	At youth healthcare centre or at home
Research	FLY-Kids data can be retrieved and used for research purposes	Youth healthcare centre and research facility

Digitising FLY-Kids may have practical advantages, e.g. no paper forms need to be distributed and stored, and no manual scoring of items. Furthermore, both parents and youth healthcare professionals suggested digitisation in our evaluation study (Chapter 8) and end-user support would be a necessary condition for successful implementation. Digitisation should involve effective engagement with key stakeholders, including parents, youth healthcare professionals, youth healthcare organizations, and IT partners. A co-design based approach involving an iterative process of drawing up requirements, requirement verification, technical development, pilot testing and refinement should result in a digital version of FLY-Kids that is aligned with current practices. Ideally, FLY-Kids would integrate with existing digital applications, such as parent portals or apps like the 'GroeiGids', as parents and youth healthcare professionals are likely to be familiar with them. Data protection and informed consent should be given the utmost attention during the digitisation process to ensure the privacy and data security of both parents and children.

To enable the accommodation of FLY-Kids in the primary process of youth healthcare, an implementation toolkit has to be developed. This toolkit should include a manual for individual use by parents and youth healthcare professionals, as well as materials for the adoption, implementation and continuation of FLY-Kids at an organizational level. The manual may also provide guidelines for specific FLY-Kids scores. For instance, it can be established that all children who score three red items or more should be given a lifestyle follow-up appointment three months later, or that children with more than four orange or red items and an unhealthy weight should be referred to a lifestyle coach. With the current rapid development of new lifestyle interventions and prevention programs, it is also important to keep the courses of action of FLY-Kids up to date.

Furthermore, we propose the launch of a national campaign to familiarize all 38 youth healthcare organizations with FLY-Kids and disseminate its use throughout the Netherlands. For example through symposia or workshops, the campaign may inform about FLY-Kids and its lifestyle themes, while also train youth healthcare professionals on how to effectively integrate FLY-Kids into consultations with parents.

Future Research with FLY-Kids

- Follow-up research could comprise user research as well as focus on (longitudinal) effectiveness of FLY-Kids. Following the implementation process described above, user research needs to determine how widely FLY-Kids is utilized nationally and to what extent it has been implemented locally at the various organizations.
- Besides, the experience of parents and youth healthcare professionals using the digital version of FLY-Kids as part of the primary youth healthcare process should be evaluated.
- A specific focus should be paid on tool utilization among parents with less command of the Dutch language, parents with a migration background, and families with lower socio-economic status. Considering the vulnerability to an unhealthy lifestyle in these populations [38-40], it is critical to assess how the instrument may best serve them, for example, by translating the questions or altering the courses of action, in order to improve tool accessibility.
- Due to the limited time available in youth healthcare practice, it should also be examined whether using FLY-Kids inhibits the discussion of other important topics during the appointment.
- The ultimate goal of FLY-Kids is to provoke behaviour change and reduce adverse lifestyle-related health effects in young children. Since these health effects, such as overweight, emerge slowly and the process of behaviour change comprises several

stages, examining an indicator early in the process of behaviour change, such as the parent's intention to change lifestyle behaviour right away and after one month, may be most relevant on the short-term. Using a randomised controlled trial design, these results could be compared with data of children in whom FLY-Kids was not used.

- To also measure later effects, we propose to conduct a study with three cohorts of 1-, 2- and 3-year-olds in which FLY-Kids is used at a youth healthcare visit and data collected on current dietary intake, physical activity, screen time, sleep and anthropometrics. After one year, measurements could be repeated and compared with the results obtained at the start of the study. Again, this could be done in a randomized controlled trial design.
- In addition, qualitative research, for example, could explore what factors lead parents to follow the lifestyle advice given by the youth healthcare professionals.

