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Lubna Mahmood

Assessment of Eating Habits of European Children In Families At High-Risk Of Type 2 Diabetes. Evaluación de los hábitos alimentarios en niños Europeos de familias con alto riesgo de diabetes tipo 2

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Tesis Doctoral

ASSESSMENT OF EATING HABITS OF EUROPEAN CHILDREN IN FAMILIES AT HIGH-RISK OF TYPE 2 DIABETES. EVALUACIÓN DE LOS HÁBITOS ALIMENTARIOS EN NIÑOS EUROPEOS DE FAMILIAS CON ALTO RIESGO DE DIABETES TIPO 2

Autor

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Manios, Yannis

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Assessment of eating habits of European children in families at high-risk of type 2 diabetes

Evaluación de los hábitos alimentarios en niños europeos de familias con alto riesgo de diabetes tipo 2

UNIVERSIDAD DE ZARAGOZA

Departamento de Fisiatría y Enfermería

Facultad de Ciencias de la Salud

LUBNA MAHMOOD

ZARAGOZA, 2023

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EVALUACIÓN DE LOS HÁBITOS ALIMENTARIOS EN NIÑOS EUROPEOS DE FAMILIAS CON ALTO RIESGO DE DIABETES TIPO 2

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2023

Departamento de Fisiatría y Enfermería
Universidad Zaragoza

“Great achievement always requires great sacrifice”

Dr. Luis A. MORENO AZNAR
Catedrático de Universidad
Departamento de Fisiatría y Enfermería
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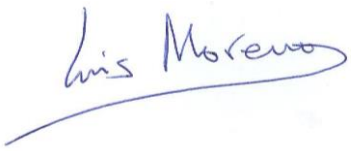
Universidad de Zaragoza, España

LUIS A. MORENO AZNAR, CATEDRÁTICO DE LA UNIVERSIDAD DE ZARAGOZA

CERTIFICA:

Que la Tesis Doctoral titulada "Evaluación de los hábitos alimentarios en niños europeos de familias con alto riesgo de diabetes tipo 2" que presenta Dña. **LUBNA MAHMOOD** al superior juicio del Tribunal que designe la Universidad de Zaragoza, ha sido realizada bajo mi dirección, siendo expresión de la capacidad técnica e interpretativa de su autora en condiciones tan aventajadas que le hacen merecedora del Título de Doctora, siempre y cuando así lo considere el citado Tribunal.



Fdo.: Luis A. Moreno Aznar
En Zaragoza, a 30 de Enero de 2023

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World Health Organization

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CERTIFICA:

Que la Tesis Doctoral titulada "Evaluación de los hábitos alimentarios en niños europeos de familias con alto riesgo de diabetes tipo 2" que presenta Dña. **LUBNA MAHMOOD** al superior juicio del Tribunal que designe la Universidad de Zaragoza, ha sido realizada bajo mi dirección, siendo expresión de la capacidad técnica e interpretativa de su autora en condiciones tan aventajadas que le hacen merecedora del Título de Doctora, siempre y cuando así lo considere el citado Tribunal.

Fdo.: Esther M. González-Gil

En Lyon, a 30 de Enero de 2023

ΧΑΡΟΚΟΠΕΙΟ ΠΑΝΕΠΙΣΤΗΜΙΟ
HAROKOPIO UNIVERSITY

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YANNIS MANIOS, PROFESSOR AT HAROKOPIO UNIVERSITY IN ATHENS, GREECE

I HEREBY DECLARE THAT:

The doctoral thesis entitled “Assessment of eating habits of European children in families at high-risk of type 2 diabetes” presented by Ms. **LUBNA MAHMOOD** has been carried out under my supervision, being an expression of the technical and interpretative capacity of the author in conditions that make her deserving the Doctoral Degree, as long as the members of the jury will have this consideration.

Yannis Manios
Athens, 30th January 2023

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Proyectos de investigación [Research projects]

The work that is developed below, as well as the manuscripts that are part of this Doctoral Thesis, are based on the following research project:

Feel4Diabetes (Families across Europe following a healthy Lifestyle for Diabetes prevention). This project has been funded by HORIZON2020, under Global Alliance for Chronic Diseases – GACD with a duration of 5 years (2015-2019). Grant agreement: 643708.

Web page: https://feel4diabetes-study.eu/

Coordinador: Yannis Manios (Harokopio University)

Principal Investigator in Spain: Luis A. Moreno Aznar

Listado de abreviaturas [List of abbreviations]

BMI	Body Mass Index
CDC	The Center for Disease Control
DQ	Diet Quality
DQI	Diet Quality Index
DXA	Dual energy X-ray Absorptiometry
FBDGs	Food-Based Dietary Guidelines
FFQ	Food Frequency Questionnaire
FINDRISC	Finnish Diabetes Risk Score
FV	Fruits and Vegetables
HbA1c	Glycated Haemoglobin
HDS	Healthy Diet Score
24HR	24-Hour Dietary Recall
HOMA-IR	Homeostatic Model Assessment for Insulin Resistance
ICC	Intra-Class Correlation
IDF	International Diabetes Federation
IOTF	The International Obesity Task Force
IR	Insulin Resistance
OH	Out-of-Home
PCOS	Polycystic Ovary Syndrome
PFSQ	Parental Feeding Style Questionnaire
SD	Standard Deviation
SES	Socioeconomic Status
SSB	Sugar-Sweetened Beverages
T2D	Type 2 Diabetes
WC	Waist Circumference
WHO	World Health Organization

Lista de publicaciones [List of publications]

This Doctoral Thesis is a compendium of scientific works previously published. The manuscripts that constitute this thesis are detailed below:

I. **Mahmood L**, Flores-Barrantes P, Moreno LA, Manios Y, Gonzalez-Gil EM. The Influence of Parental dietary behaviors and practices on children's eating habits. Nutrients. 2021, 30;13(4):1138. doi: 10.3390/nu13041138.

II. **Mahmood L**, Moreno LA, Flores-Barrantes P, Mavrogianni C, Schwarz P, Makrilakis K, Liatis S, Cardon G, Willems R, Rurik I, Radó S, Tankova T, Iotova V, Usheva N, Manios Y, Gonzalez-Gil EM. Parental food consumption and diet quality and its association with children's food consumption in families at high risk of type 2 diabetes: the Feel4Diabetes-study. Public Health Nutrition. 2022. 1-12. doi: 10.1017/S1368980022002245.

III. **Mahmood L**, Gonzalez-Gil EM, Schwarz P, Herrmann S, Karaglani E, Cardon G, De Vylder F, Willems R, Makrilakis K, Liatis S, Iotova V, Tsochev K, Tankova T, Rurik I, Radó S, Moreno LA, Manios Y. Family meals frequency and food consumption in families at high risk of type 2 diabetes: the Feel4Diabetes-study. Eur J Pediatr. 2022, 181(6):2523-2534. doi: 10.1007/s00431-022-04445-4.

IV. **Mahmood L**, Gonzalez-Gil EM, Makrilakis K, Liatis S, Schwarz P, Herrmann S, Willems R, Cardon G, Latomme J, Rurik I, Radó S, Iotova V, Usheva N, Tankova T, Karaglani E, Manios Y, Moreno LA. Cross-sectional and longitudinal associations between family meals frequency and children's overweight/obesity in families at high risk of type 2 diabetes: The Feel4Diabetes-study. Pediatr Obes. 2023: e13000. doi: 10.1111/ijpo.13000

Contribution of the doctoral student in the different publications

Manuscript I: The Influence of Parental dietary behaviors and practices on children's eating habits.

Lubna Mahmood (L.M), completed the literature searches, review and drafted the manuscript. Paloma Flores-Barrantes (P.F.-B) revised the manuscript. Esther M. Gonzalez-Gil (E.M.G.-G.), Yannis Manios (Y.M.) and Luis A Moreno (L.A.M.) reviewed, edited and approved the manuscript. All authors have read and agreed to the published version of the manuscript.

Manuscript II: Parental food consumption and diet quality and its association with children's food consumption in families at high risk of type 2 diabetes: the Feel4Diabetes-study.

(L.M.) conducted the statistical analyses, and wrote the manuscript. (Y.M.) coordinated the study. (L.A.M.), (Y.M.), Greet Cardon (G.C.), Konstantinos Makrilakis (K.M.), Tsvetalina Tankova (T.T.) participated in the design of the study. (E.M.G.G.) and (L.A.M.) critically revised the manuscript, and supervised all procedures. (P.F.B.), Christina Mavrogianni (C.M.), (G.C.), Ruben Willems (R.W.), Violeta Iotova (V.I.), and Natalya Usheva (N.U.) provided essential intellectual input; all authors have read, revised, and approved the final version of the manuscript.

Manuscript III: Family meals frequency and food consumption in families at high risk of type 2 diabetes: the Feel4Diabetes-study.

(L.M.) conducted the statistical analyses and wrote the manuscript. (Y.M.) coordinated the study. (L.A.M.), (Y.M.), (G.C.), (K.M.), (T.T.) participated in the design of the study. (E.M.G.G.) and (L.A.M.) critically revised the manuscript and supervised all procedures. Peter Schwarz (P.S.), (R.W.), and (G.C.) provided essential intellectual input; all authors have read, revised, and approved the final version of the manuscript

Manuscript IV: Cross-sectional and longitudinal associations between family meals frequency and children's overweight/obesity in families at high risk of type 2 diabetes: The Feel4Diabetes-study.

(L.M.) conducted the statistical analyses, and wrote the manuscript. (Y.M.) coordinated the study. (L.A.M.), (Y.M.), (G.C.), (K.M.), (T.T.) participated in the design of the study. (E.M.G.G.) and (L.A.M.) critically revised the manuscript, and supervised all procedures. (R.W.), (G.C.), (V.I.) provided essential intellectual input; all authors have read, revised, and approved the final version of the manuscript.

Abstract

Children's optimal nutrition is fundamental for their healthy growth and development. In this sense, unhealthy dietary habits established during childhood might persist into adulthood, increasing the risk of developing obesity and other complications such as insulin resistance, which is considered as the first stage in the development of type 2 diabetes among children. Therefore, to analyze the factors associated with children's dietary behaviors, is of great importance in order to prevent obesity and other comorbidities including type 2 diabetes in children.

The aims of the present Doctoral Thesis are: 1) to investigate the potential influence of parents' dietary behaviors and practices on European children's eating habits; 2) to examine the association between parental food consumption and diet quality and children's food consumptions in European families at high risk of type 2 diabetes; 3) to evaluate the relationship between family meals frequency and parental food consumption, diet quality, and the food consumption of European children in families at high risk of type 2 diabetes; and 4) to explore the cross-sectional and longitudinal associations between family meals frequency and children's overweight/obesity in families at high risk of type 2 diabetes across six European countries.

In order to achieve these objectives, data from an interventional multi-centric study was considered: families across Europe following a healthy Lifestyle for Diabetes prevention (Feel4Diabetes) study, aimed to promote healthy lifestyle and tackle obesity and obesity-related metabolic risk factors for the prevention of type 2 diabetes among families from vulnerable groups across six European countries (Belgium, Finland, Bulgaria, Hungary, Greece and Spain).

Out of the total sample of 11,396 families, 4,484 families were identified as "families at high-risk of type 2 diabetes" at the beginning of the Feel4diabetes-study. Families were including parents with one primary school-aged child (6-8 years old). The sample size used in the different manuscripts varied from 989 to 2,095 families, based on the number of participants providing the required complete information for the respective investigations.

Four manuscripts were performed for the present Thesis, being three of them original research and one of them a narrative review. In the first manuscript, the narrative review, we found that family environment has an active role in establishing and promoting children's eating behaviors. Moreover, it was advised that parents should encourage their children on healthy eating habits through positive social modelling with moderate restriction, and to avoid excessive pressure or restriction that could negatively affect children's acceptance of food. Additionally, it was recommended that parental child-feeding behaviors should be considered in the childhood obesity prevention policies through promoting strategies aimed at parents' unhealthy eating and that of children as

well. Regarding the second manuscript of the Thesis, that investigated the associations between parental food consumption, diet quality and children's food consumption in European families at high risk of type 2 diabetes, it was found that parental food consumption and diet quality were significantly associated with children's consumption of selected food items among boys and girls. When assessing the relationship between family meals frequency and food consumption of European children in families at high risk of type 2 diabetes in the third manuscript, it was found that the frequency of family meals was significantly associated with children's food consumption among both boys and girls. Besides, parental diet quality partially mediated the association between family meals frequency and children's food consumption in families at high-risk of type 2 diabetes. Regarding the last manuscript, which examined the cross-sectional and longitudinal association between family meals frequency and children's obesity in families at high risk of type 2 diabetes across six European countries, results showed that family meals particularly breakfast and/or dinner are inversely associated with children's body mass index. Besides, results showed that the increase of family meals frequency after 2-year follow-up was associated with decreased odds of overweight/obesity among children who consumed family breakfast and/or dinner three to seven times per week.

In conclusion, family environment, parental dietary behaviors and diet quality have an active role in establishing and promoting children's eating habits and food consumption, which can persist throughout their life. Out of the parental dietary behaviors, healthy food consumption and higher diet quality of parents are found to be positively associated with improved children's food consumption of healthy food items. Moreover, regular family meals are found to be linked with higher consumption of healthy foods, also it served as a protective factor against overweight/obesity among children from families at risk of type 2 diabetes. The present Thesis highlights the importance of diet quality and family meals for children's eating habits, food consumption, and overweight/obesity. This suggests that these factors should be taken into account when developing interventions and future strategies targeting both parents as well as their children.

Resumen

La óptima nutrición de los niños es fundamental para su crecimiento y desarrollo saludable. En este sentido, los hábitos alimentarios poco saludables establecidos durante la infancia pueden persistir en la edad adulta, aumentando el riesgo de desarrollar obesidad y otras complicaciones como la resistencia a la insulina, que se considera la primera etapa en el desarrollo de la diabetes tipo 2 en los niños. Por lo tanto, analizar los factores asociados con los comportamientos dietéticos de los niños es de gran importancia para prevenir la obesidad y otras comorbilidades, incluida la diabetes tipo 2 en los niños.

Los objetivos de la presente Tesis Doctoral son: 1) investigar la influencia potencial de los comportamientos y prácticas dietéticas de los padres en los hábitos alimentarios de los niños europeos, 2) examinar la asociación entre el consumo de alimentos de los padres y la calidad de la dieta y el consumo de alimentos de los niños en las familias europeas en Alto riesgo de diabetes tipo 2. 3) evaluar la relación entre la frecuencia de las comidas familiares y el consumo de alimentos de los padres, la calidad de la dieta y el consumo de alimentos de los niños europeos en familias con alto riesgo de diabetes tipo 2, y 4) explorar las asociaciones transversales y longitudinales entre la frecuencia de comidas familiares y obesidad infantil en familias con alto riesgo de diabetes tipo 2 en seis países europeos.

Para lograr estos objetivos, se consideraron los datos de un estudio multicéntrico de intervención: familias de toda Europa que participaron en un estudio sobre estilos de vida saludables para la prevención de la diabetes (Feel4Diabetes), cuyo objetivo era promover un estilo de vida saludable y abordar la obesidad y los factores de riesgo metabólicos relacionados con la obesidad para la prevención de diabetes tipo 2 entre familias de grupos vulnerables en seis países europeos (Bélgica, Finlandia, Bulgaria, Hungría, Grecia y España).

De la muestra total del estudio Feel4diabetes de 11 396 familias, 4484 familias fueron identificadas como "familias con alto riesgo de diabetes tipo 2" al comienzo del estudio. Las familias incluían padres con un niño en edad de enseñanza primaria (6-8 años). El tamaño de muestra utilizado en los diferentes artículos varió de 989 a 2095 familias, en función del número de participantes que brindaron la información completa requerida para la respectiva investigación.

Para la presente Tesis se realizaron cuatro manuscritos, siendo tres de ellos investigación original y uno de ellos una revisión narrativa. En el primer artículo, la revisión narrativa, observamos que el entorno familiar tiene un papel activo en el establecimiento y promoción de los comportamientos alimentarios de los niños. Además, se aconsejó que los padres deben alentar a sus hijos a tener hábitos alimenticios saludables a través de modelos sociales positivos con restricciones moderadas, y evitar una presión o restricción excesiva que pueda afectar negativamente la aceptación de los alimentos por parte de los

niños. Adicionalmente, se recomendó considerar las conductas de alimentación de los padres en las políticas de prevención de la obesidad infantil a través de la promoción de estrategias dirigidas a la alimentación no saludable de los padres y de los niños. En cuanto al segundo manuscrito de la Tesis, que investigó las asociaciones entre el consumo de alimentos de los padres, la calidad de la dieta y el consumo de alimentos de los niños en familias europeas con alto riesgo de diabetes tipo 2, se encontró que el consumo de alimentos de los padres y la calidad de la dieta estaban significativamente asociados con el consumo de los niños. de alimentos seleccionados entre niños y niñas. Al evaluar la relación entre la frecuencia de las comidas familiares y el consumo de alimentos de los niños europeos en familias con alto riesgo de diabetes tipo 2 en el tercer manuscrito, se encontró que la frecuencia de las comidas familiares se asoció significativamente con el consumo de alimentos de los niños tanto en niños como en niñas. Además, la calidad de la dieta de los padres medió parcialmente la asociación entre la frecuencia de las comidas familiares y el consumo de alimentos de los niños en familias con alto riesgo de diabetes tipo 2. Con respecto al último manuscrito, que examinó la asociación transversal y longitudinal entre la frecuencia de las comidas familiares y la obesidad infantil en familias con alto riesgo de diabetes tipo 2 en seis países europeos, los resultados mostraron que las comidas familiares, prácticamente el desayuno y/o la cena, están inversamente asociadas con el índice de masa corporal de los niños. Además, los resultados mostraron que el aumento de la frecuencia de las comidas familiares después de un seguimiento de 2 años se asoció con una disminución de la probabilidad de sobrepeso/obesidad entre los niños que desayunaban y cenaban en familia de tres a siete veces por semana.

En conclusión, el entorno familiar, los comportamientos alimentarios de los padres y la calidad de la dieta tienen un papel activo en el establecimiento y promoción de los hábitos alimentarios y de consumo de alimentos de los niños, que pueden persistir a lo largo de su vida. Fuera de los comportamientos dietéticos de los padres, el consumo de alimentos saludables y una mayor calidad de la dieta de los padres se asocian positivamente con un mejor consumo de alimentos saludables por parte de los niños. Además, se observó que las comidas familiares regulares están relacionadas con un mayor consumo de alimentos saludables, y también sirvió como un factor protector contra el sobrepeso/obesidad entre los niños de familias con riesgo de diabetes tipo 2. La presente Tesis destaca la importancia de estos factores, la calidad de la dieta y las comidas familiares, en los hábitos alimentarios, el consumo de alimentos y el sobrepeso/obesidad de los niños. Esto sugiere que estos factores deben tenerse en cuenta al desarrollar intervenciones y estrategias futuras dirigidas tanto a los padres como a sus hijos.

1. Introduction

Eating habits are defined as the repetitive behaviors of individuals regarding their regular food consumption [1]. Eating behaviors shaped during the first few years of life may persist into adulthood [1,2], therefore, childhood is considered as a critical period for the development of future eating habits [2,3]. Establishing good eating habits early in life can reduce the risk of developing obesity and related comorbidities such as Type 2 diabetes (T2D), cardiovascular diseases, and cancer [1-4].

1.1 Children's eating habits

Nutrition is the most important aspect in parent-child connection, particularly during the first year of life [1]. Children begin self-feeding and transfer to the family diet and meal routines by the end of the first year of life [1,2]. According to a review study [1] that evaluated research articles on children's eating habits, as children transition to the family diet, parental recommendations address not only food but also the eating context. According to the same study, providing children with a range of nutritious food choices can improve their diet quality (DQ) and food acceptability [1]. Children learn to recognize food by frequent exposure, which was shown to be the most effective method [3]. Therefore, parents are advised not to give up and to maintain introducing food products frequently to their children [1].

Dietary diversity has been found to be favourably connected with children's nutritional health from birth to the age of 2 years in a study conducted over 11 countries [2]. Besides, early childhood exposure to fruits and vegetables (FV) has been linked to later-life acceptance of these foods [2]. A 9-year longitudinal study of 120 2-year-old children and their parents showed that approximately 25% of the children had some eating problems, such as being unwilling to explore new cuisines or insisting on a limited set of dietary choices, concluding that those problems may lead to them becoming picky eaters [3]. Children with eating disorders (picky eating, meal skipping, etc.) may be at risk for behavioral issues as well as stunted growth and development [3].

Although numerous studies have previously examined eating habits of children in Europe, there is a lack of information on whether or how the parents and family environment could affect children's eating habits in terms of parental behaviors, food intake, diet quality as well as family meals frequency especially among European families at high risk of T2D.

1.1.1 Home environment, parental dietary behaviors and practices

The availability and accessibility of food, as well as other factors like frequency of dining out and parents' perception of food expenses, all contribute to the home food environment [4]. Also, because most of the food consumed is cooked at home, the home food environment has been proven to have remarkable impacts on the eating habits of parents

and their children [4]. The Quebec longitudinal study of 1492 children showed that children who grew up in a healthier home environment consumed less sugar-sweetened beverages (SSB) and were more fit [5]. Similarly, a cross-sectional study of 1435 European families found that home food environment had a greater influence on children's consumption of healthy meals, particularly among young children [6]. Also, a review study on the availability and accessibility of selected food items at home found that when FV were more affordable and accessible, the total calories and fat intake in children were decreased [7].

Household environment can also affect the family's frequency of eating out [8]. Nowadays, it has been noticed that families spend more money on foods prepared out-of-home (OH) which tend to be loaded with fats and sugars compared to meals prepared at home [8]. Likewise, a study on the metropolitan population in the United States observed that parents usually prefer quick, more accessible, and tasty meals that are low-cost and culturally appropriate [9]. These perceptions encourage perpetuating the cycle of fewer home-cooked meals. Accordingly, children would have less opportunity to reinforce healthy dietary habits, acquire cooking skills, and get nutritious meals [9]. According to the UK national diet survey of children and adolescents, eating meals prepared away from home was related to higher intake of foods rich in fat and sugar [8]. However, these studies only looked at the effect of dining out and ignored the impact of ready-to-eat and unhealthy meals prepared at home [10].

1.1.2 Parental dietary behaviors and practices

In the family environment, most children's eating habits were found to be influenced by parental dietary behaviors especially during the first year of life, when children's eating habits undergo a rapid evolution [11]. Parental "dietary behavior" is a broad term that encompasses the passive mechanisms influencing children's food environment as well as their dietary intake [12]. In this context, a focus group study of parents and children eating habits were performed in Belgium, showing that the effect of parenting behaviors varies with age. Hence, the younger the child, the stronger the role of parents [12]. In addition, several cross-sectional studies have found close similarities in the intakes of healthy and unhealthy food items between parents and children, particularly when more meals are consumed together [13-15]. However, these studies cannot conclude causality, thus, the exact process by which parents influence their children's dietary intake remains unclear. Similarly, previous studies on children's food intake showed positive associations between parents' and children's consumption of selected food items [16-18]. Thus, parents are considered as providers, enforcers, and role models as their dietary behaviors proved their effectiveness in establishing and promoting healthy dietary intake among children [17,18].

Parental feeding styles and practices refer to the psychological constructs that represent the interactions between parents and children in terms of rules established by parents controlling how much, what, and when their children eat [19,20]. Baumrind's taxonomy classified parenting styles into three types: authoritative, authoritarian, and permissive. In depth, authoritative includes both demanding and responsiveness, authoritarian represents high demanding with less responsiveness, and permissive is highly responsiveness but less demanding [21]. In spite of the limited studies on the role of parenting styles on children's food consumption, a recent systematic review found that preferable parental monitoring of the child's food intake was presented more in the authoritative parenting style compared to the other parenting styles [22]. While, it has been noticed that when children are raised in authoritative households, they tend to eat healthier food choices and have a healthy Body Mass Index (BMI). However, the associations were weak and indirect [23]. Furthermore, one systematic review critically evaluated prior studies on parental feeding practices, which showed that parents were advised to model good eating habits such as providing healthy foods and boosting encouragement to consume healthier food products [24]. Similarly, findings from the Parental Feeding Style Questionnaire (PFSQ) on children in Hong Kong showed that parental encouragements were associated with healthier eating habits and food choices among children (i.e., improved intake of FV) [25]. On the other hand, using unhealthy foods as rewards may promote children's preferences toward these food items and increase the intake of energy-dense products (i.e., biscuits, chocolate, and savoury dishes) [25].

A systematic review on parental feeding practices concluded that encouragement plus moderate restrictions were found to be the most effective strategies for improving children's food consumption [26]. These strategies include providing food products with positive messages along with a careful use of restrictions in which unhealthy food items are not strictly forbidden, but rather gradually decreased [25]. In contrast, longitudinal research showed increased overeating and picky eating habits in children when restricted feeding practices were followed by their parents [27]. Consequently, pressuring, force feeding, and highly-restricted practices are discouraged as they can have detrimental impacts on family eating environment and increase the chance of picky eating among children [28,29].

1.1.3 Parental food intake, diet quality and children's food consumption

Children consider parents as their models and food providers [30]. Besides, parents tend to play a pivotal role in the development of their children's dietary intake and food preferences [30]. This influence was found to be much stronger through early childhood because parents have greater control over children's food choices compared to early adolescence [31]. It is noteworthy that parental food intake could get affected by many aspects such as demographic characteristics, socioeconomic status (SES), individual

preferences, dietary beliefs and perceptions, personality characteristics, nutrition literacy, knowledge and skills [32,33].

Literature suggests that there are associations between parents' and their children's consumption of selected food items. In detail, previous studies showed a consistent positive association between parents' and children's consumption of FV [34], SSB [35] and snacks [36]. Similarly, parental healthy food choices were found to be positively associated with higher intake of FV among children [37]. Likewise, a cross-sectional study found that the low intake of FV among parents and children was found to be strongly related [38]. However, the direct causality cannot be determined because of the study design [38]. In addition, previous research showed that healthy food choices of parents were positively associated with improved FV consumption and decreased intake of unhealthy snacks in children [37, 39]. Furthermore, children were found to consume more fish in families that used to include fish in their homemade meals [49]. Therefore, parents are advised to provide their children with a variety of food choices regardless of their own food preferences [40].

In the same vein, previous studies showed an association not only between parents' and children's dietary intake, but also between the food portions provided to children and the amount consumed by parents in a regular meal [42,42]. The reason behind this similarity is not known, but could be related to the large amount of food available during a meal, the hunger state of parents, and parental motivation towards increasing children's food consumption [41].

DQ is broadly described as the dietary pattern and variety of an individual's food intake [43], in which high DQ scores reflects better food intake [44]. Literatures highlighted the importance of DQ in reducing chronic diseases, and results found that higher DQ is associated with reduced risk of T2D [43,44]. In general, different indices are used to evaluate the overall DQ tailored to the specific purpose, some of them depends on portions and frequencies derived from Food Frequency Questionnaires (FFQ) [44]. Moreover, other indicators are nutrient-based and are mostly obtained from dietary records [43]. Besides, some indices are country-specific or assessing DQ within specific population only [45].

In spite of the limited number of studies examining the relationship between parental DQ and children's food consumption [43], healthier food consumption of children (i.e., high FV and less fat/sugar intake) was associated with improved parents DQ regardless the type of indices being used [45-47]. Similarly, another study found that improved parental DQ was associated with reduced intake of snacks and sugar; however, no significant associations were found between better parental DQ and the consumption of FV of children [45]. Due to the cross-sectional nature of most studies assessing parental DQ, direct associations cannot be measured. However, the differences in results between studies could be due to the use of different tools to evaluate DQ.

1.2 Dietary assessment in children

FFQ, food record, 24-Hour dietary recall (24HR), and diet history, are some of the nutritional assessment tools established for use in adults but also acceptable for collecting data in children. Each method has its own set of advantages and limitations, and it is chosen according to the study objectives [48]. In this Doctoral Thesis, FFQs have been used to assess the eating habits and dietary intake of children and their parents.

1.2.1 Food frequency questionnaires

Due to its ease of administration and low cost, FFQ is one of the most used methods in large-scale population-based researches to asses dietary habits. FFQ consists of a finite list of meals and beverages with response categories indicating the frequency of intake over the time period queried [49]. The usual serving size for each meal and beverage can be requested individually. Alternatively, portion sizes can be combined with frequency information by asking respondents to translate their usual consumption amount to the number of specified units (e.g., How often do you eat a ½ cup of rice?). In an effort to improve reporting, some surveys contain photographs of portion sizes [49]. Nevertheless, inaccuracy of absolute nutritional values, lack of specificity regarding individual foods, and overall imprecision are all limitations of FFQ [50].

1.2.2 Food records

Food records (also known as dietary records or dietary diaries) are used to collect data on food intake by having people self-record their consumption over a set period of time [51]. Because respondents are requested to record meals and beverages as they are consumed in real time, this nutritional evaluation technique does not rely on individual recollection. The survey usually lasts for 3-7 days, depending on the study's goal and the necessary level of precision in assessing food consumption or nutrient intake [51].

To provide accurate and thorough data, responders must be well educated to record the food items consumed, including the name of the meal, the amount consumed, preparation techniques, brand names of commercially available products, and recipes for composite dishes. While, additional information about the time and place of intake, as well as the presence of other individuals during the meal, may be important in interpreting an individual's eating habit and social context of diet [51, 52].

Food intake data from records/diaries must be input into a specialist software application to get nutritional values. This data-entry process is time-consuming and necessitates the use of professional data technicians or registered dietitians. Food records are inconvenient for research participants and costly to administer due to the amount of staff effort required. As a result, food records are prohibitively expensive for large epidemiologic investigations involving tens of thousands of participants [51,52].

1.2.3 24-Hour dietary recall

24HR is a structured interview designed to collect detailed, quantitative information on individual diets by asking respondents about the type and amount of every food and drinks consumed over the previous 24 hours [53]. The nutritional data collected using the 24HR technique typically includes ingredients, food product brand names, portion sizes consumed, and preparation methods [53]. Although, the 24HR is widely used in nutrition assessment as it is easy to use, unexpensive, and does not require literacy, it has some limitations. For instance, it required well-trained interviewers who have knowledge about food and nutrition, it is time-consuming and labour-intensive. Moreover, it relies on participant's memory, and underreporting/overreporting can occurs [53,54].

1.2.4 Diet history

Diet history is a structured interview approach that consists of a complete retrospective dietary evaluation that gets comprehensive data of the individual's regular food intake pattern as well as detailed information on specific meals over months or a year. A detailed interview on the regular consumption pattern, a list of items indicating the frequency and amount ingested, and a three-day food record are all included in the diet history [55]. It is noteworthy that the diet history technique needs highly skilled interviewers with extensive expertise as the quality of information is greatly determined by the interviewer's abilities [55,56]. It is largely employed in clinical settings as well as in studies of nutrition and health to explore the traditional diet in the past. However, the high cost and length of the interview restrict its utility in large epidemiological research [56].

1.3 Family meals frequency

A family meal is defined as a meal consumed together by the family members, or by the presence of one or both parents [57]. There is not yet a standard definition of the family meals frequency due to the lack of consistency in measuring and defining it. However, it has been considered in previous literature as having three or more meals per week, or, by having five or more shared meals per week [58].

Family meals were found to influence children in terms of nutrition and behaviors as they offer routine, consistency, and good parent-children communications, and this could provide a promising entry point for change [57,59]. Moreover, the family food environment is strongly influenced by parents in terms of parent-child shared meals, the types and portions of selected food items provided to children [30].

It has been noticed that parents and children are aware of the significant roles of eating together. For instance, a recent study found that only 50% of family meals were shared; however, more than 80% of parents agreed about the importance of family meals [60].

Moreover, it is notable that “dinner” is the most common meal being shared with family members, and this could be due to the schedule flexibility compared to other meal times [61].

1.3.1 Family meals frequency and children’s food consumption

A growing body of scientific research suggests that increased family meals frequency is associated with higher DQ and better food intake in children [61]. Results of a meta-analysis of 57 studies showed that children who had reduced odds of unhealthy food intake used to share their meals with family for three times or more per week [62]. In support of this, lower intake of soft drinks and fried foods were noticed among children who share their meals with family [63]. Similarly, the Quebec longitudinal study of child development found that having family meals at age of 6 years old helped to have decreased intake of soft drinks at age of 10 years old [9]. Furthermore, previous studies found a positive association between the frequency of family meals and improved intake of milk and dairy products in children [9,64]. Moreover, cross-sectional and longitudinal studies showed that frequent family dinners were associated with improved intake of FV in children [29,61,65].

In the same vein, a cross-sectional study on FV consumption in a sample of 1060 children in Montreal found that children who reported higher intake of FV used to share their meals with parents [38]. Correspondingly, as per the results of the NEXT Generation Health Study among U.S. students, the presence of parents during mealtimes was associated with improved intake of FV and reduced meal skipping in children [66]. Although the reliable survey used plus the large and nationally representative sample, the self-report surveys were susceptible to respondent interpretation and recall bias [66]. Besides, a Harvard cohort study showed that children tend to have 5 servings of FV daily when they consumed their meals together with their parents compared to those who did not [67]. In addition, the same study found that the presence of parents during a meal helped them to serve as role models who teach children healthy eating habits and polite table manners [67]. On the contrary, some studies found no association between family meals frequency and FV intake of children [68,69]. The differences in results between studies could be due to the culture-specific meal structure, social desirability bias, less accurate reports of parents, methodological limitations, uncontrolled confounders, unadjusted analyses or unadjusted baseline intake [68,69].

It is noteworthy that regardless of the growing interest in this topic, limited studies have examined the effect of family meal frequency on children’s food consumption among populations at high risk of some chronic disease such as T2D.

1.3.2 Family meals frequency and obesity among children

Various previous research found that family mealtimes would help to promote healthy dietary habits in children; however, only a handful of studies have suggested that family meals may act as a protective factor against obesity [70]. Besides, findings have been mixed with some studies that reported no relation between family meals frequency and obesity, whereas others have reported strong relations [71,72]. These inconsistencies make it difficult to form a clear conclusion, while they may result from unadjusted analysis, focusing on both genders rather than examining them individually, and the variability in ages being examined [71,72].

A meta-analysis of 17 studies found that having three or more family meals per week is linked with 12% reduction in overweight among children [73]. Likewise, cross-sectional and longitudinal studies on children showed that more frequent family meals were associated with a significant low risk of obesity [74,75]. While, despite family meals frequency, unhealthy meals prepared at home beside large family meal portions could also contribute to overweight in children [76]. Moreover, results of a longitudinal study on Finnish schoolchildren found that increased family meals frequency overtime predicted lower BMI [77]. However, BMI is not an accurate indicator of body fat, and it does not consider bone density, sex and racial differences, overall body composition, and muscle mass [78]. In the same vein, a randomized controlled trial on family meals including 160 families being followed for 5 years found that promoting frequent family meals can decrease obesity among young children [79]. Despite the quality measurement and rigorous design of this study, the generalizability of the study findings is limited by the participants' characteristics [79].

Previous studies suggested that family meals frequency could affect children's body weight indirectly through various strategies. First, parental presence during a family mealtime can contribute in instructing their children and modelling healthier eating habits and food choices [70]. Also, more servings of FV and smaller serving portions are more likely to be considered during a family meal, which can be contributed to improved children's body composition [80]. Moreover, family meals could create a supportive environment for children to control their food intake as a result of the positive emotions that children experience over time [81].

On the contrary, some previous studies found no significant association between family meals and children's body weight [76,82]. On the other hand, in another study, significant inverse associations were found between family meals frequency and obesity status among children in cross-sectional analysis; however, no significant associations were found in the longitudinal model [71]. These differences could be related to not adjusting for potential covariates, particularly for family meals frequency and obesity indicators at baseline [71].

1.4 Childhood obesity

Obesity is defined as abnormal or excessive accumulation of body fat and is known to increase the risk of many serious diseases and decrease the life expectancy [83]. BMI is commonly used to determine the weight status of children especially in epidemiological studies [84]. Even if there are other anthropometric indexes that could reflect better the amount of body fat, BMI is still considered a good marker due to its simplicity and inexpensiveness [85]. Obesity during childhood is more likely to persist into adulthood with a higher chance of death and disabilities [86]. Childhood obesity is strongly linked to comorbidities including insulin resistance, T2D, high blood pressure, atherosclerosis musculoskeletal and orthopaedic disorders, cardiovascular disease, as well as some cancers [86,87].

The prevalence of childhood obesity has increased significantly worldwide to more than the triple during the last four decades [83]. According to the latest data from WHO childhood obesity surveillance in Europe, more than 35% of boys and girls aged 6-9 years in Europe had either overweight or obesity [88]. However, differences were observed between the European regions, where higher levels of overweight and obesity among children were detected in Cyprus, Greece, followed by Spain and Italy [89].

Weight gain is a consequence of the long-term imbalance between energy intake and energy expenditure [90]. Among the factors that have been used to explain this lack of balance are genetics and individual behaviors [90,91]. Behaviors that influence excess weight gain include the excessive intake of high-calorie diets and the consumption of foods and beverages of low nutritional value, lack of physical activity, sedentary behaviors as well as poor sleeping patterns [90,91]. These behaviors are the result not only of individual choices but could be largely determined by the surroundings and environments that do not support or promote healthy habits and lifestyle [92,93]. The availability and high price of healthy food options, social and cultural norms, marketing, and promotion of fast-food companies as well as public policies are all key factors in individual's decisions [92,93]. Furthermore, there are some parental-related factors that could affect childhood obesity such as parental eating habits, practices, perception, knowledge, and preferences along with family's mealtime structure, and parental BMI [94].

1.5 Diabetes and insulin resistance

Diabetes is a metabolic, chronic disease characterized by elevated levels of blood sugar (hyperglycaemia). T2D is the most common one, which occurs when the body becomes resistant to insulin resulting from defects in insulin action, insulin secretion, or both [95]. According to the International Diabetes Federation (IDF), the global diabetes prevalence may increase nearly to 11.3% by 2030 and 12.2% by 2045 worldwide [96]. There is a pre-state for diabetes, which is known as insulin resistance (IR). Worldwide, the

prevalence of IR in children and adolescents ranged between 3.1% and 44% [97] and from 15.5% to 46.5%, among adults [98].

IR could be defined as an impaired response to insulin stimulation in peripheral tissues, most notably the adipose tissue, skeletal muscle, and liver. This process impairs the cellular uptake of glucose, resulting in hyperinsulinemia and a compensatory increase in beta-cell insulin production [99]. Individuals with IR are considered at risk of diabetes as IR is considered as the primary cause of T2D, the most common form of diabetes [100]. In detail, when the status of IR exceeds the pancreas's ability to adjust, blood glucose levels rise. This is sometimes coupled with pancreatic-cell failure, which results in decreased insulin production and uncontrolled plasma glucose rises [100]. Overt time, chronic IR can lead to prediabetes and if left untreated, prediabetes often progresses to T2D [101]. Despite of the limited studies assessing the association between parental IR and children' IR [101], when compared to children of non-IR parents, children born to IR parents were found to be more likely to develop obesity and IR because of the genetic component and shared environment [102]. Similarly, children whose parents have diabetes are at higher risk of developing the same condition [100].

IR is usually associated with obesity, cardiovascular disease, metabolic syndrome, non-alcoholic fatty liver disease, and polycystic ovary syndrome (PCOS) [102]. Moreover, IR does not usually present symptoms until diabetes develops, while it can only be detected by a blood test [100].

The Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) has been widely used as an index to determine if IR is present. However, there is great variability in the HOMA-IR cut-offs. A HOMA-IR score ≥ 2.5 is suggested as the cut-off value for IR indication [103,104].

Yet the underlying causes of IR remain poorly understood, it has been suggested that it can be triggered by underlying risk factors such as age, race, unhealthy eating habits, sedentary lifestyle, high blood pressure, impaired lipid profile, poor sleeping patterns, a family history of diabetes, some medications, and genetic diseases [103]. However, it has been recently observed in a multi-centre European study that children of parents with IR and at high risk of T2D had higher probability of developing unhealthy lifestyle patterns [104]. Thus, assessing families that are already at risk of T2D could help in gaining a better understanding of this specific population [104].

2. Conceptual framework

For a better understanding of this Doctoral Thesis, the following conceptual model (figure 1) has been made to summarize the main relationship studied, including: (1) the association between home environment, parental dietary behaviors, practices, and children's eating habits; (2) the relationship between parental food consumption, diet quality and children's food consumption; and (3) the associations between family meals frequency and children's food intake and obesity. However, there are other factors associated with obesity and T2D among children that have not been investigated in this study, such as family's SES, physical activity, sedentary behaviors, TV viewing, and short sleep duration.

The hypothesis proposed in this conceptual model is based on the idea that home environment, parental feeding practices, parental eating habits and diet quality seem to play a critical role in developing obesity and T2D in children, through a mechanism of affecting family meals frequency, children's eating habits and food consumption and eventually leading to poorer health status of children.

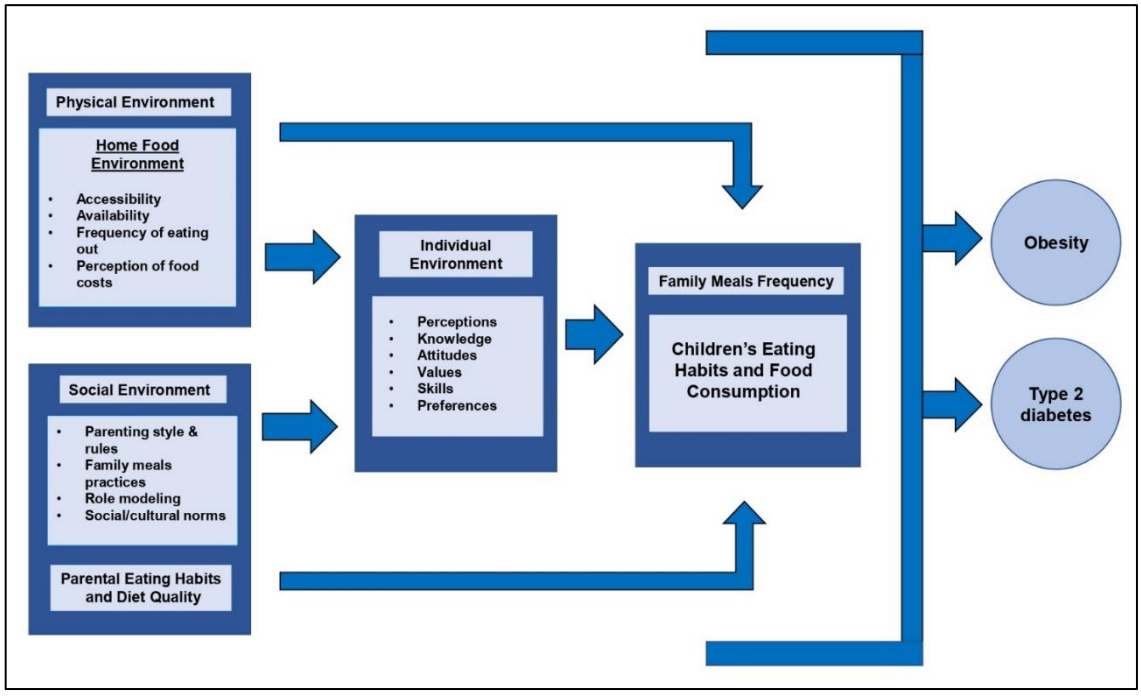

Figure 1. Conceptual framework (hypothesis). Source: self-made

3. Objectives

The general objective of this Doctoral Thesis is to study the associations between parental dietary behaviors, food consumption, diet quality and children's food consumption of selected food items. Also, to explore the associations between the frequency of family meals and children's food consumption and obesity in families at high-risk of type 2 diabetes across six European countries.