General Conclusions

In Dutch children aged 1-3 years, we identified potential nutritional challenges and distinguished both healthy and unhealthier lifestyle patterns. In children aged 5-6 years, we found that higher diet quality was associated with better cardiovascular health after six years of follow-up. Evaluation of young children's lifestyles may contribute to preventive care aimed at maintaining healthy behaviour and modifying unhealthy behaviour in order to prevent lifestyle-related health issues. While existing lifestyle screening tools for young children were mainly limited to nutrition and lacked clear courses of action, we developed FLY-Kids in consultation with parents and youth healthcare professionals. The lifestyle screening tool FLY-Kids can be used to identify unhealthy lifestyle behaviour in children aged 1-3 years and aims to guide the conversation about lifestyle between parents and youth healthcare professionals. Youth healthcare professionals are provided with topic-specific courses of action to support parents in changing their child's unfavourable lifestyle behaviours. FLY-Kids scored high on usability and feasibility. In addition, the association found between the number of items identified by FLY-Kids as requiring attention and the items discussed during the consultation suggests that FLY-Kids is likely to be helpful as a conversation aid between parents and youth healthcare professionals. To improve preventive youth healthcare and the health of future generations, efforts should be made to implement FLY-Kids and perform more (longitudinal) research. Particular attention should be devoted to the usage of FLY-Kids in children with lower socio-economic backgrounds. Ideally, FLY-Kids will contribute to a healthy future for generations to come.

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Chapter 10

Summary

Introduction

A healthy lifestyle is essential for optimal growth, development and overall health of young children (1-3 years), whereas an unhealthy lifestyle at an early age may lead to negative health outcomes, such as being overweight or underweight. Evaluating, discussing and advising on young children's lifestyles by healthcare professionals may contribute to modify unhealthy behaviours in time to prevent adverse health effects. To support youth healthcare in this, the aim of the studies in this thesis was to develop and evaluate a new lifestyle screening tool for children aged 1-3 years.

Part I – Current Lifestyle Behaviour of Children

The first part of this thesis describes the current lifestyle behaviour of Dutch children. In **Chapter 2**, we evaluated the habitual nutrient intakes of children aged 1-3 years and compared their intakes of specific food groups with the Dutch food-based dietary guidelines. Data were obtained from the Dutch National Food Consumption Survey and included 672 children. Intakes of most nutrients seemed to be adequate, but only two-thirds of children took the recommended vitamin D supplement. In addition, we found high intakes of saturated fatty acids, retinol, iodine, copper, zinc and sodium. This result may be due to the fact that the children consumed relatively many products that are not recommended by the Dutch food-based dietary guidelines. Within the same group of children, we aimed to distinguish clusters in the intake of the food groups fruit, vegetables, sugar-sweetened beverages and unhealthy snacks, and reported physical activity and screen time in **Chapter 3**. Three clusters emerged from the data: the 'relatively healthy cluster', the active snacking cluster' and the 'sedentary sweet beverage cluster'. The 1-year-olds were more likely to be in the 'relatively healthy cluster'. We also found that children of parents with lower levels of education were less likely to be in the 'relatively healthy cluster' and more likely to be in the 'sedentary sweet beverage cluster'. These results suggest that lifestyle interventions may focus more on maintaining healthy behaviour in 1-year-olds, and more on switching towards healthy behaviour in 2- and 3-year-olds. Such efforts may take into account the education level of the parents.

In **Chapter 4**, we used data of 869 children that participated in the Amsterdam Born Children and their Development study and assessed the association between diet quality at age 5-6 years and cardiovascular outcomes in children aged 11-12 years. Diet quality was operationalised as the Dietary Approaches to Stop Hypertension score and a Dutch child diet quality score. We found that higher diet quality scores at ages 5 and 6 were associated with lower BMI, lower waist circumference, lower blood pressure, and lower plasma triglyceride concentrations after 6 years of follow-up. No association was found between diet quality and LDL, HDL, and total cholesterol, fasting glucose or carotid intima-media thickness. These findings suggest that improving diet quality in children may contribute to prevent health issues in the short and long term.

Part II – Existing Tools and Requirements from Youth Healthcare Practice

In the second part of this thesis, we focus more on the lifestyle screening tool to be developed. In **Chapter 5**, we conducted a systematic literature review on existing lifestyle screening tools for children aged 0-18 years in community settings. Of the 41 unique tools we identified, the majority addressed behaviours associated with overweight and obesity. Tools for young children (1-5 years) mainly covered nutrition items only. In addition, the validation of most of the tools was limited, and there was a lack of clear courses of action following tool outcomes. We therefore concluded that there was a need to develop a new and simple lifestyle screening tool for young children that would provide specific courses of action.

In **Chapter 6**, we describe our research using the 'COVID-19 child check' questionnaire. The COVID-19 child check was developed for early identification of problems in the physical or psychological health and safety of children and families due to the COVID-19 measures. In our study, we compared the outcomes of the COVID-19 child check in children with chronic somatic conditions (n = 326) and their parents with those in children (n = 1,278) and parents from the general population. We showed that the impact of the COVID-19 measures differed between these groups. Although children with chronic somatic conditions experienced less stress than the general population, they also reported less physical activity and less social interaction with friends. Tools such as the COVID-19 child check may be helpful in supporting the conversation between parents and healthcare professionals in specific situations.

In order to tailor the screening tool under development to the requirements of the end users, i.e. parents and youth healthcare professionals, we conducted focus group interviews to assess their needs and wishes. The results of this study are presented in **Chapter 7**. First, we explored experiences of current youth healthcare practice in relation to young children's lifestyles. Both parents and youth healthcare professionals indicated that lifestyle is often discussed during consultations. Parents would like this discussion to go further, and youth healthcare professionals requested more tools to continue the conversation about lifestyle. Regarding the new lifestyle screening tool, parents and youth healthcare professionals agreed that the tool should be user-friendly, take little time and offer courses of action. It should also be attractive to complete and tailored to the family.

Part III – Development and Evaluation of FLY-Kids

The actual development and evaluation of the lifestyle screening tool is described in the third part of this thesis. **Chapter 8** gives an overview of the development process and describes the results of the first evaluation of the lifestyle screening tool 'FLY-Kids'

(Features of Lifestyle in Young Kids). FLY-Kids can be used to quickly and easily map the lifestyle of children aged 1-3 years and to support the conversation about lifestyle between parents and youth healthcare professionals. A dashboard is created based on the parent's responses to ten multiple-choice items (covering items on: parental satisfaction with the child's lifestyle, healthy food intake, unhealthy food intake, eating habits, and other lifestyle habits). This dashboard serves as a conversation tool for the parent and youth healthcare professional. The corresponding courses of action can be used by the youth healthcare professional to support the parent in improving the child's lifestyle. A total of 201 parents of children aged 1-3 years participated in the evaluation. We found that parents scored an average of 3.2 unhealthy lifestyle behaviours in their children and that only 3.0% complied with all recommendations. Both parents and youth healthcare professionals rated FLY-Kids as usable and feasible. In addition, we found an association between the number of lifestyle concerns identified by FLY-Kids and the actual number of items discussed during the youth healthcare consultation. Based on these findings, we suggest that FLY-Kids can be used to identify unhealthy behaviour in young children and to support the conversation about lifestyle within youth healthcare.

Discussion

This thesis concludes with a discussion in **Chapter 9**. In the discussion we comment on the main findings as described above. We also report on the strengths and limitations of the FLY-Kids project. Finally, we describe possible future perspectives for FLY-Kids. As FLY-Kids seems to support the conversation about lifestyle between parents and youth healthcare professionals, and both found FLY-Kids user-friendly and helpful, we suggest that the use of FLY-Kids within youth healthcare should be further expanded and studied. Digitising the tool could be a first step towards further implementation. Future research may focus on both the (digital) user experience and the possible longitudinal effects of using FLY-Kids. This research should pay particular attention to its use in families from lower socio-economic and migrant backgrounds.

Chapter 11

Samenvatting

Introductie

Een gezonde leefstijl is essentieel voor optimale groei, ontwikkeling en algehele gezondheid van jonge kinderen (1 tot en met 3 jaar). Daarentegen kan een ongezonde leefstijl op jonge leeftijd al leiden tot negatieve gezondheidseffecten, zoals bijvoorbeeld overgewicht of ondergewicht. Het signaleren en bespreken van en het adviseren over ongezond leefstijlgedrag bij jonge kinderen door zorgprofessionals zou kunnen bijdragen aan het tijdig bijsturen van ongezond gedrag en mogelijke preventie van leefstijl gerelateerde gezondheidsproblemen. Om de jeugdgezondheidszorg (JGZ) hierin te ondersteunen was het doel van de onderzoeken in dit proefschrift het ontwikkelen en evalueren van een leefstijlsignaleringsinstrument voor kinderen van 1 tot en met 3 jaar.