The specific objectives of the four manuscripts that comprises the Doctoral Thesis are the following:

Manuscript I. To investigate the potential influence of parents' dietary behaviors and practices on European children's eating habits.

Manuscript II. To examine the association between parental food consumption and diet quality and children's food consumptions in European families at high-risk of type 2 diabetes. Also, to compare food frequency consumption of parents and children to the European food-based dietary guidelines/recommendations.

Manuscript III. To evaluate the relationship between family meals frequency and parental food consumption and diet quality. Moreover, to explore the association between family meals frequency and children's consumption of selected food items. Also, to assess the mediation effects of parental diet quality on the association between the frequency of family meals and European children's food consumption in families at high-risk of type 2 diabetes.

Manuscript IV. To explore the cross-sectional and longitudinal associations between family meals frequency and children's overweight/obesity in families at high risk of type 2 diabetes across six European countries.

4. Materials and methods

This Doctoral Thesis includes results from a narrative review (manuscript I), as well as results from the European Feel4Diabetes-study (manuscript II to IV).

4.1 Study design and sampling

The Feel4Diabetes is a cluster randomized study, aimed to tackle obesity for the prevention of T2D and promoting healthy lifestyle among European families from vulnerable groups across six European countries. The Feel4Diabetes is registered within the clinical trials registry (NCT02393872), and the countries in the study were grouped in regions as: high-income countries (Finland and Belgium), countries under austerity measures following the economic crisis (Spain and Greece), and low-income countries (Hungary and Bulgaria). In Feel4diabetes study, the "vulnerable areas" were defined as every area in low-income countries and countries under austerity measures, and only low SES areas in high-income countries [104,105]. The participated municipalities were then assigned to the intervention or control group (ratio 1:1) [106].

The duration of the intervention period was two years (2016–2018), baseline (T0) data were collected in 2016, the first follow-up of the study (T1) was carried out one year later, and the second follow-up (T2) was conducted in 2018. For the recruitment of families in each country, primary schools located in the selected provinces were randomly selected and used as the entry-points to the community. While children of the first three grades and their parents were invited to participate in the study.

During the Feel4Diabetes-study, families were divided into two categories including "all families" and "high-risk families". The identification of "high-risk families" was based on having at least one parent at high risk of T2D estimated by using the Finnish Diabetes Risk Score (FINDRISC) through fulfilling the country-specific cut-off point. The FINDRISC is a validated tool that scores eight components related to age, consumption of FV, physical activity, family history of diabetes, history of high blood glucose, BMI, waist circumference (WC), and the use of antihypertensive medication [105].

At baseline, 4484 families were identified as "high-risk families" out of the total sample of 11,396 from "all families" group. Families at high-risk assigned to the "intervention group" received 2-years intervention plan which involved three different components (family, school, and community). During the first year, the intervention included six counselling sessions (two individual and four group sessions) on behavioural change approaches, promoting a healthier lifestyle, self-regulation, self-efficacy, and motivation to adopt a healthier and more active lifestyle. The intervention during the second year was less intensive and intended to maintain the Improvements using an SMS-intervention [106].

The data included in this Doctoral Thesis were only baseline and follow-up irrespective of the interventions being used. The inclusion criteria for manuscript II and III were parent-child dyads who had completed food frequency and eating behaviour questionnaire, and energy balance-related behaviors questionnaire (one for adult and one for children) and anthropometric measurements at baseline. In manuscript II, from the 2648 families that met the inclusion criteria, 553 families were excluded for incomplete information on food consumptions and anthropometric measurements, and 2095 parent-child dyads were included. Moreover, in manuscript III, out of the total sample of 2648 families, 702 families were excluded for incomplete information on family meals frequency and anthropometric measurements at baseline, and 1946 parent-child dyads were included. On the other hand, because of the longitudinal nature of manuscript IV and the fact that the availability of data from the same parent-child dyad at baseline (T0) and 2nd year of follow-up (T2) was mandatory for inclusion, only 989 parent-child dyads had completed data at both time points for inclusion in this study. Furthermore, in manuscript II to IV, only one child per family was randomly selected and then linked to the parental information since some families included more than one child and in order not to duplicate parental information. But in families where both parents were at risk of T2D, parents were selected randomly according to FINDRISC.

4.2 Ethics committee

The Feel4Diabetes-study was carried out following the ethical guidelines of the Declaration of Helsinki (1961), the standards of Good Clinical Practice and the legislation on clinical research in humans. The Feel4Diabetes-study was also approved by the Ethical Committees of each European country involved: Spain (CP03/2016), Greece (46/3-4-2015), Hungary (20095/2016/EKU), Bulgaria (52/10-3-201r), Belgium (B670201524237), and Finland (174/1801/2015).

The parents of the children participating in the study were informed about the study purposes and procedures. Also, they signed an informed consent showing their acceptance for participation in the study, and giving them the chance to withdraw from the study at any point.

4.3 Measurement methods

4.3.1 **Socio-demographics factors** (manuscript II to IV)

To assess the socio-demographic factors, data related to age and gender of both children and parents, as well as the marital status, educational and occupational level of parents were collected through questionnaires completed by parents. Parents were asked to identify their occupation during the last six months and the responses included seven choices: “stay at home parent”, “work full-time”, “work part-time”, “unemployed”, “full-time education”, “retired”, “something else”. Regarding the marital status of parents, the

answers were including “single”, “married or cohabiting”, “separated or divorced”, “widowed”, and “other”. While, the responses of parental educational level ranged from “less than 7 years” to “more than 16 years” of education, with a six-point scale response option.

4.3.2 **Anthropometric measurements** (manuscript II to IV)

The anthropometric measurements were conducted according to standardized protocols [106]. The height and weight of children were objectively measured at schools by a team of trained researchers, but those of parents were self-reported (except for high-risk families in which anthropometric measurements were taken in home setting). In children, the standing height was measured by Seca 217 stadiometer for mobile height measurement and recorded to the nearest 0.1 cm, and weight was measured by Seca 813 digital flat scale and recorded to the nearest 0.1 kg. The measurements of weight and height were taken while children were barefoot with light clothing and head in the Frankfurt plane. Two readings were obtained out of each measurement and the mean was used for the analysis. In case, the two readings were differed for weight > 100gm or > 1 cm for height, a third measurement was taken. The BMI was calculated as weight (kg) divided by height (m) squared. The BMI z-scores were calculated for children according to Cole et al. [108] to obtain an optimal measure for their weight in accordance with their age and sex. Children were categorized as having “normal weight”, “overweight”, or “obesity” through using the International Obesity Task Force (IOTF) cut-off points [107]. Only for manuscript IV and because of the longitudinal nature of the study, children’s changes in BMI (ΔBMI= BMI T2 – BMI T0) were calculated over the two years follow-up period.

4.3.3 **Dietary assessment** (manuscript II to IV)

The food frequency and eating behaviour questionnaires and energy balance–related behaviour questionnaires were self-reported and completed by one of the parents, who filled the questionnaires for him/herself and their child. The FFQ questions were derived from a questionnaire developed for a Finnish diabetes prevention program (FIN-D2D) [108]. While some modifications were added in order to adapt the questionnaire culturally for the target population across the six European country. The initial form of the FFQ was developed in English language and in order to ensure quality and reliability, the questionnaires were then translated back to the language of each country participating in the study. The questionnaire designed for children was similar to that of parents, except for excluding questions related to the consumption of alcohol and coffee. Moreover, the reliability of the questionnaires was tested by the intra-class correlation coefficients (ICC) of test-retest [108] in 191 pairs of parents and their children, who completed the questionnaires on two occasions within 1–2-week intervals.

In manuscript II and III, the food consumption of parents and their children was assessed according to specific food groups including cereals, milk and milk products, FV, legumes, fish and seafood, white meat, red meat, nuts, fat, sweets, and salty snacks. While, the intake of beverages such as fruit juices, soft drinks, and water was also assessed. The answers of each food item were based on specific portion sizes and included the following options: on a weekly (less than 1, 1-2, 3-4, or 5-6 times per week) or daily basis (1-2, 3-4, 5 times or more per day). The portion sizes of each food item were defined with a household unit and placed under each question [108]. While the standard portion size was multiplied by the number of servings consumed in order to convert the consumption of each food item to daily intake in grams.
For manuscript III and IV, the family meals frequency was assessed individually for each meal occasion including breakfast, lunch, and dinner through the following question: "how often do your children have the following meals with family". The question could be answered by choosing one of the following six options: never, less than 1 time/week, 1-2 times/week, 3-4 times/week, 5-6 times/week, and daily.

4.3.4 **Healthy diet score** (manuscript II to IV)

The Healthy diet score (HDS) was developed for adults [109] but also adapted to be used for children [104]. The HDS was used to assess the DQ of parents (manuscript II to IV) and children (manuscript IV) as a validated indicator based on the dietary questions of the Feel4Diabetes-study, which has been tested before over families at high-risk of T2D. The main points of the HDS were based on the total of 12 intervention goals of the Feel4Diabetes-study related to food choices and food-related behaviors. These points include the following: breakfast, family meals, whole-grain cereals, fruits and berries, vegetables, low-fat dairy products, nuts and seeds, oils and fats, red meat, salty snacks, sweet snacks, and sugary drinks.

The HDS has a specific scoring system. For parents, a maximum score of 6 was given to the consumption of low-fat dairy, sweet snacks, salty snacks, nuts and seeds. A maximum score of 8 was given to the consumption of oils and fats and frequency of family meals. The rest of the food groups received a maximum score of 10. On the other hand, for children, the group of nuts and seeds were not included, only the oils and fats used for cooking were included from the fat group. Therefore, the scoring system was adapted accordingly to the available information from children. For children, the cooking oil and fats component was given a maximum score of 4. A maximum score of 6 was given to the consumption of low-fat dairy, sweet snacks, salty snacks. A maximum score of 8 was given to the component of family meals frequency. The rest of the food groups received a maximum score of 10. The higher scores indicate higher consumption, except for sugary drinks, sweet snacks, salty snacks, and of red meat, in which higher scores indicated lower consumption. In general, higher total scores of HDS indicating better diet quality, in which the total score of HDS ranged between 0 to 100 for parents and from 0 to 86 for children [104,109].

4.4 Statistical analysis

In general, the descriptive characteristics of the participants were presented as mean and standard deviation (SD) for continuous variables, and as percentages for categorical variables. The normality was tested using the Kolmogorov-Smirnov test. Pearson's chi-square test was used in the case of categorical variables, and Student's t-test was used to compare means of continuous variables by gender.

All the analyses shown throughout the different articles included in this Doctoral Thesis were carried out separately by the sex of children as new literature identified sex interactions in eating habits among pre-pubertal children [110].

In manuscript II, the frequencies of food consumptions (servings) of parents and their children were compared to the European Food-Based Dietary Guidelines (FBDGs) [111] and presented as percentages. Linear regression analyses were performed to: 1) assess the association between parental food consumption and DQ using HDS and the children's food consumption; 2) examine the association between mothers' food consumption and DQ using HDS and the children's food consumption. All the analyses were adjusted for parental age, gender, country, marital status, educational level, and BMI of both parents and children.

In manuscript III, multiple regression analyses were carried out to: 1) examine the association between family meals frequency and food consumption of both parents and children; 2) test for association between the frequency of family meals and parental DQ using HDS. Separate models were run for each meal (i.e., breakfast, lunch and dinner) independently, and all analyses were adjusted for parental age, gender, marital status, country, educational level, SES, and BMI of both parents and children. Moreover, a mediation analysis was tested with regression analyses to examine if the parental DQ (M) mediate the association between family meals frequency (X) and children's food consumption (Y). A partial mediation is indicted if the effect of (X) on (Y) is reduced when (M) is included. While, a complete mediation is indicated if the effect of (X) on (Y) disappears entirely when (M) is included. Significant mediations were then calculated as percentages through dividing (a*b) by the total effect (c-coefficient), in which (a-path) represents the association between family meals frequency and parental DQ, and the (b-path) represents the association between parental DQ and children's food consumption used as outcome, adjusted for family meals frequency.

In manuscript IV, multivariable regression analyses were performed to: 1) study the cross-sectional associations between family meals frequency and BMI of children at T0 and T2; 2) assess the longitudinal associations between the changes in family meals frequency and changes in BMI of children from T0 to T2. For the cross-sectional associations, regression analyses were adjusted for group (intervention-control), country, DQ and age of children, and parental characteristics (age, gender, marital status, educational level, SES, DQ and BMI). For the longitudinal associations, the model was

adjusted for country, group (intervention-control), DQ and age of children, parental characteristics (age, gender, marital status, educational level, SES, DQ, and BMI) in addition to family meals frequency and BMI of children at baseline. Furthermore, multilevel logistic regression was carried out to examine the odds of overweight/ obesity at T2 as a function of family meals frequency at baseline, considering country and group (control vs. intervention) as levels. The family meals frequency was introduced as the independent variable and classified into three categories: never, 1-2 times/week, 3-7 times/week. The "never" group was considered as a reference, and children's BMI was introduced as the dependent variable.

Finally, multilevel logistic regression analysis was used to examine the prospective associations between: 1) changes in family meals frequency during a period of 2-years and BMI of children at T2, in which family meals frequency were characterized in five groups: (never, decreased, remained low, increased, remained high), and "never" was considered as a reference. In addition, the BMI categories included were categorized as (normal vs. overweight/obese). The model was adjusted for parental characteristics (education level, marital status, sex, DQ, and BMI) as well as children's age, DQ, and BMI at baseline; 2) Changes in both family meals frequency and BMI from T0 to T2, in which family meals frequency were characterized in five groups: (never, decreased, remained low, increased, remained high). While four categories of BMI changes were created classified in groups from better to worse: "normal at T0 and T2", "overweight/obese at T0 but normal at T2", "normal at T0 but overweight/obese at T2", and "overweight/obese at T0 and T2". The model was adjusted for parental characteristics (education level, sex, marital status, DQ, and BMI) and children's DQ, and age.

In manuscript II to IV, data were analysed with IBM-SPSS Statistics for Windows (Version 26.0. Armonk, NY: IBM Corp, USA), with a $p<0.05$ representing statistical significance for all tests. While, for manuscript III, the indirect effects (a*b) were obtained through conducting Bootstrapping (5000 samples) using the PROCESS macro for SPSS by Andrew Hayes [112]. Except for manuscript IV, Stata/SE 13 (Stata Corp LP, College Station, TX, USA) was used for the logistic regression model.

5. Results

The results of this Doctoral Thesis are presented as published research manuscripts.

Manuscript I: The influence of parental dietary behaviors and practices on children's eating habits.

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Review

The Influence of Parental Dietary Behaviors and Practices on Children's Eating Habits

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Abstract: Poor dietary habits established during childhood might persist into adulthood, increasing the risk of developing obesity and obesity-related complications such as Type 2 Diabetes Mellitus. It has been found that early modifications in eating habits, especially during childhood, might promote health and decrease the risk of developing diseases during later life. Various studies found a great influence of parental dietary habits on dietary behaviors of their children regardless of demographic characteristics such as gender, age, socioeconomic status and country; however, the exact mechanism is still not clear. Therefore, in this review, we aimed to investigate both parents' and children's dietary behaviors, and to provide evidence for the potential influence of parents' dietary behaviors and practices on certain children's eating habits. Family meals were found to contribute the most in modeling children's dietary habits as they represent an important moment of control and interaction between parents and their children. The parental practices that influenced their children most were role modeling and moderate restriction, suggesting that the increase of parental encouragement and decrease of excessive pressure could have a positive impact in their children's dietary behaviors. This narrative review highlights that parental child-feeding behaviors should receive more attention in research studies as modifiable risk factors, which could help to design future dietary interventions and policies to prevent dietary-related diseases.

Keywords: parents; dietary intake; feeding practices; children; family meals; breakfast; snacking habits

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1. Introduction

Obesity is a complex condition influenced by both genetic and environmental factors [1]. Dietary intake has been linked with obesity in terms of volume, composition, meals' frequency, snacking habits and diet quality [2]. Additionally, there is indication that children are likely to maintain their dietary habits into adulthood [2]. Thus, understanding children's eating habits is very important in terms of children's health [3]. There are some factors that could influence children's eating habits such as the home food environment, as well as the social environment, contexts where perceptions, knowledge and eating habits are established [4]. However, parental dietary patterns seem to affect children most,

as parents are the ones who shape the home food environment, influence how a child thinks about food, and, accordingly, start forming their own food preferences and eating behavior [4].

Out of the dietary habits, family mealtime becomes the main social context in which children can eat with their parents, who are considered as their main role-models [5]. Sharing meals with children, having breakfast together regularly and encouraging children to have healthy snacks with moderate restrictions have shown positive impacts on children's dietary behaviors [6]. Furthermore, one review study evaluated these practices and found that they were associated with higher consumption of dairy products, fruits and vegetables (FV), along with healthier breakfast patterns among children [7]. Also, the same review stated that encouragement practice gives children a chance of making decisions, whereas the moderate restriction practice help parents to imply clearer instructions to their children. Therefore, it was recommended to use a combination of the two practices, so that both parents and children would have the ability to contribute to determining food choices [8]. In this narrative review, we focus on the effect of parental dietary habits on children's eating behaviors, including family meals, breakfast routine and snacking habits.

2. Method for Literature Search

Serial literature searches for articles of interest were performed between August and December 2020. PubMed, Scopus, Education Resources Information Center (ERIC), Science Direct and Google scholar databases were searched using the following keywords: "parents", "dietary intake", "feeding practices", "children", "family meals", "breakfast", "snacking habits", "food choices", "food consumption", "role model", "diabetes", "parenting style", "behavior". We included both original researches and review articles published between 2000 and 2020. Studies were eligible if they were published in English and included preschoolers (ages 2–5 years), or school-age children (ages 6–13 years). A total of 2590 studies were identified, 508 duplicates were removed, 455 related titles were chosen, 92 articles met the inclusion criteria and 83 studies were included in this review.

3. Definitions

"Eating habits" can be defined as the conscious and repetitive way a person eats, and this includes what types of food are eaten, their quantities and timing of consumption, in response to cultural and social influences [9]. On the other hand, "eating behaviors" have been considered as a group of actions starting from a simple food chewing to food shopping, food preparation and food policy decision-making [10]. Food patterns or dietary patterns refer to the quantity, quality and variety of foods and beverages consumed as well as the frequency with which they are habitually consumed, and it refers to the diet as a whole [10]. A balanced diet is characterized by high intake of fresh FV, whole grains, legumes, nuts, fiber, polyunsaturated fatty acids and low in both refined grains as well as saturated fatty acids [11]. However, guidelines may differ in their recommendations regarding the consumption of processed meat and dairy products, probably relating to the national food culture, sustainable food choices and food safety [11].

4. Children's Eating Habits

Dietary habits from childhood track into adulthood, so understanding children's eating habits is very important in terms of children's health [12]. Nutrition is the main factor of interaction between parents and children, especially during the first year of life, starting by breastfeeding [12]. By the end of the first year of life, children start learning to feed themselves and make the transition to the family diet and meal patterns [12]. A review study that assessed both national and international research articles on child nutrition and eating behaviors concluded that as children switch to the family diet, recommendations from parents address not only food, but also the eating context, which refers to the immediate environment of each eating occasion [12]. Moreover, the same study suggested that a

variety of healthy food items provided to children can promote their diet quality and food acceptance [12].

A study across 11 countries suggested that the nutritional status of children from birth to the age of 2 years was positively associated with dietary variety [13]. Furthermore, exposures to FV in early childhood have been associated with higher acceptance of these foods at later ages [13]. A longitudinal study of 120 2-year-old children and their parents followed for 9 years found that around 25% of children experienced some eating problems such as being hesitant to try new foods or insist on a limited number of food items (no variety), concluding that those problems may lead them to become picky eaters [14].

However, children with eating problems (i.e., picky eaters, meal skippers) may be at risk for behavioral problems, as well as impaired growth and development [14], whereas repeated exposure was found to be the main way for children to recognize the food. Thus, parents are advised to keep introducing food items more than once, and to avoid getting discouraged or giving up [12].

5. Home Food Environment

The home food environment includes the availability and accessibility of food, as well as other factors such as frequency of eating out, and parents' perception of food costs [15]. In addition, the home food environment was found to have remarkable effects on eating behaviors of parents and their children as most of the food consumed is stored and prepared at home [15]. Although children are likely to be influenced by their home food environment and the community, they may have limited control over it [16]. Results from the Quebec Longitudinal Study of Child Development, which included 1492 children, found that children who had a better family environment, i.e., less family pressure to eat, had low levels of soft-drinks consumption (unstandardized $\beta = -0.43$, $p < 0.001$, 95% confidence interval (CI), –0.62 to −0.23), and high level of fitness (unstandardized $\beta = 0.24$, $p < 0.001$, 95% CI, 0.12–0.36) [16]. In the same vein, the baseline survey of the Identification and prevention of Dietary- and lifestyle-induced health Effects in Children and infants (IDEFICS) study, which included 1435 families from eight European countries, found that home food environment plays a stronger role in shaping children's intake of healthy foods than unhealthy foods, especially for younger children [17].