Deel I – Huidig leefstijlgedrag van kinderen

Het eerste deel van dit proefschrift beschrijft het huidige leefstijlgedrag van Nederlandse kinderen. In **Hoofdstuk 2** hebben we bij kinderen van 1 tot en met 3 jaar de gebruikelijke voedingsinname geëvalueerd op nutriëntniveau en de consumptie van specifieke voedingsgroepen vergeleken met de Richtlijnen van de Schijf van Vijf van het Voedingscentrum. Hiervoor is gebruikgemaakt van data van 672 kinderen die hadden deelgenomen aan de Voedselconsumptiepeiling 2012-2016 van het RIVM. De inname van de meeste nutriënten leek adequaat, maar slechts twee derde van de kinderen nam het aanbevolen vitamine D supplement. Daarnaast werden hoge innames van verzadigde vetzuren, retinol, jodium, koper, zink en zout gevonden. De oorzaak hiervan ligt mogelijk in het feit dat de kinderen relatief veel producten buiten de Schijf van Vijf nuttigden. Binnen dezelfde groep kinderen hebben we in **Hoofdstuk 3** bekeken of we clusters konden onderscheiden in de inname van de voedingsgroepen fruit, groente, suikerhoudende dranken en ongezonde snacks en de leefstijlfactoren beweging en schermtijd. Er kwamen drie clusters uit de data naar voren: het 'relatief gezonde cluster', het 'actieve snackcluster' en het 'sedentaire zoete drankcluster'. De kinderen van 1 jaar werden vaker ingedeeld in het 'relatief gezonde cluster'. Ook vonden we dat kinderen van ouders met een lager opleidingsniveau minder vaak in het 'relatief gezonde cluster' voorkwamen en juist vaker in het 'sedentaire zoete drankcluster'. Deze resultaten impliceren dat leefstijlinterventies zich bij 1-jarigen meer zouden moeten richten op het behouden van en bij 2- en 3-jarigen meer op het omschakelen naar gezond leefstijlgedrag. Daarbij zou rekening gehouden moeten worden met het opleidingsniveau van de ouders.

In **Hoofdstuk 4** gebruikten we data van 869 kinderen die meededen aan de '*Amsterdam Born Children and their Development study*'. We onderzochten de associatie tussen dieetkwaliteit op de leeftijd van 5-6 jaar en cardiovasculaire uitkomsten bij kinderen van 11-12 jaar. Hierbij werd dieetkwaliteit geoperationaliseerd als de '*Dietary Approaches to Stop Hypertension score*' en een Nederlandse dieetkwaliteitsscore voor kinderen. We vonden we dat een hogere dieetkwaliteitsscore op de leeftijd van 5 en 6 jaar geassocieerd was met een lagere BMI, een kleinere middelomtrek, een lagere bloeddruk en een lagere concentratie triglyceriden in het bloed na 6 jaar follow-up. Deze resultaten suggereren dat het verbeteren van dieetkwaliteit bij kinderen mogelijk bijdraagt aan het voorkomen van gezondheidsproblemen op zowel de korte als langere termijn.

Deel II – Bestaande instrumenten en voorwaarden vanuit de praktijk van de jeugdgezondheidszorg

In het tweede deel van het proefschrift richten we ons op het te ontwikkelen leefstijlsignaleringsinstrument. In **Hoofdstuk 5** voerden we een systematisch literatuuronderzoek uit naar bestaande leefstijlsignaleringsinstrumenten voor kinderen van 0-18 jaar uit de algemene populatie. Van de 41 instrumenten die we identificeerden bevatte het merendeel items over gedrag dat geassocieerd was met overgewicht of obesitas. De instrumenten voor jonge kinderen (1-5 jaar) waren vaak gelimiteerd tot items over voeding. Bovendien was de validatie van de meeste instrumenten beperkt en waren duidelijke handelingsperspectieven volgend op het afnemen van de instrumenten schaars. We concludeerden dan ook dat er behoefte was aan de ontwikkeling van een nieuw en eenvoudig leefstijlsignaleringsinstrument voor jonge kinderen dat specifieke handelingsperspectieven zou bieden.

In **Hoofdstuk 6** beschrijven we onderzoek met het instrument de 'COVID-19 kind check'. De 'COVID-19 kind check' werd ontwikkeld voor het vroegtijdig signaleren van problemen in de lichamelijke of psychische gezondheid en veiligheid van kinderen en gezinnen ten gevolge van de COVID-19 maatregelen. In ons onderzoek vergeleken we uitkomsten van de 'COVID-19 kind check' van kinderen met een chronische somatische aandoening (n = 326) en hun ouders met kinderen (n = 1.287) en ouders uit de algemene populatie. We laten zien dat de impact van de COVID-19 maatregelen tussen deze groepen verschilt. Alhoewel kinderen met chronische somatische aandoeningen minder stress ervaarden dan de algemene populatie, gaven de kinderen tevens aan minder te bewegen en minder sociaal contact te hebben met vrienden en vriendinnen. Instrumenten zoals de COVID-19 kind check kunnen behulpzaam zijn om in specifieke situaties ondersteuning te bieden aan het gesprek tussen ouder en zorgprofessional.

Om het signaleringsinstrument zo goed mogelijk te laten aansluiten bij de eindgebruikers, dat wil zeggen ouders en JGZ-professionals, zijn er focusgroepinterviews georganiseerd om hun vereisten voor het instrument te achterhalen. **Hoofdstuk 7** bevat de resultaten van dit onderzoek. Eerst onderzochten we de ervaringen met de huidige praktijk van de JGZ met betrekking tot het bespreken van leefstijl bij jonge kinderen tijdens het consult. Zowel ouders als JGZ-professionals gaven aan dat leefstijl vaak aan bod komt in het gesprek. Ouders zouden graag wat meer diepgang in dit gesprek willen en JGZ-professionals misten soms handvatten om het gesprek voort te zetten. Aangaande het nieuwe signaleringsinstrument zaten ouders en JGZ-professionals op één lijn: het instrument moest gebruiksvriendelijk zijn, weinig tijd vergen en handelingsperspectieven bieden. Bovendien zou het aantrekkelijk moeten zijn om in te vullen en aansluiten bij het gezin in kwestie.

Deel III – Ontwikkeling en evaluatie van FLY-Kids

De daadwerkelijke ontwikkeling en evaluatie van het leefstijlsignaleringsinstrument is beschreven in het derde deel van dit proefschrift. **Hoofdstuk 8** geeft een overzicht van het ontwikkelingsproces en beschrijft de resultaten van de eerste evaluatie van het leefstijlsignaleringsinstrument 'FLY-Kids' (Features of Lifestyle in Young Kids). FLY-Kids kan gebruikt worden om eenvoudig en snel de leefstijl van kinderen van 1 tot en met 3 jaar in kaart te brengen en het gesprek over leefstijl tussen ouders en JGZ-professionals te ondersteunen. Aan de hand van de antwoorden op tien meerkeuze items (betreffende de themaß tevredenheid, gezonde voeding, ongezonde voeding, eetgewoonten en andere leefstijlgewoonten) wordt een dashboard gecreëerd. Dit dashboard biedt de ouder en JGZ-professional aanknopingspunten voor het gesprek. De bijbehorende handelingsperspectieven kan de JGZ-professional gebruiken om de ouder te helpen in het verbeteren van de leefstijl van het kind. In totaal deden 201 ouders van kinderen in de leeftijd van 1-3 jaar mee met de evaluatie. We vonden dat ouders gemiddeld 3,2 ongezonde leefstijlgedragingen bij hun kinderen scoorden en dat slechts 3,0 % aan alle aanbevelingen voldeed. Zowel ouders als JGZ-professionals vonden FLY-Kids behulpzaam en gebruiksvriendelijk. Daarnaast vonden we een associatie tussen het aantal door FLY-Kids gesignaleerde aandachtspunten en het daadwerkelijk aantal besproken items tijdens het JGZ-consult. Op basis van deze resultaten suggereren wij dat FLY-Kids gebruikt kan worden om ongezond leefstijlgedrag bij jonge kinderen te signaleren en het gesprek over leefstijl binnen de JGZ kan ondersteunen.