As previously mentioned, the home food environment determines what kind of foods are available and accessible to children [15]. While availability and accessibility are often merged into a single construct, the content map presented in Vaughn's study [18] considered them separately because they may have differential effects on children's diet and eating behaviors. Accordingly, these diverse definitions could explain the differences found in the results of studies. Availability is related to the physical presence of food [18], whereas accessibility refers to parental actions to control how easy or difficult it is for children to access food by themselves or with limited assistance [18]. A review about the availability and accessibility of FV at home found that both availability and accessibility were associated with FV consumption among children and adolescents and inversely associated with children's total energy and fat intake [19].

Besides, low consumption of nutrient-poor, energy-dense food items, like sugar-sweetened beverages, cookies, packed snacks, food high in saturated/transfat, simple sugars and sodium, were noticed when these items were and were not available at home [19]. However, low-income families seem to have low access to healthy foods and possibly greater access to fast food due to dietary costs, which could explain some of the relationships between Socioeconomic Status (SES) and nutrient density of consumed foods [19].

Frequency of eating out is one of the dietary habits that are most influenced by the household environment [20]. Ready-to-eat and out-of-home (OH) foods include vending machines, take-away, cafes, restaurants, supermarkets and convenience stores [20]. Nowadays, families seem to prepare less food at home and spend more money on foods prepared away from home [20], and food prepared OH tends to be more energy-dense than food prepared at home, particularly in terms of fat and sugar content [20]. In addition, focus

groups among the urban community in the US found that parents desire easy, convenient and tasteful meals that are culturally appropriate and low-cost, while some families may believe that food eaten out is lower in cost and tastier [21]. These beliefs would encourage parents to eat out and thus perpetuate the cycle of decreased home-prepared meals. Consequently, children may have less opportunities to learn culinary skills, have access to healthy diet, or reinforce healthy eating habits [21]. Cross-sectional data from the UK National Diet and Nutrition Survey Rolling Program of 4636 children and adolescents aged 1.5–18 years showed that consuming food prepared outside the home was associated with a greater intake of foods with high levels of fat and sugar in children [20]. Also, a systematic review documented the nutritional characteristics of eating away from home and its relations with the diet quality and energy intake. The results of this review concluded that eating outside the home is associated with lower diet quality and micronutrients intake, like vitamin C, Fe and Ca. However, the conclusion needed further confirmation as the review was based on studies from national surveys from Belgium and the United States only [22]. Similar results were obtained in a cross-sectional study conducted in Japan among 4258 caregivers, where children with obesity had a lower frequency of shared home-made meals, after adjusting for confounding factors.

However, validity and reliability of the questionnaire used to assess the frequency of cooking were not examined [23]. Unfortunately, these studies have only considered the effect of eating out without concerning the effect of ready-to-eat (unhealthy) meals prepared at home.

6. Parenting Styles and Feeding Practices

In the literature, parenting styles have been defined as psychological constructs representing the more general interactions between parents and children, whereas parental feeding practices includes specific rules or behaviors used by parents to control when, what and how much their children eat [24,25].

It has been previously stated by Horst and Sleddens [26] that according to Baumrind's taxonomy, parenting styles have been divided into three categories: authoritarian, permissive and authoritative. Whereas authoritarian styles are highly demanding but less responsive, permissive styles include less demanding but high responsiveness, and authoritative styles present both demanding and responsive [26].

Studies examining the direct role of parenting styles on children's eating behaviors are limited. However, a recent review of the evidence found that less parental monitoring was presented in the permissive style, whereas more restrictive food and high pressure on children to eat were linked to authoritarian parenting style. On the other hand, preferable parental monitoring of the child's food intake was associated with the authoritative parenting style [27]. Another two systematic reviews concluded that children tend to eat more healthily with a healthy body mass index (BMI) if they raised in authoritative households. However, the effects of these generic parenting styles were generally indirect and weak [28,29].

One review critically summarized previous research on parental feeding practices and found that role models can play a really important part in shaping children's eating habits. Therefore, role modeling behaviors were recommended for parents such as: providing healthy foods, modeling healthy eating and increasing encouragement to eat healthy foods [30]. Results from a study that used the Parental Feeding Style Questionnaire (PFSQ), which included 100 children (aged 2–5) in Hong Kong, showed that encouraging children to consume a variety of foods was associated with healthier eating behaviors, like meal frequency, better food choices and higher intake of fruits (Odd Ratio (OR) = 1.357; 95% confidence interval (CI) = 1.188 to 1.551) and vegetables (OR = 1.335; 95% CI = 1.128 to 1.579) [31]. Whereas, using foods as rewards could increase the child's preferences for these food items. Thus, using unhealthy foods as rewards may promote children's consumption of unhealthy energy-dense palatable foods [31]. Likewise, a cross-sectional study conducted in 17 primary schools in Dunedin city in New Zealand found that through

a good parental role modeling, higher parental diet quality was associated with lower consumption of cakes, chocolate, biscuits and savory dishes in children [32]. A cross-sectional study included 13,305 children in nine European countries and found associations (OR between 1.40 and 2.42, $p < 0.02$) between parental role modeling of healthful foods with children's dietary habits, food intake and preferences for fruits and vegetables [33].

The results of these studies highlighted the importance of parental modeling in terms of their dietary behaviors and food choices on the diet of their children. However, parental role modeling studies have employed different methods, with varying validity, to measure children's dietary intake, such as 24 h dietary recalls, food frequency questionnaires, parent report of child dietary intake and child report of parental role modeling. This could explain why correlations between parent and child reports for these studies have also been mixed, whereas studies that have utilized both parent and child report are very limited.

A review study summarizing previous results on parental strategies and practices concluded that a "moderate restriction" could be beneficial as children of moderately restrictive parents were found to consume fewer calories, eat more fruits, and eat less fatty snacks and sweets [34]. Besides, the "prompting and encouragement" feeding practice made by parents could help their children to have healthier dietary habits [34]. The term "moderate restrictions" indicates a careful use of restrictions by parents in which unhealthy food items were gradually decreased and limited rather than being strictly forbidden, whereas the word 'encouragement' refers to the situation when parents offer more types of food with positive messages, but at the same time, children can still make decisions in combination with their parents [31].

On the other hand, restricted parental feeding practice seemed to be related to overeating, especially among preschool-age children [35]. One longitudinal study assessed the maternal influences on picky eating behaviors and diet of 173 9-year-old non-Hispanic white girls [36]. The results of this study suggested that with mothers who were less likely to pressure their children to eat, their children were less likely to be picky eaters or overweight [36]. While, when parents highly restrict energy-dense foods from their children's diet hoping children choose healthful alternatives, children usually increase their desire for it and start to eat when they are not hungry [34]. Therefore, various research studies discourage pressuring practice as it can create a negative family eating environment and make children pickier eaters [37,38].

Evidence suggests that high involvement and role-modeling practices are more favorable for supporting positive food-related behaviors, especially among young children. But unfortunately, these studies cannot be taken as proof of causality. Thus, long-term studies are needed to determine the causal link between parental feeding practices and children's eating habits.

Household food rules is another factor which is usually established by parents to guide youth behaviors and achieve goals for their growth [39]. To explain further, for example, both "limited fast food" and "limited portion sizes at meals" were significantly linked with improved food consumption and weight status [39]. Whereas a rule of "no fried snacks" was positively associated with percent body fat (PBF), however, the link between fat intake, snacking and excess weight was unclear as snack foods are often grouped as one item (e.g., chips, candies, ice cream and cookies) [39]. Besides, the "no snacking while watching television" rule was found to be an effective one as children tend to eat more when they are distracted and eating while watching TV also prolongs the eating period [39]. In a School of Public Health Project, Eating and Activity over Time (EAT) researchers found that children in families who watch TV while eating meals had a lower-quality diet than the children of families who turned the TV off during meals [40]. In the same study, children who watched TV while eating family meals seemed to consume fewer grains and vegetables, and more soft drinks, than those who did not watch TV. Similar results were also found among Australian children in which watching TV was associated with the consumption of energy-dense foods and drinks [41]. However, these studies do not definitively prove

direct causal effects of household food rules on unhealthy food preferences and overall unhealthy diet.

7. Parental Dietary Behaviors Influence on Children's Eating Habits

Dietary preferences are formed by a combination of a complex interplay of genetic, familiar and environmental factors. However, parents seemed to have a high degree of control in modeling their children's eating behaviors [42]. During the first year of life, children's dietary patterns undergo a rapid evolution since parents are the ones who select the foods of the family and serve as models of eating. Thus, children tend to imitate their parents' behaviors as well as eating habits [42]. As illustrated in Figure 1, children's eating behaviors are affected by social, physical and intra-individual factors. In the family environment, parents establish more than 70% of their children's dietary behaviors by their own intake and the methods followed to socialize their children [42]. To systematically assess the effect of parental dietary patterns on children, several studies have been revised, which summarize how parental eating habits and feeding styles have been significantly associated with children's eating behaviors, food preferences, intake and consumption (Supplementary Table S1).

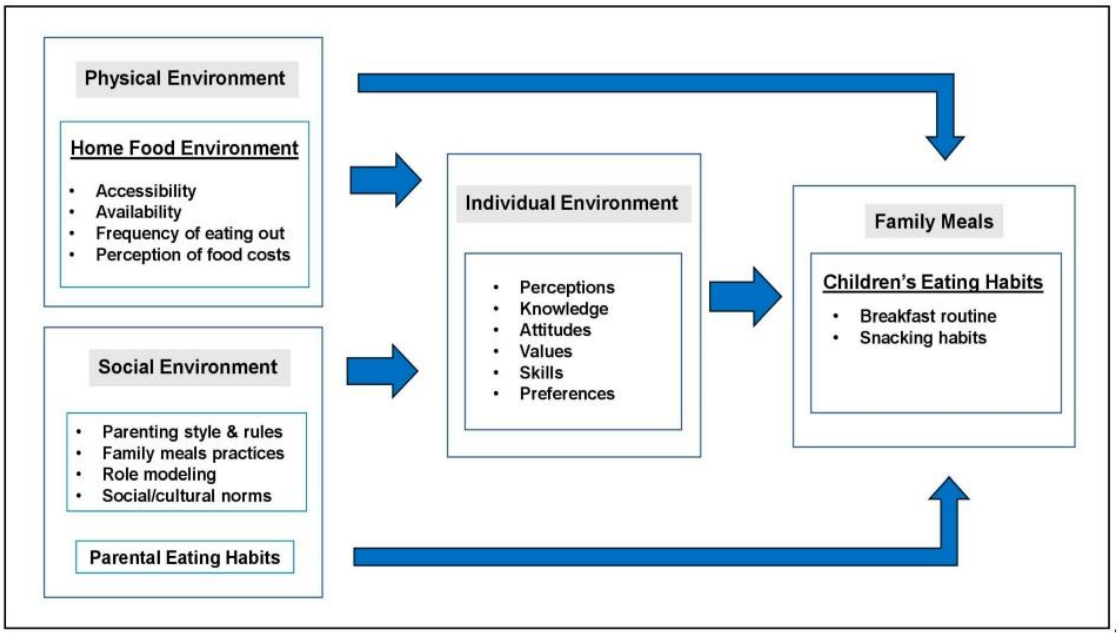

Figure 1. Summary of home/family-related determinants of children's eating habits.

Parental dietary behaviors refer to the passive processes that influence their children's dietary behaviors and food environment [43]. Various cross-sectional studies have indicated the close similarity between parents and children in the intakes of some healthy and unhealthy foods and beverages, as well as dietary composition, especially when more meals are eaten together [44–48]. Although this association has demonstrated that parents' dietary behavior might influence children's intake, these studies cannot be used to conclude causality. Therefore, the process by which parents affect their children's food intake remains largely unclear.

Four focus groups were conducted in Belgium among parents and caregivers showing that the influence of parental practices differs by age. The younger the child, especially at preschool age and first years of primary education, the stronger the role of parental practices [43]. The same study found that children may consider parents' norms and perceptions as a reference for what is appropriate to consume [43].

Various cross-sectional studies found showed a significant positive association and substantial correlation between children's and parent's intake of various foods [49–51]. Thus, parents' eating behaviors have proven to be a part of the whole process of establishing and promoting healthy or unhealthy dietary patterns among children and adolescents [42]. A Parent Mealtime Action Scale (PMAS) was developed among 439 fathers and 541 mothers in the USA to examine the dimensions of mealtime behaviors used by parents on children's diet and weight status. The results showed that parents could be influenced by their environment and culture, which may also affect their food choices, suggesting that their children's dietary patterns and nutritional status may also be altered accordingly [52]. Whereas the same study found that obliging a child to accept healthy food through giving advice only, without eating it themselves, is a dead end in nutrition education [52].

Previous studies concluded that parents' influence is thought to be strongest during childhood, especially in early ages, when parents act as role models, enforcers and providers. Therefore, intervention programs should consider what parents consume as well as the parental influence in terms of what parents feed their children and how they feed them.

7.1. Family Meals

Family meal has been defined as a meal being shared with family members or when one, or both, of the parents are present [53]. There are differences when analyzing the frequency of family meals: some considered it as having $\geq$3 and others $\geq$5 family meals taken weekly [53]. Thus, the lack of specificity and consistency in measuring, analyzing and defining family meals makes it difficult to come up with definite results and to compare results [53].

A systematic review [54] that focused on the effects of family meal frequency and psychosocial consequences in youth concluded that more frequent family meals were inversely associated with disordered eating, violent behaviors and depression in children. Additionally, in the same review, it was found that more frequent family meals were positively associated with an increased self-esteem among children [54]. It is agreed that family meals represent an important moment of both control and interaction in the family [55]. A study of family mealtime characteristics of Australian families with children aged 6 months to 6 years old showed that parents place high value on mealtime when they share meals with their children, which helps children to promote healthy eating behaviors. An important strength of this study was the reliable survey measures, but the used online, self-report surveys can be affected by respondent interpretation bias [55]. The presence of parents during mealtime has been linked to decreased meal skipping and increased consumption of dairy products and FV [43]. Correspondingly, results of the Next Generation Health Study in the US showed a higher FV consumption among children whose parents were eating the same food items and sharing their meals with them. This study included a large, nationally representative and generalizable sample; however, the self-estimation and self-report assessment were susceptible to recall bias [56].

In Scotland, a cohort of young children followed-up for 10 years suggested that determining the characteristics of family mealtime practices is needed to increase diet quality and improve children' eating behaviors, such as reduced access to TV viewing during meals, portion sizes, sitting at a table, besides social engagement between parents and children [57]. Similarly, the Quebec Longitudinal Study of Child Development investigated the effect of frequent family meals on children, and results showed that children who had a better family meal environment at the age of 6 years had lower levels of soft-drinks consumption and higher levels of fitness when they reached 10 years [16]. In the same vein, a Harvard cohort study found that children who eat together with their parents are twice as likely to eat their five servings of FV compared to families who do not share their meals. Moreover, in the same study, family meals seemed to help parents to perform as role models and be considered as an example of polite table manners and healthy eating habits [58]. In addition, results from the same study also showed that shared meals seem

to help in childhood obesity prevention as children tend to eat less when they eat in the presence of their parents [58]. Participants in this study were children of nurses, hence, they all came from highly educated families compared to the general population [58].

One meta-analysis concluded that higher frequency of shared family meals in children and adolescents was significantly associated with a normal body weight and healthier dietary habits when they shared family meals 3 or more times per week [59]. Additionally, home cooking and shared family meals have been considered as a key strategy to promote healthy dietary habits and prevent obesity among children [60,61]. A family meals-focused randomized controlled trial in 160 families of 12-year-old children followed-up for about 5 years. Data were collected at baseline, post-intervention and follow-up, and results indicated that promoting healthy shared family meals could lead to a moderate reduction in excess body weight, especially among young children.

Despite the rigorous design, quality measurement and strong theoretical framework used in this study, the generalizability of study findings is limited [61], while engagement in family meals has been considered as the simplest and easiest independent intervention that could be applied to establish a healthy family environment [61]. Therefore, eating environment should be taken into account as it usually affects family communication, parents and children interactions, what kind of food is served, how much is eaten at meals and frequency and lengths of meals. However, it seems that the specific mechanisms of how family mealtimes influence children's nutritional outcomes are yet unclear and should be investigated.

7.2. Breakfast Routine

"Breakfast" refers to the first meal of the day, or a meal often eaten in the early morning [62]. The findings from the "Anthropometry, Intake and Energy Balance" (ANIBES) Study [62] reported that around 85% of the Spanish population (9–75 years) were regular breakfast consumers, although one in five adolescents were breakfast skippers. It has also been found in the same study that breakfast provides only 16–19% of the daily energy intake. Among the specific foods, the most commonly consumed breakfast foods among children and teenagers were chocolate, pastries and milk [62]. Additionally, a review studied the benefits of breakfast by involving national dietary survey data from various countries including Spain, the UK, Canada, the USA, Denmark and France. Its results found that a healthy regular breakfast has been associated with improved cognitive health, nutritional status and lower plasma cholesterol levels among children and adolescents [63]. These results were supported by a cross-sectional study conducted among 126 children in four elementary schools in Indonesia. Results from that study found that breakfast habits of children were significantly associated with the parent's breakfast habits [64]. Moreover, in the same study, 23% of fathers and 15.9% of mothers were not having breakfast daily, whereas, 17% of children reported that they are not taking their breakfast because no food was available at home in the morning [64].

One of the most wide-reaching reports is that of the European branch of the World Health Organization, who conducted a health behavior survey of over 200,000 male and female schoolchildren, 11–13 and 15 years of age in 39 European states in 2009/2010 [63]. Overall, 61% of 13-year-olds consumed a breakfast on each school day, while the figure fell to 55% among 15-year-olds. In general, breakfast consumption was most common among boys and declined with lower socio-economic status [63]. These data showed that about half to one third of children do not have breakfast every day, although the data does not reveal the actual frequency of breakfast intake [63]. The report also indicates that regular breakfast consumption is associated with higher intakes of micronutrients, a better diet that includes FV and less frequency of consumption of soft drinks [63]. According to the Health Sponsorship Council (HSC), there are more than 100,000 children worldwide aged 1–5 years missing breakfast at least once per week, while their parents are also skipping this meal. Besides, over 36,000 children worldwide never consume breakfast at home. It has been revealed that children of parents who skip breakfast are more likely to skip

their breakfast, consume more energy-dense nutrient-poor food and are more likely to be overweight [65]. A cross-sectional study including 426 children aged 10–14 years from 4 local schools in Queensland found that skipping breakfast among children was associated with the lack of perceived parental emphasis on consuming breakfast (OR = 3.67, 95% CI: 1.75–7.68) [66].

Another cross-sectional survey conducted among preschoolers aged 2–5 years in Hong Kong showed that most children were having their breakfast daily but less than half of them consumed the recommended number of dairy products and FV [31]. Consequently, these studies suggested that parental breakfast-skipping habits are strongly associated with breakfast skipping among their children. Thus, findings underline the importance of addressing parental habits and their children's in the intervention plan.

7.3. Snacking Habits

"Snack" has been defined as a small portion of foods or drinks that is taken between regular meals [67]. Another study considered snacks as food items consumed at different times of the day [68]. A study conducted in Spain defined snacking as the process of consuming any food intake outside the three main meals, including mid-morning snack "between breakfast and lunch" and mid-afternoon snack "between lunch and dinner", and nibbling, "disorganized and without defined timing" [69]. The term "snack" seems not to have a static definition [67]. Thus, the impact of snacking is difficult to be assessed due to the variety of its definitions in the literature [67].

In Spain, it has been found that 84.4% of younger and 78.3% of older children were mid-afternoon snack consumers. Specifically, sandwich was the most common food item consumed [69]. Excessive consumption of soft drinks and high-fat-containing snacks and low intake of fruits and vegetables was reported among Mexican children in five Baja California counties [70]. Similar findings were found in a cross-sectional study which involved 109 students and their parents in Milan. Results showed that more than 35% of snacks consumed by school-age children were sweets, 23.8% sugary drinks, 9.4% savory snacks, whereas consumption of nuts, yogurt and fresh fruits was very low [71].

Despite limited data, a systematic review concluded that parents' eating behaviors, whether positive or negative, have an impact on the quality of snacks consumed by their children [72]. Whereas consumptions of lower-quality snacks were associated with increased prevalence of overweight among children [73–75]. Some research studies found that the influence of parents on children's snacking habits depends on the children's life stage and age. For instance, parental influence decreases in the transition from childhood to adolescence [76,77]. The nationally representative surveys of food intake in US children demonstrated a positive association between parents' and children's snack consumption, where children tend to consume more snacks if their parents prefer to have more snacks throughout the day [78]. A cross-sectional study which included 1632 elementary school children in Japan showed that their snacking habits were affected by paternal eating habits, for example, children did not consume vegetables as snacks as it was not offered by their parents. Nonetheless, since data were collected only from children in Takaoka city in Japan, the results may not be generalizable to a global population [79], whereas children's consumptions of FV as snacks were high in homes with greater FV intake among parents as well as FV availability [79]. These results were confirmed by another study which used a Web-based survey among 9842 students in Australia and found that when parents offered more snacks, children consumed more snacks [80]. Another cross-sectional study conducted among 667 students selected from schools in West-Flanders (Belgium) confirmed that parental monitoring and child's eating schedule or routine set by parents were associated with more FV intake among girls ($p \leq 0.001$, 95% CI: −1.8 to −0.5) and boys ($p \leq 0.001$, 95% CI: −1.7 to −0.5), and reduced negative eating behaviors such as less unhealthy snacking [81]. Results of comprehensive questionnaires, completed by parents of children aged 4–8 years ($n = 203$) in New Zealand, found that the lack of rules regarding the offering of foods to children was associated with a higher intake of fatty snacks [82].