Discussie

In de discussie becommentariëren wij de belangrijkste resultaten van de studies in dit proefschrift zoals hierboven beschreven. Ook benoemen we de sterke punten en beperkingen van het FLY-Kids project. Tenslotte beschrijven we mogelijke toekomstperspectieven van FLY-Kids. Daar FLY-Kids ondersteunend lijkt te zijn in het gesprek tussen ouder en JGZ-professional en zij beiden FLY-Kids waardeerden als behulpzaam en gebruiksvriendelijk, stellen we voor het gebruik van FLY-Kids binnen de JGZ verder uit te breiden en meer onderzoek te verrichten. Het digitaliseren van het instrument is mogelijk een eerste stap richting uitbreiding en mogelijk zelfs tot implementatie. Toekomstig onderzoek zou zich enerzijds kunnen richten op de (digitale) gebruikerservaring en anderzijds op de mogelijk longitudinale effecten van het gebruik van FLY-Kids. Bij dit onderzoek zou specifieke aandacht moeten zijn voor het gebruik bij families met lagere sociaaleconomische en migratie achtergronden.

Appendices

I List of Publications

Evaluation of nutrient intake and food consumption among Dutch toddlers
Elly Steenbergen, **Anne Krijger**, Janneke Verkaik-Kloosterman, Liset Elstgeest, Sovianne ter Borg, Koen Joosten, Caroline van Rossum
Nutrients. 2021 May 1;13(5):1531

Diet quality at age 5-6 and cardiovascular outcomes in preadolescents
Anne Krijger, Mary Nicolaou, Anh Nhi Nguyen, Trudy Voortman, Barbara Hutten, Tanja Vrijkotte
Clin Nutr ESPEN. 2021 Jun;43:506-513

Perceived stress, family impact, and changes in physical and social daily life activities of children with chronic somatic conditions during the COVID-19 pandemic
Anne Krijger, Karolijn Dulfer, Hedy van Oers, Lorynn Teela, Brita de Jong-van Kempen, Anne van Els, Lotte Haverman, Koen Joosten
BMC Public Health. 2022 Jun 3;22(1):1106

Lifestyle screening tools for children in the community setting: a systematic review
Anne Krijger, Sovianne ter Borg, Liset Elstgeest, Caroline van Rossum, Janneke Verkaik-Kloosterman, Elly Steenbergen, Hein Raat, Koen Joosten
Nutrients. 2022 Jul 14;14(14):2899

Clusters of lifestyle behaviours and their associations with socio-demographic characteristics in Dutch toddlers
Anne Krijger, Elly Steenbergen, Lieke Schiphof-Godart, Caroline van Rossum, Janneke Verkaik-Kloosterman, Liset Elstgeest, Sovianne ter Borg, Hein Raat, Koen Joosten
Eur J Nutr. 2023 Apr;62(3):1143-1151

A lifestyle screening tool for young children in the community: needs and wishes of parents and youth healthcare professionals
Anne Krijger, Lieke Schiphof-Godart, Caren Lanting, Liset Elstgeest, Hein Raat, Koen Joosten
Submitted

Development and evaluation study of FLY-Kids: a new lifestyle screening tool for young children
Anne Krijger, Lieke Schiphof-Godart, Liset Elstgeest, Caroline van Rossum, Janneke Verkaik-Kloosterman, Elly Steenbergen, Sovianne ter Borg, Caren Lanting, Karen van Drongelen, Ondine Engelse, Angelika Kindermann, Symone Detmar, Carolien Frenkel, Hein Raat, Koen Joosten
Submitted

II About the Author

Anne Krijger was born on October 1st 1993 and grew up in 's-Heer Abtskerke (Zeeland), the Netherlands. In 2012 she completed her pre-university education at the Ostrea Lyceum in Goes. She started a bachelor's degree in biomedical sciences at the University of Antwerp, but switched to medicine after being admitted to the medical program at the University of Amsterdam in 2013. During her studies, Anne developed a great interest in the role of nutrition and lifestyle in health, particularly in children. She conducted her master's research within the Amsterdam Born Children and their Development study, and studied the longitudinal associations between diet quality and cardiovascular outcomes during childhood. After obtaining her medical degree in 2019, she continued with a one-year master's program in nutrition science at the Karolinska Institutet in Stockholm, Sweden. During her degree project, she was involved in the development of a psychological distress score to examine postpartum maternal stress in lactating women. In May 2020, Anne started her PhD project on the development of a lifestyle screening tool for young children under supervision of Prof. Dr. K.F.M. Joosten and Prof. Dr. H. Raat. The project was a combined effort of the departments of Paediatric Intensive Care and Public Health of the Erasmus MC, as well as other public research institutes, including the National Institute for Public Health and the Environment (RIVM), the Netherlands Organisation for Applied Scientific Research (TNO) and the Netherlands Nutrition Centre (Voedingscentrum). The results of this research project are presented in this thesis. Anne has been working at Diaboss/Onze Lieve Vrouwe Gasthuis as a paediatric diabetes physician since July 2023.

III PhD Portfolio

Name PhD student: Anne Krijger
Erasmus MC Department: Department of Paediatrics and Paediatric Surgery; Department of Public Health
Research School: Netherlands Institute for Health Sciences (NIHES)
PhD period: May 2020 – April 2023
Promotors: Prof. dr. K.F.M. Joosten
Prof. dr. H. Raat
Copromotor: Dr. L. Schiphof-Godart

1. PhD training	**Year**	**Workload (ECTS)**
Courses		
Systematic Literature Retrieval in PubMed and Embase	2020	0.6
Endnote	2020	0.2
Advances in Clinical Epidemiology	2020	0.7
Methods of Health Services Research	2020	0.7
Methods of Public Health Research	2020	0.7
Scientific Integrity	2021	0.3
Introduction to Data-Analysis	2021	0.7
Regression Analysis	2021	1.4
Practice of Epidemiologic Analysis	2021	0.7
Biomedical Writing for PhD Candidates	2022	1.5
Motivational Interviewing	2022-2023	0.4
Seminars and meetings		
Seminar Obesitas, kinderen en COVID-19	2020	0.1
Seminar Need for standardization in the global surveillance of physical activity of children and youth	2020	0.1
Meeting Beweegadvies 0-4 jarigen	2021	0.2
Symposium Gezonde, duurzame voeding en leefstijl voor kinderen	2022	0.5
Scholingsdag Jong Leren Eten GGD Zeeland	2022	0.3
Meetings Nutrition & Lifestyle Epidemiology	2020-2021	1.0
Meetings and Seminars at the Department of Public Health	2020-2023	2.0
Meetings Youth Section	2020-2023	1.0
Organisation Research Meetings Youth Section	2021-2022	2.0
(Inter)national conferences and presentations		
VNFKD Lustrumcongres Blik op de Toekomst	2021	0.1
Sophia Research Days	2021-2023	1.0
Nutricia Global Virtual Conference	2021	0.3
Nutrition & Growth conference (poster presentation)	2021	0.9
Excellence in Pediatrics conference (oral presentation)	2021	1.0
European Academy of Pediatric Societies Congress (poster presentation)	2022	1.0
Duin en Kruidberg Voedingsdagen	2022	0.5
Nutrition & Growth conference (poster presentation)	2023	1.0

2. Teaching activities		
Supervision Community Project, 3rd year medical students	2020-2022	2.0
Teaching 'Lifestyle advice in clinical practice', 1st year medical students	2021-2022	1.0
Teaching 'Nutrition and Health', 5th year medical students	2021-2022	0.8
Tutoring, 1st year medical students	2022	1.4
Teaching 'Searching literature', 1st year medical students	2022	0.4
Supervision youth doctor in training	2022-2023	1.0
3. Other activities	**Year**	**Workload (ECTS)**
Project general tasks	2020-2023	4.0
Peer review	2020-2022	0.8

IV Dankwoord

Wat geweldig om na drie jaar onderzoek het eindresultaat in handen te hebben! Dit was niet gelukt zonder hulp van velen. Iedereen hartelijk bedankt!

Allereerst uiteraard heel veel dank aan mijn promotoren en copromotoren. Prof. dr. Joosten, beste Koen, ontzettend bedankt voor alle begeleiding, de samenwerking en het waken over de grote lijnen van het project. Ik heb enorme bewondering voor je eindeloze enthousiasme, energie en scherpzinnigheid! Prof. dr. Raat, beste Hein, bedankt voor de goede samenwerking en mijn plek binnen de jeugdsectie . Jouw directe link met de praktijk van de Jeugdgezondheidszorg was altijd waardevol in onze overleggen. Liset, door jouw fijne begeleiding, empathie en betrokkenheid bij het project heb ik me in het eerste jaar enorm gesteund gevoeld. Bedankt hiervoor! Lieke, jou wil ik bedanken voor je directheid, bliksemsnelle antwoord op mijn vragen via Teams en je peptalks. Ik heb genoten van onze informele overleggen en je scherpe commentaar.

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