Based on previous studies, it is suggested that during school age, parents play an important role in the control of children's food intake and food choices. Thus, the whole family is encouraged to be involved in the educational interventions to prevent imbalanced snacking behaviors in children.

8. Conclusions

Multiple parental factors influence a child's dietary habits and are reciprocally interacting, so they cannot be considered separately. The family environment that surrounds a child's domestic life has an active role in establishing and promoting behaviors that will persist throughout their life. Family meals seem to represent an important moment of both control and interaction, which contributes the most in modeling children's dietary habits. Parents should avoid excessive pressure or restriction as it can create a negative social and emotional experience that could affect children's acceptance of the food. Instead, parents should encourage their children on healthy snacking as well as not to skip their breakfast. This can be achieved through positive and active social modeling as well as moderate restriction. Given the considerable evidence for the strong effect of parents on their children's dietary habits, we believe that parents' child-feeding behaviors should receive more attention in childhood obesity prevention policies. We recommend that parents should be provided with information and guidance on how, as well as what, to feed their children, and these promotion strategies should be particularly aimed at parents' unhealthy eating too so they can improve their diet and so their children will imitate them.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/nu13041138/s1, Table S1: Studies assessing the influence of parental dietary behaviors on children's eating habits.

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Manuscript II: Parental food consumption and diet quality and its association with children's food consumption in families at high risk of type 2 diabetes: the Feel4Diabetes-study

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Parental food consumption and diet quality and its association with children's food consumption in families at high risk of type 2 diabetes: the Feel4Diabetes-study

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Abstract

Objective: To examine the parental food consumption and diet quality and its associations with children's consumption in families at high risk for developing type 2 diabetes mellitus across Europe. Also, to compare food frequency consumption among parents and children from high-risk families to the European Dietary guidelines/recommendations.

Design: Cross-sectional study using Feel4diabetes FFQ.

Setting: Families completed FFQ and anthropometric measures were obtained. Linear regression analyses were applied to investigate the relations between parental food consumption and diet quality and their children's food consumption after consideration of potential confounders.

Participants: 2095 European families (74·6 % mothers, 50·9 % girls). The participants included parent and one child, aged 6–8 years.

Results: Parental food consumption was significantly associated with children's intake from the same food groups among boys and girls. Most parents and children showed under-consumption of healthy foods according to the European Dietary Guidelines. Parental diet quality was positively associated with children's intake of 'fruit' (boys: $\beta = 0{\cdot}233$, $P < 0{\cdot}001$; girls: $\beta = 0{\cdot}134$, $P < 0{\cdot}05$) and 'vegetables' (boys: $\beta = 0{\cdot}177$, $P < 0{\cdot}01$; girls: $\beta = 0{\cdot}234$, $P < 0{\cdot}001$) and inversely associated with their 'snacks' consumption (boys: $\beta = -0{\cdot}143$, $P < 0{\cdot}05$; girls: $\beta = -0{\cdot}186$, $P < 0{\cdot}01$).

Conclusion: The present study suggests an association between parental food consumption and diet quality and children's food intake. More in-depth studies and lifestyle interventions that include both parents and children are therefore recommended for future research.

Keywords
Food consumption
Diet quality
Type 2 diabetes
Parents
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Lifestyle behaviours have their onset during childhood and their development depends on the familial environment, like parental habits and preferences, among others[1]. Among the lifestyle behaviours, dietary habits have been specially associated with the development of type 2 diabetes (T2D) in both children[2] and adults[3] and the pre-state condition of T2D and insulin resistance (IR). There is a familial link regarding T2D as there is a genetic component meaning that children from parents with T2D are more likely to have this condition[4]. However, there are not so many studies assessing the association between parental IR and children' IR. Recently, it has been observed that children from parents at risk of T2D have less family meals frequency[5]. Also, in a previous study with European data, it has been observed that children from parents at risk of T2D that already had IR were found to have higher odds of unhealthy lifestyle patterns[6]. Moreover, having IR and obesity during childhood could increase the risk of developing T2D[4]. Therefore, assessing those families that are already at risk of T2D could help to get a better insight of this specific population as children from these families already have worse lifestyle behaviours[6] and less family meals frequency[5].

It has been observed that children's dietary intake is largely influenced by parental diet and eating behaviours[7]. In detail, parents act as role modelling for their children, and they are the ones who shape the home food environment, make food available and accessible to children, influence how a child thinks about food, and, accordingly, start forming their own food preferences and eating behaviour[8]. Thus, role modelling behaviours were recommended for parents through providing healthy foods, modelling healthy eating and increasing encouragement to eat healthy foods[9]. In this sense, a cross-sectional observational study on 145 parents and their preschool children in Houston found a strong relation between portions offered and served by parents and the amounts that children consumed during a regular meal[10]. Moreover, in Japan, results of questionnaire answered by 244 mothers of children aged 3–5 years found that mothers' preferences, as well as food habits, affected their children's food intake[11]. For instance, a recent cross-sectional study with baseline data from a multicentre European study were collected in 2016 and included 10 038 families from six European countries found that fathers' intake of fruits and vegetables (FV) was positively associated with children's daily intake of these foods[12]. Similarly, previous studies on family's eating habits showed that the low FV consumption of parents and their children are strongly related[13,14], suggesting that children consider parents' food preferences as their models[15], and this process was found to be stronger during early childhood[16]. Moreover, according to cross-sectional and cohort studies on the role of parental control practices and home food environment, positive associations have been found between parental healthy food choices and high FV consumption in children[17,18], as well as low intake of unhealthy snacks[19]. Likewise, in a recent survey conducted among 104 Italian children, children were found to consume more fish in families where parents used to cook and include more fish in their meals[20].

Diet quality (DQ) is broadly defined as a dietary pattern, frequently used to describe how well an individual's diet conforms to the key food groups recommended in dietary guidelines[21]. High DQ thereby reflects a healthier food intake[21,22] while improvements in DQ have been associated with lower T2D risk[21]. However, very few studies have examined the association between parents' DQ and children's food intake[21]. In general, previous studies using DQ indicators[23,24] showed that improvement in parental DQ was associated with healthier dietary intake of children, like more intake of FV and less consumption of food high in fat and sugar.

To date, the majority of studies looking at parental and children food consumption and DQ presented findings considering only one gender or population with specific race/ethnicity, with healthy subjects or for specific age groups. To our knowledge, no study yet has examined the association between familial dietary habits among populations at high risk of T2D which could give a better insight of the associations in this specific population. Therefore, the aim of the present study was to examine the parental food consumption and DQ and its associations with children's consumption in families at high risk for developing T2D across Europe. A secondary aim was to compare the food frequency consumption of parents and children from high-risk families according to the European Dietary guidelines/recommendations.

Methods

Study design

This cross-sectional study was conducted as a part of the Feel4Diabetes-study, a European interventional study which included a school- and community-based intervention, aiming to promote healthy lifestyle and tackle obesity and obesity-related metabolic risk factors for the prevention of T2D among families from vulnerable groups in six European countries[25]. The participating countries were classified as low-income countries (Bulgaria and Hungary), countries under austerity measures (Greece and Spain) and high-income countries (Belgium and Finland). Vulnerable groups were defined as the population in low-/middle-income countries and families from low-socioeconomic neighbourhoods in high-income countries[6,25]. In each country, primary schools were randomly selected and recruited in selected provinces with low socioeconomic status areas. All parents having children in the first three grades of primary school were invited to participate. Data were collected at baseline (2016), first (2017) and second year (2018) of the study by well-trained researchers, while the initial recruitments were done

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between January and November 2016. The current paper used the baseline cross-sectional data only. Feel4Diabetes-study is registered within the clinical trials registry http://clinicaltrials.gov, (NCT02393872), and more details regarding study design can be found elsewhere[26].

Study sample

Out of the total sample of 11 396 families, 4484 families were identified as 'high-risk families' at baseline. The Finnish Diabetes Risk Score (FINDRISC) questionnaire was used to identify the 'high-risk' families based on T2D risk estimation[6,27]. It is a reliable and valid questionnaire that consisted of eight questions related to age, blood pressure medication, history of high blood glucose, family history of diabetes, BMI, waist circumference, physical activity and consumption of FV[27]. The FINDRISC score ranged from 0 to 26, and a family was considered at 'high risk' if at least one parent fulfilled the FINDRISC cut-off point that was set as ≥ 9, indicating an increased risk of T2D[6,27]. The specific inclusion criteria were parent with one primary school-aged child (6–8 years old), who completed two questionnaires: FFQ and eating behaviour questionnaires as well as energy balance-related behaviour questionnaires (one for adult and one for children). From 2648 families that met the inclusion criteria (response rate = 59·1 %), 553 were excluded for incomplete information and lack of weight and/or height measurements, and 2095 were included in this study. Flowchart is shown in Fig. 1.

FFQ

Self-reported questionnaires were filled out by one of the parents, who completed these questionnaires both for him/herself and their child. For the present study, relevant demographic data such as age, sex, parental employment, education and marital status were included. Also, measures on food consumption from parents and children were considered, such as meal frequencies and selected food items consumed. The FFQ were derived from a questionnaire developed for the National T2D prevention program in Finland (FIN-D2D)[28], with some modifications so as to be relevant for the target multi-country population of the Feel4-Diabetes study. The initial forms of the FFQ were developed in English language and then translated back to the language of each participating country and back to English to ensure quality and reliability. The FFQ used is a validated tool, and a reliability study was conducted in 191 pairs of parents and their children. Parents completed the questionnaires on two occasions, within a 1–2-week interval. Reliability was tested by the intra-class correlation coefficients of test–retest[28]. The questionnaires were culturally adapted for the target population of the Feel4Diabetes-study across the six countries. The questionnaire for children was similar to that of parents, except for excluding questions regarding coffee and alcohol consumption. The questionnaire included various food groups such as milk and milk products, cereals, fat, fruits, vegetables, legumes, red meat, white meat, fish and seafood, nuts, salty snacks and sweets. The answers were presented as frequency of consumption based on a specified portion size of each food item and options included the following: on a weekly (less than 1, 1–2, 3–4, or 5–6 times per week) or daily basis (1–2, 3–4, 5 times or more per day). In this study, the consumption of each food item was converted to daily intake in grams through multiplying the number of servings consumed by the standard portion size. The food portion sizes provided of both parents and children were similar, also the portions were defined with a household unit and placed under the questions. Whereas, the listed answers provided the frequency of consumption of the specified portion of each food item[28].

Feel4Diabetes Healthy Diet Score

In the current study, the Healthy Diet Score (HDS) was used to assess the parental DQ as a validated indicator based on Feel4Diabetes-study dietary questions and tested before over families at high risk of T2D[6,24]. The DQ was assessed using only adults' food consumption data as HDS was developed for adults. While, the main components of the HDS were based on a total of twelve Feel4Diabetes intervention goals related to food behaviour and food choices and were obtained from the FFQ of the Feel4Diabetes-study[6,24]. These components included family meals, breakfast, whole-grain cereals, salty snacks, sweet snacks, oils and fats, low-fat dairy products, nuts

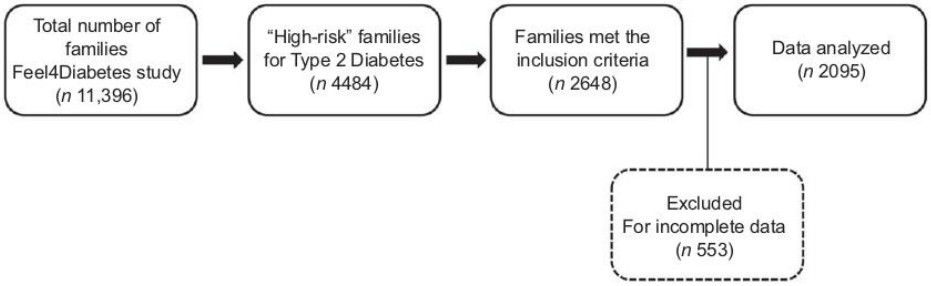

Fig. 1 Flow diagram of participants throughout the study

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and seeds, red meat, sugary drinks, vegetables, fruits and berries[24]. A maximum score of 6 was given to salty snacks, sweet snacks, low-fat dairy, nuts and seeds consumption. A maximum score of 8 was given to the frequency of family meals and the consumption of oils and fats. The rest of the components received a maximum score of 10[24]. The total score ranged from 0 to 100, in which higher scores indicate a better diet quality while higher scores of sugary drinks, red meat, salty snacks and sweet snacks indicated lower consumption. More details regarding the scoring of HDS can be found elsewhere[6,24].

Anthropometric measurements

The height and weight of parents were self-reported, while for children were objectively measured with light clothing and without shoes at schools by a well-trained research team[26]. Weight was measured by Seca 813 and recorded to the nearest 0·1 kg, and standing height was measured by Seca 217 and recorded to the nearest 0·1 cm[26]. BMI was calculated as weight (kg) divided by height (m) squared. Finally, children's BMI z-scores were calculated according to Cole *et al.*[29] to obtain an optimal measure for their weight in accordance with their sex and age.

Statistical analysis

Normality for data was checked using the Kolmogorov–Smirnov test. Descriptive statistics were computed to describe the participant's characteristics and presented as mean and standard deviation. The frequencies of food consumption of parents and children were presented as percentages (%) and compared to the European Food-Based Dietary Guidelines[30]. The HDS for parents was calculated with a total score ranged from 0 to 100, in which higher scores indicating better quality diet. Multiple regression analyses were used to examine the association between parents' consumption from different food groups and parents' HDS with the children's food consumptions by sex. The analyses of children were split by sex as new literature on sex differences in eating behaviours among prepubertal children identified sex differences in appetitive traits, food intake, food acceptance, self-regulatory eating and neural response to food images[31]. The analyses were adjusted for age, country, educational level, parental sex and BMI of parents and children. Multiple regression analyses were also performed to assess the association between mothers' consumption from different food groups and mothers' HDS with the children's food consumptions by sex. These analyses were adjusted for age, country, educational level and BMI of mothers and children. For regression models, the analysis of residuals confirmed the assumptions of linearity, and the sample size requirement for the sex-specific models was also met. The moderating role of parental gender was tested in the relationship between parents' and children's food consumption (Fig. 2). Since the majority of parent's sample was mother,

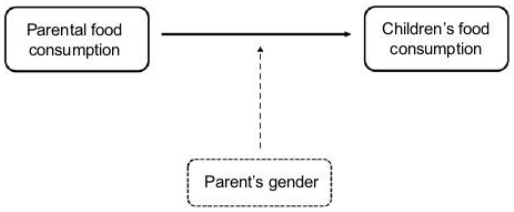

Fig. 2 The moderation effect of parental age on the relationship between parents' and children food consumption

a sensitivity analysis was conducted to check if the significance of parents' results was similar in mothers-only sample. Data were analysed with IBM SPSS Statistics for Windows, Version 26.0. IBM Corp, with a $P < 0{\cdot}05$ representing statistical significance for all tests.

Results

Characteristics of study participants

Descriptive statistics of the sample and variables can be found in Table 1. In total, data of 2095 parents and children from high-risk families were analysed (mean age parents: 38·87 ± 5·32 years; 74·6 % females (mothers); mean age children: 7·24 ± 1·0 years; 50·9 % girls). The majority of parents were employed (72·9 %) and around 62 % of them had a tertiary education of more than 13–14 years (e.g. bachelor program).

Association between dietary intake of parents and children

The mean food intake of parents and children (g/d) is presented in Fig. 3. As shown in Table 2, parental consumption of most food groups was significantly associated with children's intake among both boys and girls. Parental intake of 'full-fat milk and milk products' was not associated with children's intake from the same group among both boys and girls. Also, parental 'salty snack' intake did not show any significant association with boys' intake from the same food group.

Compliance of food frequency consumption among parents and children

Table 3 illustrates the frequency of the consumption of food and beverages among parents and children compared to the Food-Based Dietary Guidelines in Europe. Both parents and children did not comply with current dietary recommendations of vegetables, grains (excluding pasta and rice), milk and milk products (excluding cheese). More than 70 % of children consumed more than two servings of sweets per week which exceeded the recommended servings/week[30]. 70·9 % of parents and 58·0 % of children were not consuming the daily required number

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Table 1 Characteristics of the study participants at baseline

Characteristics	Parents			Children		
	%	Mean	SD	%	Mean	SD
Age (in years)		38·87	5·32		7·24	1·0
Sex (% females)	74·6			50·9		
Education level (% high education*)	65·9			–		
Employment status (% employed)	62·3			–		
Marital status (% married)	78·1			–		
Body weight (kg)		78·4	17·4		30·4	7·9
Height (cm)		166·5	8·7		130·8	8·1
BMI (kg/m^2)†		28·1	5·57		17·62	3·08
BMI z-score	–				0·73	1·10

n 2095 parents and children. This table provides mean ± SD for the continuous variables and frequency (%) for the categorical variables.
*13–14 years of education or more.
†BMI z-scores were calculated according to Cole *et al.*[29]

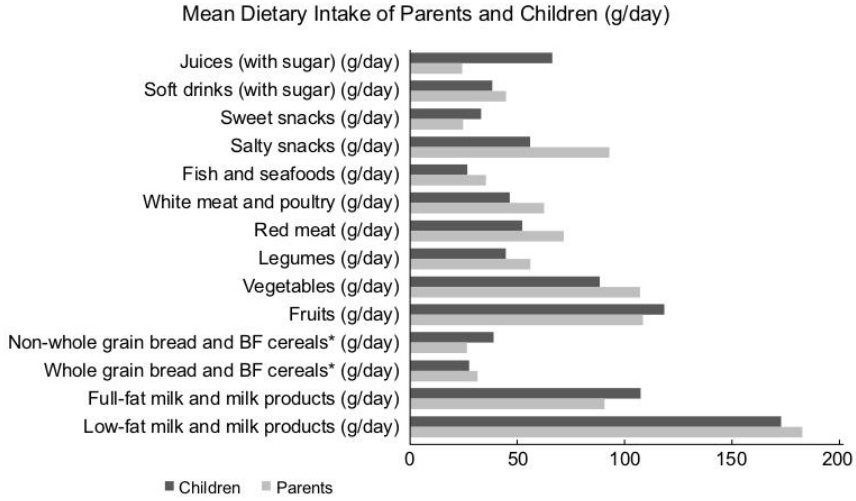

Fig. 3 Average dietary intake (g/d) of parents and children from the Feel4Diabetes-study for different food groups and beverages

of water cups according to the Food-Based Dietary Guidelines[30].

Feel4Diabetes HDS of parents

A higher score indicated higher or more frequent consumption, except for red meat, salty snacks, sugary drinks and sweet snacks where higher scores indicated lower consumption.

The mean total score was 46·6 ± 12·1 among mothers and 43·1 ± 11·2 among fathers ($P = 0·01$). Score value was generally low for vegetables and high for salty snacks and breakfast. In general, the scores were higher among mothers compared to fathers in the red meat group (6·1 ± 3·6 *v.* 4·0 ± 3·8), but almost similar in the salty snacks category (mothers: 5·1 ± 1·3; fathers: 5·0 ± 1·5), milk and milk products (mothers: 3·7 ± 2·1; fathers: 3·7 ± 2·5), oil and fat (mothers: 3·5 ± 2·4; fathers: 3·5 ± 2·2) and sweet snacks (mothers: 3·6 ± 2·0; fathers: 3·7 ± 2·0) (data not shown).

Association between total parental Healthy Diet Score and children's food consumption

Table 4 shows the association between parental DQ determined by the HDS and children's consumption of various food groups. Parental' HDS was positively associated with girls' intake of milk and milk products ($\beta = 0·152$, $P < 0·01$), whole grains ($\beta = 0·215$, $P < 0·001$), fruits ($\beta = 0·134$, $P < 0·05$), vegetables ($\beta = 0·234$, $P < 0·001$) and water ($\beta = 0·111$, $P < 0·05$) and inversely associated with their intake of salty snacks ($\beta = –0·186$, $P < 0·01$), sweet snacks ($\beta = –0·135$, $P < 0·05$) and soft drinks ($\beta = –0·202$, $P < 0·001$). Among boys, the HDS of parents showed a significant positive association with boys' intake of full-fat milk and milk products ($\beta = 0·173$, $P < 0·01$), whole grains

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Table 2 Association between dietary intake of parents and corresponding intake of the same food groups in their children

	Children's food consumption			
	Boys		Girls	
Parental dietary intake (food groups)	β	95 % CI	β	95 % CI
Low-fat milk and milk products†	0·282***	0·091, 0·420	0·341***	0·111, 0·443
Full-fat milk and milk products†	–0·005	–0·076, 0·065	–0·012	–0·063, 0·024
Whole grain bread and BF cereals‡	0·252***	0·102, 0·381	0·454***	0·192, 0·681
Non-whole grain bread and BF cereal‡	0·312***	0·183, 0·470	0·368***	0·274, 0·553
Fruits	0·271***	0·054, 0·577	0·204***	0·081, 0·614
Vegetables	0·306***	0·211, 0·660	0·423***	0·176. 0·592
Legumes	0·681***	0·355, 1·101	0·543***	0·233, 0·717
Red meat	0·385***	0·182, 0·741	0·431***	0·223, 0·714
White meat and poultry	0·660***	0·221, 0·860	0·448***	0·191, 0·587
Fish and seafood	0·518***	0·310, 0·770	0·582***	0·233, 0·725
Salty snacks	0·072	0·022, 0·183	0·168**	0·072, 0·317
Sweet snacks	0·203***	0·095, 0·451	0·375***	0·123, 0·516
Soft drinks (with sugar)	0·423***	0·215, 0·887	0·558***	0·331, 0·927
Juices (with sugar)	0·501***	0·303, 0·795	0·268***	0·115, 0·443
Water	0·487***	0·250, 0·760	0·387***	0·177, 0·801

*$P < 0·05$.
**$P < 0·01$.
***$P < 0·001$ (indicate significance); β: Regression coefficient. All analyses were adjusted for age, country, parental sex, educational level and BMI of parents and children.
†Cheese was not counted.
‡BF: breakfast (rice and pasta were not mentioned under grains group in the questionnaire).

Table 3 Frequency of food consumption among parents and children according to Food-Based Dietary Guidelines in Europe

Foods and beverages	Servings	Dietary Guidelines	Parents (%)	Children (%)
Milk and milk products (no cheese)	< 2 servings/d	Not met	67·3	64·2
	2–3 servings/d	Met	11·5	13·1
	> 3 servings/d	Exceed	21·2	22·7
Grains (bread and BF cereals only)*	< 3 servings/d	Not met	88·3	86·4
	3–5 servings/d	Met	7·40	5·80
	> 5 servings/d	Exceed	4·30	7·80
Fruits	< 2 servings/d	Not met	64·4	61·7
	2–3 servings/d	Met	28·1	30·0
	> 3 servings/d	Exceed	7·50	8·30
Vegetables	< 3 servings/d	Not met	90·4	96·0
	3–4 servings/d	Met	6·50	2·90
	> 4 servings/d	Exceed	3·10	1·10
Legumes	< 2 servings/week	Not met	20·6	30·8
	2–3 servings/week	Met	21·4	23·2
	> 3 servings/week	Exceed	58·0	46·0
Red meat	< 2 servings/week	Not met	16·0	25·7
	2–3 servings/week	Met	30·2	34·2
	> 3 servings/week	Exceed	53·8	40·1
White meat and poultry	< 2 servings/week	Not met	19·0	30·0
	2–3 servings/week	Met	34·8	36·3
	> 3 servings/week	Exceed	46·2	33·7
Fish and seafood	< 2 servings/week	Not met	48·4	62·5
	2–3 servings/week	Met	33·1	26·3
	> 3 servings/week	Exceed	18·5	11·2
Salty snacks	< 1 servings/week	Recommended	22·9	35·0
	1–2 servings/week	Accepted	29·2	36·2
	> 2 servings/week	Exceed	47·9	28·8
Sweet snacks	< 1 servings/week	Recommended	23·0	5·00
	1–2 servings/week	Accepted	29·1	23·0
	> 2 servings/week	Exceed	47·9	72·0
Soft drinks (with added sugar)†	–	N/A	–	–
Juices (with added sugar)†	–	N/A	–	–
Water	< 6 cups/d‡	Not met	70·9	58·0
	6–8 cups/d	Met	20·5	20·4
	> 8 cups/d	Preferred	8·60	21·6

N/A: not applicable.
*BF: breakfast (rice and pasta were not mentioned under grains group in the questionnaire).
†Mentioned in the dietary guidelines as grams of sugar, not as portions or servings of products.
‡According to the dietary guidelines, the measurement of cups differs between parents (250 ml) and children (150 ml).

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Table 4 Association between health diet score of parents and children's intake from different food groups

	Children's food consumption				
		Boys		Girls	
Parental healthy diet score	(Food groups)	*B*	95 % CI	*β*	95 % CI
	Low-fat milk and milk products†	0·007	0·002, 0·081	0·152**	0·025, 0·304
	Full-fat milk and milk products†	0·173**	0·065, 0·321	0·124*	0·077, 0·298
	Whole grain bread and BF cereals‡	0·123*	0·077, 0·344	0·215***	0·101, 0·366
	Non-whole grain bread and BF cereal‡	−0·078	−0·143, 0·002	−0·108	−0·201, −0·033
	Fruits	0·233***	0·110, 0·522	0·134*	0·096, 0·301
	Vegetables	0·177**	0·078, 0·290	0·234***	0·102, 0·385
	Legumes	−0·177*	−0·224, −0·052	−0·075	−0·110, 0·026
	Red meat	−0·206***	−0·315, −0·044	−0·101	−0·255, −0·011
	White meat and poultry	−0·033	−0·122, 0·077	0·093	0·065, 0·189
	Fish and seafood	0·044	0·011, 0·089	0·104	0·086, 0·255
	Salty snacks	−0·143*	−0·269, −0·034	−0·186**	−0·239, −0·061
	Sweet snacks	0·014	0·008, 0·098	−0·135*	−0·288, −0·076
	Soft drinks (with sugar)	−0·105	−0·198, −0·084	−0·202***	−0·301, −0·095
	Juices (with sugar)	−0·113	−0·210, −0·044	−0·066	−0·133, 0·015
	Water	0·101	0·055, 0·271	0·111*	0·077, 0·263

*$P < 0·05$.
**$P < 0·01$.
***$P < 0·001$ (indicate significance); *β*: Standardised Regression coefficient. All analyses were adjusted for age, country, parental sex, educational level and BMI of parents and children.
†Cheese was not counted.
‡BF: breakfast (rice and pasta were not mentioned under grains group in the questionnaire).

($\beta = 0·123$, $P < 0·05$), fruits ($\beta = 0·233$, $P < 0·001$) and vegetables ($\beta = –0·177$, $P < 0·01$), but a negative association with their intake of legumes ($\beta = –0·177$, $P < 0·05$), red meat ($\beta = –0·206$, $P < 0·001$) and salty snacks ($\beta = –0·143$, $P < 0·05$).

Association between food consumptions of mothers and children

As shown in Table 5, mothers' consumption of most food groups was significantly associated with children's intake among both boys and girls. Mothers' intake of 'Full-fat milk and milk products' was not associated with children's intake from the same group among both boys and girls. The mothers' intake of 'salty snack' intake did not show any significant association with boys' intake from the same food group, but it did with that of girls: [($\beta = 0·072$, $P > 0·05$) *v.* ($\beta = 0·135$, $P < 0·01$)].

Association between Healthy Diet Score of mothers and children's dietary intake

Table 6 illustrates the association between the DQ of mothers using HDS and children's consumption of various food groups. Maternal' HDS was positively associated with girls' intake of milk and milk products ($\beta = 0·170$, $P < 0·01$), whole grains ($\beta = 0·245$, $P < 0·001$), fruits ($\beta = 0·221$, $P < 0·001$), vegetables ($\beta = 0·238$, $P < 0·001$), white meat and poultry ($\beta = 0·140$, $P < 0·05$), fish and seafood ($\beta = 0·182$, $P < 0·01$) and inversely associated with their intake of salty snacks ($\beta = –0·160$. $P < 0·01$), sweet snacks ($\beta = –0·127$, $P < 0·05$) and soft drinks ($\beta = –0·185$, $P < 0·01$). The HDS of mothers showed a significant positive association with boys' intake of full-fat milk and milk products ($\beta = 0·202$, $P < 0·01$), whole grains ($\beta = 0·135$, $P < 0·05$), fruits ($\beta = 0·231$, $P < 0·001$) and vegetables ($\beta = 0·175$, $P < 0·01$), but a negative association with their intake of legumes ($\beta = –0·169$, $P < 0·01$), red meat ($\beta = –0·248$, $P < 0·001$) and salty snacks ($\beta = –0·172$, $P < 0·05$).

Discussion

The present study found that parental food consumption and DQ were significantly associated with children's consumption of selected food items among boys and girls in families at high risk of T2D. Among the food items, those more associated were FV, grains, milk and milk products. In addition, most parents and children from families at increased risk for T2D showed under-consumption of healthy foods when compared to the European Dietary Guidelines. All these results were found independently of education level, parental sex, age, country and BMI of both parents and children.

In line with the findings of previous systematic reviews on the association between parental and children's intake[32,33], our results found that parental consumption from FV, legumes, milk and milk products, red meat, poultry, grains, sweets, soft drinks, juices, water, fish and seafood was positively associated with children's intake from the same food groups. These results suggest that parental dietary intake is strongly linked to children's food consumption and eating behaviours. Children tend to follow their parents' diets as seen in a nationally

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Table 5 Association between dietary intake of mothers and corresponding intake of the same food groups in their children

Mothers' dietary intake (Food groups)	Children's food consumption			
	Boys		Girls	
	β	95 % CI	*β*	95 % CI
Low-fat milk and milk products†	0·251***	0·091, 0·420	0·341***	0·111, 0·443
Full-fat milk and milk products†	0·013	0·008, 0·067	−0·007	−0·058, 0·023
Whole grain bread and BF cereals‡	0·268***	0·102, 0·344	0·467***	0·211, 0·685
Non-whole grain bread and BF cereal‡	0·288***	0·092, 0·441	0·360***	0·133, 0·540
Fruits	0·271***	0·100, 0·521	0·231***	0·098, 0·422
Vegetables	0·304***	0·185, 0·606	0·442***	0·212, 0·770
Legumes	0·677***	0·324, 1·021	0·560***	0·230, 0·886
Red meat	0·425***	0·202, 0·709	0·417***	0·135, 0·665
White meat and poultry	0·674***	0·287, 0·923	0·474***	0·155, 0·865
Fish and seafood	0·682***	0·388, 1·098	0·492***	0·237, 0·668
Salty snacks	0·072	0·022, 0·132	0·135**	0·092, 0·302
Sweet snacks	0·203**	0·098, 0·440	0·348***	0·112, 0·477
Soft drinks (with sugar)	0·409***	0·165, 0·831	0·540***	0·377, 0·759
Juices (with sugar)	0·561***	0·339, 0·856	0·277***	0·104, 0·411
Water	0·459***	0·250, 0·766	0·368***	0·109, 0·588

*$P < 0·05$.
**$P < 0·01$.
***$P < 0·001$ (indicate significance); *β*: Regression coefficient. All analyses were adjusted for age, country, educational level and BMI of mothers and children.
†Cheese was not counted.
‡BF: breakfast (rice and pasta were not mentioned under grains group in the questionnaire).

Table 6 Association between Healthy Diet Score of mothers and children's intake from different food

Mothers' Healthy Diet Score	(Food groups)	Children's food consumption			
		Boys		Girls	
		β	95 % CI	*β*	95 % CI
	Low-fat milk and milk products†	0·016	0·008, 0·049	0·170**	0·034, 0·256
	Full-fat milk and milk products†	0·202**	0·089, 0·422	0·118*	0·087, 0·321
	Whole grain bread and BF cereals‡	0·135*	0·087, 0·344	0·245***	0·102, 0·443
	Non-whole grain bread and BF cereal‡	−0·071	−0·120, 0·003	−0·089	−0·141, 0·024
	Fruits	0·231***	0·103, 0·465	0·221***	0·087, 0·520
	Vegetables	0·175**	0·076, 0·324	0·238***	0·054, 0·419
	Legumes	−0·169**	−0·223, −0·052	−0·037	−0·131, 0·022
	Red meat	−0·248***	−0·331, −0·096	−0·043	−0·114, 0·018
	White meat and poultry	−0·037	−0·101, 0·065	0·140*	0·086, 0·310
	Fish and seafood	0·060	0·022, 0·089	0·182**	0·064, 0·376
	Salty snacks	−0·172*	−0·266, −0·077	−0·160**	−0·225, −0·032
	Sweet snacks	−0·018	−0·097, 0·056	−0·127*	−0·214, −0·044
	Soft drinks (with sugar)	−0·100	−0·201, −0·044	−0·185**	−0·290, −0·057
	Juices (with sugar)	−0·119	−0·255, −0·031	−0·059	−0·122, 0·016
	Water	0·109	0·075, 0·287	0·082	0·043, 0·185

*$P < 0·05$.
**$P < 0·01$.
***$P < 0·001$ (indicate significance); *β*: standardised regression coefficient. All analyses were adjusted for age, country, educational level and BMI of mothers and children.
†Cheese was not counted.
‡BF: breakfast (rice and pasta were not mentioned under grains group in the questionnaire).

representative data of 1230 parents and children collected by the US Department of Agriculture since parents are considered as role models and food providers[34]. Likewise, results from a recent large study across six European countries on 2967 parent–child dyads indicated that children's dietary intake was strongly associated with the home availability of 100 % fruit juice, also parental role modelling of fruit intake was associated with increased fruit consumption of children[35]. Additionally, in the present study, the mean intake of parents and their children were found to be nearly similar in some food groups like fruits, whole grains, milk and milk products. This could be due to the fact that the questionnaire on children's food intake was completed by parents, which could differ from children's report of their own diet[23]. Moreover, parents may have found it difficult to estimate an average daily consumption

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of children, particularly the food items that are usually distributed throughout the day in different meals and might be difficult to properly quantify.

Our results found that the majority of parents and their children from families at high risk of T2D did not meet the daily recommendations for FV. Our findings were consistent with those observed by Gerritsen *et al.*[36] which aimed to compare the children's intake of FV to the guidelines and generate sustainable actions within a local community to improve children's FV intake in New Zealand, indicating that children's FV intake is below than the recommended amount. Among the possible explanations of these results for children is that they get affected by their parents' dietary intake through role modelling and feeding practices, and thus, children's FV consumption can be related to their parental FV consumption and the availability of FV at home[37]. In addition, children might refuse the consumption of FV because they dislike their taste especially vegetables[37]. Moreover, the low FV consumption among parents and children could be also related to the higher prices of healthy foods relative to unhealthy foods, besides the low levels of nutritional knowledge and awareness of parents[36,37].

This study showed that more than 60 % of families at high risk of T2D were not consuming the recommended servings of grains. On the contrary, in a previous study of 1526 preschooler children that aimed to assess the diet of young children attending daycare in the Netherlands, the majority of children was found to meet or exceed the daily recommended intake of grains especially from the refined grains[38]. The difference in these results could be due to different tools being used to assess the children's dietary intake (i.e. FFQ in our study *v.* 2-day food consumption records). Moreover, the FFQ used in our study did not include 'rice', 'pasta' and other 'dough products' under the grains group, but focussed only on bread and breakfast cereals; therefore, the consumption of parents and their children from these food groups might be underestimated in our study.

As shown in our study, the majority of children exceeded the suggested servings of sweets. These results were consistent with previous findings of a cross-sectional study that examined the probability of obesity with higher sweets and sugar intakes in a national representative sample of 781 children and 384 adolescents in Greece, indicating that most of the participants exceeded the recommended intake of sweets and sugar-sweetened beverages[39]. Similar results were also observed in a cross-sectional study of 109 children in Ontario, in which 80 % of children had intakes of free sugar greater than the recommended intake[40]. In support of this, recent systematic review evaluating the world dietary sugar intake trends in children and adolescents reported that the sugar intakes as a percentage of total energy are the highest for children and adolescents, and despite some reductions in sugar intake observed in a few individual studies, overall intakes of sugars remain above recommendations[41]. These results could be explained by the fact that children usually tend to have positive responses to sweets compared to other items with neutral tastes[42]. Also, children's acceptance/refusal of foods and beverages (i.e. sweets and sugar-sweetened beverages) is related to whether they have been repeatedly exposed to them or not during infancy and young ages[43]. Food preferences are thought to peak between the age of 2 and 6 years old, so this can shape the child's DQ later[43].

Additionally, in accordance with previous studies[44,45], in our sample of parents and children, almost half of them did not meet the recommended servings of fish and seafood. The possible explanation of our results could be that parents who do not like fish and seafood themselves may never buy, prepare or offer them to their children[45]. Besides, low consumption of fish and seafood among children could be a result of food neophobia and fear from ingesting its bones, its strong aroma and rubbery texture[45]. This could also be related to the dietary cultures in the participating countries as the consumption of fish and seafood was found to be higher in fishing areas[46].

The DQ was also considered in this study, in which mothers showed a higher DQ, measured with the HDS, than fathers. The same results were found in a previous randomised clinical trial aimed to compare adults' DQ scores between seven research centres in Europe, which showed that women tend to have higher DQ than men in Europe using Healthy Eating Index[47], and this could be explained by better nutrition knowledge and awareness in women compared to men[48]. Indeed, mothers were found to be the most important source for their children in terms of food consumption and dietary habits through teaching, role modelling and nutritional knowledge[49]. Moreover, in our analysis, it has been found that parental gender acts as a moderator in the relationship between parents' and children's food consumption. However, it is noteworthy that the majority of the participants in our study were mothers (74·6 %).

Our research demonstrated significant associations between parental DQ and children's food consumption. Previous studies on the effect of parental DQ on children's dietary intake demonstrated significant associations between parental DQ and children's food consumption[22,23], which was indeed confirmed by our results among both boys and girls. Similarly, a large cross-sectional multinational sample of 5185 European families that investigated parental influences on preschool children's healthy and unhealthy snacking indicated that healthier food choices made by parents were associated with greater child healthy snack intake[19]. In depth, our research showed a significant inverse association between parental DQ and the intake of sweets and soft drinks only among girls in families at high risk of T2D. The possible reason of these results could be due to the fact that boys tend to consume more sugar than girls in all age groups[50]. Besides, boys' food

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preferences and food choices are influenced mainly by taste, whereas girls are usually influenced by how healthy foods are than how they taste[50].

In our sample, both parental and mother's DQ were significantly and positively associated with boys' and girls' intake of FV, whole grains and inversely associated with their snack's consumption. Although a direct relationship cannot be measured due to the cross-sectional nature of this study, we can assume based on our findings, that improving parental DQ has the potential to positively change children's food consumptions. These associations are in line with the findings of Davison *et al.*[23], which aimed to investigate the relationship between parental DQ and child dietary patterns in New Zealand, stated that better parental DQ using the Diet Quality Index (DQI) was associated with children's lower intake of snacks. But on the contrary, they found no significant association with the children's consumption of FV. This difference in the results could be due to the use of different tools to identify the quality of a diet (i.e. using HDS in our study *v.* DQI).

There are some limitations of the present study that need to be accounted for. First, children's data were based on parental report, and this can be considered as a bias, but this weakness is very hard to overcome when studying food intake. Also, some of the children were only in first grades; therefore, it was not possible to get self-reported food intake data from them. Second, the cross-sectional nature of this study does not allow for causality inferences. Moreover, the FFQ is not able to adequately determine absolute food intakes compared to other methods (i.e. 24-hour dietary recall). The FFQ focussed more on breakfast cereal and bread, but other products under the carbohydrates group were not listed (i.e. pasta and rice). Also, cheese was not counted under the group of milk and milk products which may affect the participants' estimated intake. In addition, a potential correlated bias could be created as the food component scoring of HDS was done according to the fourteen diet-related questions in the Feel4Diabetes questionnaire which is the same tool used to estimate food intake in this study. Furthermore, the response rate contributed to the limitations of this research. Although several strategies were used to improve participation, the low response rate (59·1 %) limits generalisability beyond the study sample. Finally, generalisability of the results is limited to a very specific group of the population, namely members of families with an increased risk on T2D. On the other hand, important strengths of this study included the use of a large data set from six European countries with cultural dietary diversity. Additionally, the anthropometric measurements were obtained by well-trained researchers through using highly validated and standardised procedures to ensure and increase accuracy. Furthermore, to the best of our knowledge, this is the first study to examine the association between parental food consumption, DQ and children's food consumption in Europe especially among population at high risk of developing T2D.

In conclusion, the present study found that parent's food consumption of most food groups was associated with the food intake of their children in families at high risk of T2D. Moreover, significant associations were also found between parental DQ and children's healthy food consumption in boys and girls. However, in families at risk for developing T2D, the food intake of both parents and their children still requires greater emphasis to meet the dietary recommendations. Parents function as role models, who set the rules for their children's food intake and dietary habits. Therefore, targeting parental food consumption and DQ could be an important strategy to limit the unhealthy eating habits of children and thereby prevent T2D and childhood obesity. More in-depth studies and lifestyle interventions that include both parents and children are therefore recommended for future research.

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(code:174/1801/2015), Belgium (code: B670201524237), Bulgaria (code: 52/10-3-201r) and Hungary (code: 20095/2016/EKU). All parents were informed about the purpose of the study, and they signed a written informed consent for their participation, which gave them the chance to withdraw from the study at any point.

Supplementary material

For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/S1368980022002245

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Manuscript III: Frequency of family meals and food consumption in families at high risk of type 2 diabetes: the Feel4Diabetes-study.

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ORIGINAL ARTICLE

Frequency of family meals and food consumption in families at high risk of type 2 diabetes: the Feel4Diabetes-study

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Abstract

A family meal is defined as a meal consumed together by the members of a family or by having ≥ 1 parent present during a meal. The frequency of family meals has been associated with healthier food intake patterns in both children and parents. This study aimed to investigate in families at high risk for developing type 2 diabetes across Europe the association (i) between family meals' frequency and food consumption and diet quality among parents and (ii) between family meals' frequency and children's food consumption. Moreover, the study aimed to elucidate the mediating effect of parental diet quality on the association between family meals' frequency and children's food consumption. Food consumption frequency and anthropometric were collected cross-sectionally from a representative sample of 1964 families from the European Feel4Diabetes-study. Regression and mediation analyses were applied by gender of children. Positive and significant associations were found between the frequency of family meals and parental food consumption ($\beta = 0.84$; 95% CI 0.57, 1.45) and diet quality ($\beta = 0.30$; 95% CI 0.19, 0.42). For children, more frequent family meals were significantly associated with healthier food consumption (boys, $\beta = 0.172$, $p < 0.05$; girls, $\beta = 0.114$, $p < 0.01$). A partial mediation effect of the parental diet quality was shown on the association between the frequency of family meals and the consumption of some selected food items (i.e., milk products and salty snacks) among boys and girls. The strongest mediation effect of parental diet quality was found on the association between the frequency of family breakfast and the consumption of salty snacks and milk and milk products (62.5% and 37.5%, respectively) among girls.

Conclusions: The frequency of family meals is positively associated with improved food consumption patterns (i.e., higher intake of fruits and vegetables and reduced consumption of sweets) in both parents and children. However, the association in children is partially mediated by parents' diet quality. The promotion of consuming meals together in the family could be a potentially effective strategy for interventions aiming to establish and maintain healthy food consumption patterns among children.

Trial registration: The Feel4Diabetes-study is registered with the clinical trials registry (NCT02393872), http://clinicaltrials.gov, March 20, 2015.

What is Known:
- *Parents' eating habits and diet quality play an important role in shaping dietary patterns in children*
- *Family meals frequency is associated with improved diet quality of children in healthy population*

What is New:
- *Frequency of family meals was significantly associated with healthier food consumption among parents and children in families at high risk of type 2 diabetes in six European countries.*
- *Parental diet quality mediates the association between family meals frequency and the consumption of some selected food items among children.*

Keywords Family meals · Food consumption · Diet quality · Type 2 diabetes · Parents · Children

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Extended author information available on the last page of the article

Introduction

Children's optimal nutrition is fundamental for their healthy growth and development [1]. In this sense, the type and variety of food items provided during childhood may influence life-long health and shape long-lasting dietary patterns [2]. In children, unhealthy dietary habits have been associated with adiposity [3] and other comorbidities such as insulin resistance, considered the first stage in the development of type 2 diabetes mellitus (T2DM) among children [3, 4].

It has been found that parents' eating habits and food preferences play an important role in shaping food intake patterns in children [5] as children consider their parents as role models. Previous studies suggested that parents who are "healthy role models" would be more likely to have children who consume healthier foods [6, 7]. Moreover, parents were found to have a strong influence over the family environment where meals take place and the types and portions of foods provided to children [8].

Family mealtime environment including meal structure, parental modelling, food socialization practices, and types of food provided has great potential to affect the eating behaviors of children [9, 10]. Thus, family meals could offer a promising entry point for change. Although the majority of parents and their children recognize the importance of eating together, they also reported several barriers for sharing mealtimes, including different schedules, implying the difficulty of finding time to share meals [11]. For this reason, "evening meal" or "dinner" is the most common shared meal as families eat together more usually at this meal occasion versus other times of the day [12].

The growing body of scientific evidence has shown that having more frequent family meals is positively associated with improved food intake and enhanced diet quality (DQ) in children [12]. In support of this, children who frequently have shared meals with family show healthier dietary patterns and were found to consume less sodium, sugar, and fat compared to those who seldom do so [13–15]. Cross-sectional and longitudinal studies suggested that regular family meals were associated with higher consumption of fruit and vegetables (FV) in children [16, 17]. Other studies showed that children who eat meals with their family reported healthier dietary intake including higher consumption of fiber, FV, vitamins, and minerals [12]. The high intake of dairy products has also been reported among children who share breakfast with their family [16]. Furthermore, a meta-analysis including over 180,000 children found that children who shared their meals with parents three times or more per week had reduced odds of eating unhealthy food and becoming overweight [15], concluding that family meals' frequency is positively related to children's food intake and that further research is needed on how family meals' quality relates to children's nutritional intake. Similarly, it has been reported that children who had a lower intake of fried foods and soft drinks frequently consume their meals together with family [13]. Despite the growing interest in this topic, there are still limited studies examining the effects of regular shared family meals and children's food consumption especially among populations at high risk of developing non-communicable diseases, such as T2DM.

Previous studies associating DQ of parents and children's intake have shown that improvement in parental DQ was associated with healthier food consumption of children [18, 19]. In addition, more frequent family meals have been positively linked to higher DQ in parents [20] and children [15]. However, no previous study has examined whether parental DQ could have an impact in the association between family meals' frequency and the food consumption of children. Therefore, the current study attempts to fill gaps in the literature by (1) investigating whether parents who share meals with family have a better food consumption and DQ; (2) examining the association between family meals frequency and children's consumption of selected food items; (3) assessing the mediation effects of parental DQ on the association between family meals' frequency and children's food consumption in families at high risk of T2DM across six European countries.

Methods

Study design

Feel4Diabetes-study (Families across Europe following a Healthy Lifestyle for Diabetes prevention) is a cluster randomized study that took place between 2016 and 2018 across six European countries and 11,396 families were included. The study aimed to develop, implement, and evaluate a school- and community-based intervention to promote healthy lifestyle and tackle obesity for the prevention of T2DM among families from vulnerable groups. Thus, an intervention area and a control area in each country were defined. The participating countries were grouped in regions as low-income countries (Bulgaria and Hungary), high-income countries (Belgium and Finland), and countries under austerity measures following the economic crisis (Greece and Spain). Children attending the first three grades of compulsory education in primary schools as well as their parents were invited to participate in the study. Data were collected at baseline (2016), first (2017), and second year (2018) of the program by well-trained researchers. The current paper used the baseline cross-sectional data only. The Feel4Diabetes-study is registered within the clinical trials registry http://clinicaltrials.gov, (NCT02393872). Details of the study protocol have been previously published (https://feel4diabetes-study.eu/) [21].

The "high-risk families" were considered when being at risk for developing T2DM in the following 10 years, predicted by the FINDRISC score, based on T2DM risk estimation, if at least one parent fulfilled the country-specific cut-off point for FINDRISC [17]. FINDRISC is a reliable and valid questionnaire that consisted of eight questions related to age, blood pressure medication, history of high blood glucose, family history of diabetes, body mass index (BMI), waist circumference (WC), physical activity, and consumption of FV [22].

The Feel4Diabetes-study followed the conventions of the Council of Europe Convention on Human Rights and Biomedicine and the Declaration of Helsinki. Ethical approval was provided by the Ethical Committees of all participating European countries including Spain (ethical approval code: CP03/2016), Greece (code: 46/3–4-2015), Finland (code:174/1801/2015), Belgium (code: B670201524237), Bulgaria (code: 52/10–3-201r), and Hungary (code: 20,095/2016/EKU). All parents were informed about the purpose of the study, and they signed a written informed consent for their participation, which gave them the chance to withdraw from the study at any point.

Study sample

Identified as "high-risk families" were 4484 families at baseline in the Feel4Diabetes-study. In order not to duplicate parental information, since some families included more than one child, one child from each family was randomly included and was linked to the reported parental information. Inclusion criteria were parent with one primary school-aged child having complete data of two questionnaires: food frequency and eating behaviour questionnaires and energy balance–related behaviours questionnaires (one for adult and one for children). From 2648 families that met the inclusion criteria, 702 were excluded for incomplete information and lack of anthropometric measurements, and 1946 were included in this study.

Food frequency questionnaires

Two self-reported questionnaires, food frequency and eating behaviour questionnaires and energy balance–related behaviour questionnaires, were filled out by one of the parents, who completed these questionnaires both for himself/herself and their child [23]. The initial forms of the Food Frequency Questionnaire (FFQ) were developed in English language and then translated back to the language of each participating country to ensure quality and reliability. Some modifications and additional questions were added which helped to culturally adapt the questionnaire for the target population of the Feel4Diabetes-study across the six countries. The reliability of the validated FFQ was testes in 191 pairs of parents and their children ($N=191$). Parents completed the questionnaires on two occasions, within a 1–2-week interval. Reliability was tested by the intra-class correlation coefficients (ICC) of test–retest [24].

For the present study, only relevant demographic data and measures on family meals' frequency, food consumption, and selected food items of children were used.

The frequency of family meals was assessed using the question "how often do your children have the following meals with family including breakfast, lunch and dinner", which could be answered by choosing one of the following options for each meal occasion: never, less than 1 time/week, 1–2 times/week, 3–4 times/week, 5–6 times/week, and daily. Children's food consumption was assessed according to specific food groups: milk and milk products, cereals, fat, FV, legumes, red meat, white meat, fish and seafood, nuts, salty snacks, and sweets. The intake of beverages such as water, fruit juices, and soft drinks was also assessed. The answers of food consumption were based on a specified portion size of each food item and included the following: on a weekly (less than 1, 1–2, 3–4, or 5–6 times per week) or daily basis (1–2, 3–4, 5 times, or more per day). The portion size provided for each food item was defined with a household unit and placed under the questions [24]. In this study, the consumption of each food item was converted to daily intake in grams by multiplying the standard portion size by the number of servings consumed.

Anthropometric measurements

The height and weight of parents were self-reported, while those of children were objectively measured at schools by a well-trained research team. Anthropometric measurements were conducted according to standardized protocols [25] with children standing barefoot in light clothing. Weight was measured by Seca 813 and recorded to the nearest 0.1 kg, and standing height was measured by Seca 217 and recorded to the nearest 0.1 cm. Two readings were obtained out of each measurement and the mean was used for the analysis. BMI was calculated as weight (kg) divided by height (m) squared. Finally, children's BMI z-scores were calculated according to Cole and Lobstein [26] to obtain an optimal measure for their weight in accordance with their gender and age.

Measures of parental diet quality

In this study, the parental DQ was assessed using the Healthy Diet Score (HDS), a validated indicator that has been formed based on Feel4Diabetes-study dietary

questions and tested before over families at high risk of developing T2DM [27]. The HDS consists of 12 components related to food choices and food behaviours with a special scoring system. The total score ranged from 0 to 100, with higher scores indicating better DQ.

Parent's demographic characteristics

Information on demographic characteristics of the parents participating in the Feel4Diabetes-study was collected using self-reported questionnaires in all study participants. The education level of parents was asked in a 5-point Likert-type scale question and responses ranged from "less than 7 years" to "more than 16 years" of education. The questions of marital status included five choices: "single", "married or cohabiting", "separated or divorced", "widowed", and "other". Regarding the employment status, parents were asked to identify their main occupation over the last 6 months, and 7 answers were included: "stay at home parent", "work full-time", "work part-time", "unemployed", "full-time education", "retired", and "something else".

Statistical analysis

Demographic data were described using descriptive measures. Continuous variables were presented using mean and standard deviation, and categorical variables with frequencies and percentages. The normal distribution of variables was checked by Kolmogorov–Smirnov test. The analyses of children were split by gender as new literature on gender differences in eating behaviors among pre-pubertal children identified gender differences in appetitive traits, food intake, food acceptance, self-regulatory eating, and neural response to food images [28]. To assess the relation between family meals' frequency and food consumption among both parents and children, multiple regression analysis was carried out using the frequency of each family meal as the independent variable and the consumption of selected food items as the dependent variables. The regression analysis was also used to examine the association between family meals' frequency and parental DQ through using the HDS as the dependent variable. Separate models were run for each meal (i.e., breakfast, lunch, and dinner), and all regression analyses were adjusted for parental age, gender, country, educational level, marital status, socioeconomic status (SES), and BMI of both parents and children, as they were considered as potential predictors of the outcome [12, 16, 18]. Figure 1 provides an outline of the hypothesized relationships between the exposure variable (family meals frequency), potential mediator (parental DQ), and outcome (children's food consumption). In mediation analysis, the (a-path) represents the association between family meals frequency and the mediator. The (b-path) represents the association between mediator and children's food consumption used as outcome, adjusted for family meals frequency. The (c'-path) represents the association between family meals frequency and parental DQ and children's food consumption used as outcome, adjusted for the mediator. The (c-path) represents the total association between family meals' frequency and the outcome variables. As recommended by Baron and Kenny [29], the following assumptions must be fulfilled to establish a mediation effect: (i) the predictor and outcome variable need to be significantly correlated, and (ii) mediators need to be significantly correlated with both the predictor and outcome variable in order to include them in the model. These assumptions were checked through regression analyses. Covariates included were parent age, gender, country, educational level, marital status, and BMI of parents and

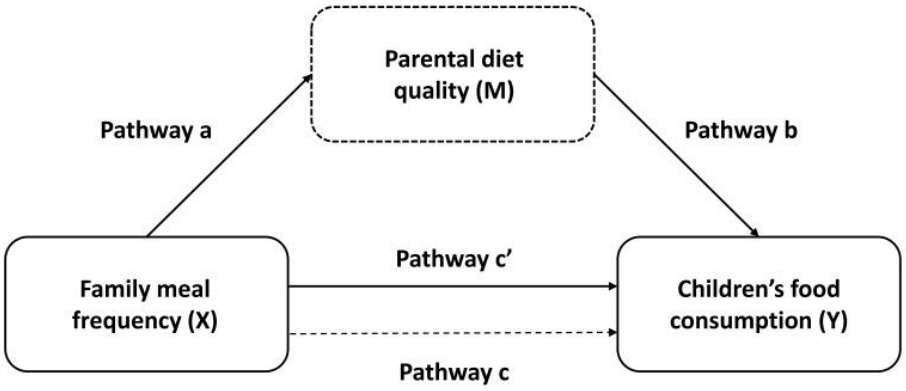

Fig. 1 Graphical illustration of the possible interactions between of family meals frequency (X), parental diet quality (M), and children's food consumption (Y). The mediation analyses adjusted for parent age, gender, country, marital status, education level, and BMI of parents and children. Pathway a: association between (X) and (M). Pathway b: association between (M) and (Y). Pathway c': direct association between (X) and (Y) after adjustment of (M). (a*b): indirect effect of (M) on the association between (X) and (Y)

children. The indirect effects (a*b) were obtained through conducting Bootstrapping (5000 samples) using the PROCESS macro for SPSS by Preacher and Hayes [30]. Finally, if the effect of (X) on (Y) disappears entirely when (M) is included, complete mediation is indicated. Partial mediation is indicated when the effect of (X) on (Y) is reduced when (M) is included. Significant mediations were then calculated as percentages by dividing (a*b) by the total effect (c-coefficient).

Data were analysed with IBM-SPSS Statistics for Windows (Version 26.0. Armonk, NY: IBM Corp, USA), with a $p < 0.05$ representing statistical significance for all tests.

Results

Characteristics of study participants

Descriptive statistics of the sample and variables can be found in Table 1. In total, data of 1946 parents and children from "high-risk" families were analysed (mean age parents, 36.9 ± 4.9 years; 69% mothers; mean age children, 7.1 ± 0.9 years; 52% girls). More than half of the parents were employed (66%) and had a tertiary education of more than 13–14 years (63%).

The frequency of shared family meals for parents and children

The mean of shared family breakfast, lunch, and dinner were 3–4 times, 3–4 times, and 5–6 times a week respectively. Around half of children were sharing breakfast with their parents for more than two times a week, and the majority of children were taking their lunch with one parent at least for more than 3 times weekly. More than 80% of children had more than five times a week family dinner. The percentages of shared family meals for breakfast, lunch, and dinner were almost similar among boys and girls.

Table 1 Descriptive statistics

Characteristics	Parents	Children
Age (in years)	36.9 (4.9)	7.19 (0.9)
Sex (% female)	69%	52%
Education level (% high education*)	63%	–
Employment status (% employed)	66%	–
Marital status (% married)	74%	–
Body weight (kg)	72.8 (16.1)	28.2 (7.3)
Height (cm)	164.6 (7.9)	131.4 (7.5)
[a]BMI (kg/m^2)	26.4 (5.1)	16.3 (2.8)
BMI z-score		0.68 (1.0)

$N = 1946$ parents and children. This table provides mean (SD) for the continuous variables and frequency (%) for the categorical variables

*13–14 years of education or more

[a]*BMI* body mass index. BMI z-scores were calculated according to Cole et al.

Relationships between the frequency of family meals and parental food consumption

As presented in Table 2, significant associations were found between family meals' frequency and the food consumption of parents. The shared breakfast was positively associated with an increased intake of milk and milk products, grain bread, and breakfast cereals, fruits, and legumes. The family lunch was positively associated with the consumption of grain groups, FV, and legumes and negatively associated with the intake of sweets. Family dinner was positively related to more consumption of legumes, white meat, and poultry and negatively related to the intake of sweets and sugar-sweetened beverages (SSB).

Associations between family meals' frequency and parental diet quality

Table 2 shows the significant positive associations between parental HDS and the frequency of family meals in all shared meal occasions including breakfast ($\beta = 0.30$, $p < 0.001$), lunch ($\beta = 0.19$, $p < 0.05$), and dinner ($\beta = 0.15$, $p < 0.01$).

Associations between family meals' frequency and children's food consumption

As shown in Table 3, significant associations were found between family meals' frequency and children's food consumption of selected food items. More frequent family breakfast was positively associated with the intake of milk and milk products and negatively associated with salty snack consumption among boys and girls. Sharing lunch with family was positively linked to higher intake of fruits and poultry among girls. In boys, frequent family lunch was positively related to increased intake of vegetables. Shared dinner was positively associated with higher intake of vegetables, fish, and seafood among boys. In girls, family dinner was associated with higher consumption of fruits and decreased intake of sweets.

Relationships between parental diet quality and children's food consumption

Table 3 shows significant associations between parental DQ and children's food consumption, and this association continued to be observed even after controlling for frequency of family meals. Negative association was found between the HDS of parents and the intake of sweets and SSB among girls only. The DQ of parents was positively

Table 2 Association between family meals' frequency, parental food consumption, and parental diet quality

	Breakfast with family		Lunch with family		Dinner with family	
	β (95% CI)	*p* value	β (95% CI)	*p* value	β (95% CI)	*p* value
Parental food consumption (g/day)						
Milk and milk products [a]	0.84 (0.57, 1.45)	**0.040**	0.009 (0.01, 0.02)	0.172	0.009 (0.001, 0.05)	0.151
Grain bread and BF cereals [b]	0.65 (0.27, 1.56)	**0.005**	0.26 (0.09, 0.70)	**0.030**	0.21 (0.09, 0.32)	0.104
Fruits	0.48 (0.34, 1.32)	**0.033**	0.66 (0.21, 2.05)	**0.013**	0.48 (0.28, 0.84)	0.225
Vegetables	0.28 (0.14, 1.24)	0.060	0.39 (0.07, 2.07)	**0.006**	0.08 (0.01, 0.44)	**0.043**
Legumes	0.58 (0.32, 1.06)	**0.010**	0.59 (0.34, 1.00)	**0.045**	0.17 (0.01, 0.20)	0.469
Red meat	0.08 (0.06, 0.17)	0.379	0.08 (0.55, 1.29)	0.463	0.005 (0.001, 0.03)	0.579
White meat and poultry	0.09 (0.03, 0.26)	0.135	0.03 (0.02, 0.08)	0.556	0.67 (0.21, 1.88)	**0.009**
Fish and seafood	0.02 (0.01, 0.03)	0.052	0.05 (0.01, 0.07)	0.278	0.25 (0.08, 0.90)	0.407
Salty snacks	0.06 (0.04, 0.08)	0.070	0.11 (0.85, 0.16)	0.191	0.47 (0.14, 0.97)	0.098
Sweets	0.22 (0.02, 2.53)	0.188	−0.09 (−0.01, −0.17)	**0.012**	−0.13 (−0.05, −0.22)	**0.017**
Sugar sweetened-beverages	0.08 (0.04, 1.63)	0.595	0.65 (0.27, 1.56)	0.059	−0.09 (−0.03, −0.16)	**0.013**
Parental diet quality (HDS)	0.30 (0.19, 0.42)	**0.001**	0.19 (0.80, 0.26)	**0.038**	−0.15 (0.09, 0.77)	**0.002**

$N = 1946$ parents. Regression analyses were adjusted for parent age, gender, country, marital status, educational level, SES, and BMI of parents and children

$P < 0{\cdot}05$ (bold indicate significance)

BF breakfast, β standardized coefficient, *CI* confidence interval

[a] cheese was not counted

[b] rice and pasta were not mentioned under grains group in the questionnaire

associated with the children's consumption of FV, grains, milk and milk products, and fish and seafood and negatively associated with the intake of salty snacks in both boys and girls.

Mediation analysis

As presented in Table 4, results indicated a partial mediation effect of the parental DQ on the association between the frequency of family breakfast and boys' consumption of salty snacks and milk and milk products with 32.7% and 28.4%, respectively. The association between vegetable intake in boys and the family lunch frequency was partially mediated by parental DQ with a percentage of 15.8, and the association between boys' consumption of vegetables and fish and the shared family dinner was partially mediated by parental DQ with 10.1% and 6.0% respectively. In girls, a partial mediation effect of the mediator was shown on the association between the frequency of family breakfast and consumption of salty snacks, milk and milk products (62.5% vs. 37.5%). The association between the girl's intake of fruits and poultry with the family lunch frequency was partially mediated with mediator (16.8% vs. 9.3%). The association between the shared family dinner and the intake of fruits and sweets among girl was partially mediated by parental DQ with 13.2% and 24.2%, respectively.

Discussion

The main results in the present study suggest that parental food consumption and DQ were significantly associated with the frequency of shared family meals in families at high risk of developing T2DM. Also, a significant association was observed between family meals' frequency and children's food consumption. Besides, partial mediation effect of the parental DQ has been identified on the association between the frequency of family meals and the consumption of some food items among boys and girls. All these results were found independently of parent gender, marital status, education level, age, country, SES, and BMI of parents and children.

In this study of a diverse sample of European families, almost 50% of children used to have family breakfast more than five times per week. These findings are consistent with previous research conducted in the USA among children and adolescents, which found similar percentages [12]. In addition, our results indicated that dinner is the most shared meal among children and their parents, most probably because it is the only time of the day when the whole family can get together, especially on working days. This was also supported by previous studies which found that family breakfast occurs less often than family dinners (1.5 breakfast meals versus 4.1 dinner meals per week) [31, 32]. Additionally, a high proportion of school-age children usually consume

Table 3 The associations between family meals' frequency, parental diet quality, and children's food consumption

	Family meals' frequency β (SE)			Parental diet quality β (SE)
	Breakfast	Lunch	Dinner	
Children's food consumption (g/day)				
Milk and milk products[a]				
Boys	0.172 (0.04)*	0.096 (0.04)	0.095 (0.02)	0.164 (0.03)*
Girls	0.144 (0.04)**	0.119 (0.02)	0.140 (0.02)	0.182 (0.01)**
Grain bread and BF cereals[b]				
Boys	0.090 (0.02)	0.180 (0.03)	0.100 (0.10)	0.132 (0.01)*
Girls	0.154 (0.09)	0.160 (0.09)	0.097 (0.02)	0.125 (0.06)*
Fruits				
Boys	0.166 (0.05)	0.136 (0.07)	0.149 (0.10)	0.231 (0.02)***
Girls	0.140 (0.05)	0.113 (0.04)**	0.106 (0.05)**	0.103 (0.02)*
Vegetables				
Boys	0.171 (0.08)	0.126 (0.04)*	0.148 (0.06)**	0.109 (0.01)**
Girls				
Girls	0.079 (0.06)	0.123 (0.01)	0.126 (0.02)	0.271 (0.00)***
Legumes				
Boys	0.084 (0.08)	0.182 (0.08)	0.083 (0.00)	0.070 (0.03)**
Girls	0.106 (0.10)	0.143 (0.09)	0.130 (0.04)	0.052 (0.01)
Red meat				
Boys	0.090 (0.08)	−0.102 (0.00)	0.095 (0.07)	−0.135 (0.00)
Girls				
Girls	0.102 (0.05)	0.107 (0.09)	-0.093 (0.09)	0.090 (0.01)
White meat and poultry				
Boys	0.079 (0.05)	0.121 (0.02)	0.160 (0.09)	0.036 (0.01)
Girls	0.223 (0.08)	0.092 (0.06)	0.101 (0.01)	0.100 (0.01)*
Salty snacks				
Boys	−0.174 (0.01)**	−0.088 (0.10)	0.120 (0.03)	−0.194 (0.05)*
Girls	−0.136 (0.12)*	0.120 (0.06)	−0.107 (0.05)	−0.282 (0.01)***
Sweets				
Boys	−0.093 (0.09)	0.079 (0.08)	0.095 (0.04)	0.101 (0.03)
Girls	−0.020 (0.05)	0.085 (0.04)	−0.103 (0.09)*	−0.183 (0.02)**
Sugar sweetened-beverages				
Boys	−0.130 (0.00)	0.092 (0.08)	−0.096 (0.05)	−0.104 (0.01)
Girls	−0.129 (0.01)	−0.124 (0.03)	0.102 (0.06)	−0.217 (0.05)**

$N = 1946$ parents and children. Regression analyses were adjusted for parent age, gender, country, marital status, educational level, SES, and BMI of parents and children

BF breakfast, *β* standardized coefficient, *SE* standard error

*$P < 0{\cdot}05$; **$P < 0{\cdot}01$; ***$P < 0{\cdot}001$ (indicate significance)

[a]cheese was not counted

[b]rice and pasta were not mentioned under grains group in the questionnaire

a school-provided lunch or packed-lunch box at least five times a week [33], and this could explain the reasons behind the low frequency of family lunch.

Positive and significant associations were found in our study between family meals' frequency and parental DQ. In detail, parents who share their meals with family showed higher scores with better DQ records in all meal occasions including breakfast, lunch, and dinner. These findings help to fill an important gap in the literature as no previous research have examined this association among families at high risk of T2DM and due to the limited research focusing on the DQ of parents related to family meals' frequency; therefore, a direct comparison could not be made. In addition, in our sample of parents, family meals' frequency was

Table 4 Mediation analyses for the association between family meals frequency and children's consumption of selected food items

	Indirect effect (a*b)			Direct effect (c'- path)			Mediation %		
	β (95% CI)			β (95% CI)					
Children's food consumption (g/day)	**BF**	**Lunch**	**Dinner**	**BF**	**Lunch**	**Dinner**	**BF**	**Lunch**	**Dinner**
Milk and milk products [a]									
Boys	0.049 (0.020, 0.063)	_____	_____	0.123 (0.089, 0.140)	_____	_____	28.40%	_____	_____
Girls	0.054 (0.024, 0.080)			0.090 (0.065, 0.103)			37.50%		
Fruits									
Girls	_____	0.019 (0.008, 0.040)	0.014 (0.007, 0.038)	_____	0.094 (0.052, 0.157)	0.092 (0.063, 0.019)	_____	16.80%	13.20%
Vegetables									
Boys	_____	0.02 (0.009, 0.042)	0.015 (0.008, 0.0403)	_____	0.16 (0.086, 0.197)	0.133 (0.079, 0.190)	_____	15.80%	10.10%
White meat and poultry									
Girls	_____	0.011 (0.007, 0.037)	_____	_____	0.107 (0.066, 0.194)	_____	_____	9.30%	_____
Fish and seafood									
Boys	_____	_____	0.013 (0.008, 0.026)	_____	_____	0.203 (0.109, 0.301)	_____	_____	6.00%
Salty snacks									
Boys	−0.057 (−0.084, −0.018)	_____	_____	−0.117 (−0.201, −0.096)	_____	_____	32.70%	_____	_____
Girls	−0.085 (−0.102, −0.045)			−0.051(−0.085, −0.014)			62.50%		
Sweets									
Girls	_____	_____	−0.025 (−0.035, −0.014)	_____	_____	−0.078 (−0.100, −0.059)	_____	_____	24.20%

$N = 1946$ parents and children. Only significant data is presented

β standardized coefficient, *CI* confidence intervals. Mediation analyses were adjusted for parent age, gender, country, marital status, educational level, SES, and BMI of parents and children, *BF* breakfast

[a] cheese was not counted

[b] rice and pasta were not mentioned under grains group in the questionnaire

significantly associated with parents' food consumption of selected food items. Likewise, cross-sectional and longitudinal studies linking the frequency of family mealtimes with overall dietary intake of parents have also found positive connections [34, 35]. Similar to our results, cross-sectional studies in adults showed that those who share their meals with family more frequently consume less sweets, and SSB, with higher intake of fibres, FV, whole-grain compared to those who do not share their meals with family [36, 37]. Moreover, one systematic review on shared meals with dietary and weight outcomes in youth and adults indicated associations between family meals frequency and improved DQ with increased intake of FV, and decreased intake of soda, fast food, fried foods, higher-fat foods, unhealthy snacks, and cakes [38]. However, the systematic review was based mainly on cross-sectional studies, thus limiting attribution of causality [38].

In our analysis, frequent family meals were associated with a healthier food consumption of children. Children who frequently share breakfast with their families showed increased consumption of milk and milk products and reduced intake of salty snacks. Similarly, a study among American children reported higher consumption of milk and milk products among those who regularly have a family breakfast [31]. However, in contrast with some prior studies [31, 39], we did not find an association between family breakfast and consumption of grain and FV in children. These differences may also be in part related to social desirability bias or less accurate reports of parents [32]. Additionally, in accordance with a previous study in Arab families [40], our results found that more frequent family lunch and dinner was associated with higher intake of FV. Likewise, results of previous studies showed that family lunch and dinner was associated with a higher consumption of FV [31, 40, 41]. The possible explanation of this could be that vegetables are more typically served with lunch and dinner than with breakfast in Europe [38]. Unlike previous research findings [38, 42], in the present study, associations between family meals' frequency and SSB were not found in all meal occasions including breakfast, lunch, and dinner, which may be the result of low SSB intake in the study population. It is noteworthy that most of the previous studies investigated only one meal occasion and did not specify the meal type, and only few studies examined family breakfast and/or dinner. Besides, very limited studies have examined the effect of shared family lunch on children's food intake since children tend to consume their lunch at school due to the school schedule in these countries. Moreover, the lack of associations between a specific meal occasion and the intake of some selected food items in our study could be due to culture-specific meal patterns, in which offering this food item may be less dependent upon meal structure than many other foods in the European context. Besides, differences in results in this study compared to that of others could be due to the unadjusted analyses of other studies with uncontrolled confounders or methodological limitations [32].

The present study found that the association between family meals' frequency and some food items consumed by children occurred, partially, through parental DQ. These results proposed that the children's consumption of some food items could get affected by the DQ of parents not only by family meals' frequency. It is noteworthy that this study is the first to examine the mediation effect of parental DQ on the relationship between family meals frequency (i.e., breakfast, lunch, dinner) and children's food intake. This could, as suggested in previous studies [19, 43] as well as in this study, imply that the DQ of parents play a unique and important role in establishing and maintaining healthy eating behaviours in their children, thereby affecting their food consumption. In this context, our analysis showed significant associations between parental DQ and children's food consumption among both boys and girls in families at high-risk of T2DM. In detail, a study in children reported lower intake of chocolate, biscuits, cakes, and savoury snacks among children when the parental DQ scores were higher [18]. Similarly, our results found that parental DQ is negatively associated with the consumption of sweets and SSB but only among girls. The possible reason of these results could be that boys tend to consume more sugar than girls in all age-groups [44] and that boys' food preference and food choice are influenced mainly by taste and not by how healthy foods are, compared to girls [44]. In contrast to our results, a cross-sectional study including primary school children in New Zealand showed no significant associations between DQ of parents and children's intake of FV [18]. This difference in the results could be due to the use of a different tool to assess the parental DQ compared to the tool used in this study (i.e., Diet Quality Index (DQI) vs. HDS).

This study has some limitations. Firstly, self-reported questionnaires were used for collecting the food consumption data, a method which is not able to adequately determine absolute food intakes compared to other methods (i.e., 24-h dietary recall). Secondly, the cross-sectional nature of this study did not provide information in determining the cause-and-effect association. Another limitation of this study is that children's data were based on parental report, and therefore, a bias must be considered. However, there are several strengths in this study that need to be mentioned. To the best of our knowledge, the present study is the first to examine the association between family meals' frequency and parental DQ and parent's and children's food consumption in European families at high risk of developing T2DM. This study also provides a unique opportunity in measuring the effect of each type of family meals (i.e., breakfast, lunch, and dinner) on parent's and children's food intake. Besides, the anthropometric measurements were obtained by well-trained researchers using highly validated and standardized procedures

to ensure and increase accuracy. In addition, the sample size had been selected from a wide geographical spread, including six European countries with a large cultural and dietary diversity, which increases the generalizability of the results.

Conclusion

Family meals' frequency was associated with parental DQ and food consumption, while there was also an association between family meals frequency and food consumption of children in families with an increased risk of developing T2DM. Besides, parental DQ partially mediates the association between family meals frequency and children's consumption of some selected food items. Parents are usually considered as role models, who set the rules for their children's food intake and dietary habits, while family mealtime environment could have a great potential to change the eating behaviors of children. Therefore, improving parental DQ and increasing the frequency of family meals, both factors could have an impact in children's food consumption and offer a promising entry point for change through limiting the unhealthy eating habits of children and thereby prevent childhood obesity and T2DM. Further studies are needed to examine the prolonged effects of family meals' frequency and parental DQ on food consumption of children in families at high risk of T2DM.

Abbreviations BMI: Body mass index; DQ: Diet quality; DQI: Diet Quality Index; Feel4Diabetes: Families across Europe following a Healthy Lifestyle for Diabetes Prevention; FFQ: Food Frequency Questionnaire; FINDRISC: Finnish Diabetes Risk Score; FV: Fruit and vegetables; HDS: Healthy Diet Score; SES: Socioeconomic status; SSB: Sugar-sweetened beverages; T2DM: Type 2 diabetes mellitus; WC: Waist circumference

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Authors' contributions L.M. conducted the statistical analyses and wrote the manuscript. Y.M. coordinated the study. L.A.M., Y.M., G.C., K.M., T.T. participated in the design of the study. E.M.G.G. and L.A.M. critically revised the manuscript and supervised all procedures. P.S., R.W., and G.C. provided essential intellectual input; all authors have read, revised, and approved the final version of the manuscript.

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Availability of data and material The data of the present study are available for further scientific analysis from the corresponding author on reasonable request.

Declarations

Ethics approval The study was conducted according to the guidelines of the Declaration of Helsinki. The ethical approval was obtained from the Ethical Committees of all participating European countries including Spain (ethical approval code: CP03/2016), Greece (code: 46/3–4-2015), Finland (code:174/1801/2015), Belgium (code: B670201524237), Bulgaria (code: 52/10–3-201r), and Hungary (code: 20095/2016/EKU).

Consent to participate Informed consent was obtained from all participants involved in the study.

Consent for publication Not applicable.

Conflict of interest The authors declare no competing interests.

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Manuscript IV: Cross-sectional and longitudinal associations between family meals frequency and children's overweight/obesity in families at high risk of type 2 diabetes: the Feel4Diabetes-study.

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Cross-sectional and longitudinal associations between family meals frequency and children's overweight/obesity in families at high risk of type 2 diabetes: The Feel4Diabetes-study

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Summary

Background: The frequency of family meals has been suggested as a protective factor against obesity among children.

Objective: This study aimed to investigate the cross-sectional and longitudinal associations between family meals frequency and children's overweight/obesity in families at high risk of type 2 diabetes (T2D) across six European countries.

Methods: 989 parent–child dyads (52% girls and 72% mothers) were included. Participants completed validated measures to assess the frequency of family meals and anthropometrics. Multivariable regression models were applied to examine the

longitudinal associations between family meals frequency and overweight/obesity in children. Logistic regression was performed to predict the odds of having overweight/obesity depending on changes in family meals frequency over a two-year follow-up period. Analyses were stratified for children's sex.

Results: High frequency of family breakfasts and/or dinners was inversely associated with children's BMI in boys and girls at T2. Results showed decreased odds of overweight/obesity at follow-up among both boys (OR = 0.65; 95% CI 0.41, 0.96) and girls (OR = 0.53; 95% CI 0.31, 0.87) who consumed minimum of three times family breakfasts and/or family dinners a week at baseline. An increase in family breakfasts and/or dinners frequency was associated with lower odds of overweight/obesity in both boys and girls at follow-up.

Conclusion: A high frequency of family breakfasts and/or dinners but not lunch during childhood is associated with lower odds of overweight/obesity development in children from families at high risk of T2D. The promotion of family meals could help in preventing the development of overweight/obesity among children.

KEYWORDS
body composition, body mass index, children, family meals frequency, obesity, type 2 diabetes

1 | INTRODUCTION

Childhood obesity is a serious health condition, which has major health consequences and contributes to the onset of type 2 diabetes (T2D) in childhood and adulthood.[1] In addition, obesity among children tends to persist into later life and may increase the risk of obesity during adulthood.[2,3] Parents are carrying a major responsibility for shaping their children's eating habits and dietary environment,[4] having a direct impact on children's food preferences, food consumption and weight status.[3]

One aspect of family life is eating meals together, which has shown social and behavioural benefits for young children.[5] For instance, family meals provide consistency, routine, and opportunity for a better communication between children and their parents,[5] helping children to learn more about nutrition and building adequate eating habits.[5] Family meals frequency is positively associated with children's diet quality (DQ)[3] such as a higher fruit and vegetables (FV),[5] whole grains and calcium consumption.[6] Similarly, several longitudinal studies have shown that children having 3–5 times family meals per week had also higher intakes of FV, calcium and fibre-rich foods.[7,8]

In addition, previous research suggests that family meals are one of the most important potential factors in protecting against childhood obesity through targeting their dietary behaviours.[9,10] A meta-analysis found a 12% reduction in overweight among children who used to have family meals three or more times per week.[11] Likewise, some longitudinal and cross-sectional studies found that having frequent family meals was associated with reduced risk of obesity.[12,13] Similarly, a cross-sectional study of family dinners frequency among American children showed that family dinners frequency measures were inversely associated with children's body composition measures.[14] Recent studies also found that children with normal body weight share family meals more frequently in comparison with children with obesity.[11,13,15,16] Moreover, one longitudinal study of school children in Finland determined that high frequency of family meals predicted a lower body mass index (BMI) 2 years later.[16] Although the association between family meals in general and obesity in children has been sufficiently demonstrated, there is less known about which meal impacts children's food consumption and weight status most. Such information is however crucial to develop targeted nutrition interventions.[11,12]

It has been shown that children of parents with insulin resistance (IR) are more likely to develop obesity and IR compared to children of non-IR parents.[17] Recently, it has been found that European children from families at high risk of developing T2D have low frequency of family meals.[18] Besides, results of a large multicentred European study showed that children born to IR parents and at risk of T2D were more likely to have unhealthy dietary patterns.[19] Thus, assessing families at high risk of T2D who potentially have already unhealthy lifestyle behaviours could help to identify modifiable factors in the family meals' structure that can protect against overweight/obesity and to get a better insight into this specific population.

To date, despite the growing interest in this topic, most of the studies looking at the association between family meals and children's body weight presented findings considering only healthy subjects, or only one of the genders, social class, and race/ethnicity. To our knowledge, studies assessing the relationship between family meals frequency and their impact over time on children's BMI in European populations at high-risk to develop T2D are missing. Therefore, the present study aims to investigate the cross-sectional and longitudinal associations, over a two-year follow-up, between the frequency of family meals and children's overweight/obesity in families at high risk of developing T2D across six European countries.

2 | METHODS

2.1 | Study design

The European Feel4Diabetes study developed a community-based intervention, aimed to promote healthy lifestyle and tackle obesity and obesity-related metabolic risk factors for the prevention of T2D among families from vulnerable groups. The study was implemented between 2016 and 2018, with data collection at baseline in 2016 (T0) and at 1 (T1) and 2 years (T2) follow-up. The six European countries involved in the study were categorized as countries under austerity measures following the economic crisis (Greece and Spain), low-income countries (Bulgaria and Hungary), and high-income countries (Belgium and Finland). For the recruitment of families, primary schools were used as the entry-point to the community in each selected province. Children of 1st, 2nd and 3rd grade and their parent(s) were invited to participate in the study, with 11 396 families enrolling at baseline. More details on the general procedures, recruitment strategy and the study protocol can be found elsewhere.[20]

Families were seen as "High-risk families" when at least one parent was identified by the Finnish Diabetes Risk Score (FINDRISC) as being at risk of developing T2D.[19] The FINDRISC score is obtained based on eight questions related to age, waist circumference (WC), BMI, consumption of FV, physical activity, history of high blood glucose, family history of diabetes, and the use of antihypertensive medication.[21]

Families assigned to the intervention group were invited to participate in a 2-year intervention plan to promote a healthier lifestyle. During the first year, behavioural change approaches were used in the counselling sessions to promote motivation and self-efficacy, improve self-regulation, and develop objectives to adopt a healthier and more active lifestyle. A more complete summary of the counselling sessions' content may be obtained elsewhere.[20] The intervention during the second year intended to sustain the improvements made during the first year of intervention, therefore it was less intensive than the first. Parents got motivating advice via text messages delivered to their cell phones during the second year.

All countries involved in the study provided good clinical practices and followed the conventions of the council of Europe on human rights and biomedicine as well as the ethical guidelines of the Declaration of Helsinki. Ethical approval was obtained in each country involved in the study: Spain (CP03/2016), Greece (46/3-4-2015), Finland (174/1801/2015), Belgium (B670201524237), Bulgaria (52/10-3-201r), and Hungary (20095/2016/EKU). All parents were informed about the purpose of the study, and signed a written informed consent for their participation, which gave them the chance to withdraw from the study at any point. The Feel4Diabetes-study is registered within the clinical trials registry (NCT02393872).

2.2 | Study sample

For this study, parent–child dyads including a parent at risk of T2D were included. All dyads with full anthropometric measurements and completely filled out questionnaires for both the parent and the child at baseline and T2, were included in the study. Since some families participated with more than one child, we randomly selected one child per family in order not to duplicate parental information. Parents were randomly selected in those families with both parents at risk of T2D according to FINDRISC. Due to the longitudinal nature of the study and the fact that the availability of data from the same parent–child dyad at both time points was mandatory for inclusion, from the 2748 high-risk families that were identified and measured at baseline, 989 parent–child dyads had complete data at both time points for inclusion in this study.

2.3 | Dietary assessment

Two self-reported questionnaires (i.e., the food frequency and eating behaviour questionnaire and the energy balance-related behaviour questionnaire) were filled out by one of the parents, who completed the questionnaires both for him/herself and their child. The frequency of family meals was measured individually for each meal occasion (i.e., breakfast, lunch, and dinner), and it was assessed through the question: "How often does your child have the following meals with the family?", which could be answered by choosing one of the following options: never, less than 1 time/week, 1–2 times/week, 3–4 times/week, 5–6 times/week, and daily.

2.4 | Anthropometric measurements

Anthropometric measurements were conducted according to standardized protocols.[22] In children, weight was measured by Seca 813 digital flat scale and recorded to the nearest 0.1 kg, and standing height was measured by Seca 217 stadiometer for mobile height measurement and recorded to the nearest 0.1 cm. Height and weight were measured while children were barefoot and head in the Frankfurt plane with light clothing. The BMI of parents and children was calculated by dividing body weight (kg) to height squared (m^2). Parental BMI was calculated based on their self-reported weight and height, while, children's BMI was calculated based on their objective weight and height which were measured at schools by trained researchers. Two readings were obtained for each measurement and the mean was used for the analysis. Children's changes in BMI (ΔBMI = BMI T2 − BMI T0) were calculated, and BMI z-scores were calculated for children according to Cole et al.[23] to obtain an optimal measure for their weight in accordance with their sex and age, the International Obesity Task Force (IOTF) cut-off points[23] were used to categorize children as having "normal weight", "overweight", or "obesity".

2.5 | Parental demographic characteristics

Information on demographic characteristics of the parents included in the present study was considered. The marital status of parents was

obtained by questionnaire, and the responses included five choices: "single", "married or cohabiting", "separated or divorced", "widowed", and "other". Regarding the employment status, parents were asked to identify their main occupation over the last 6 months, and 7 answer possibilities were included: "stay at home parent", "work full-time", "work part-time", "unemployed", "full-time education", "retired", "something else". The education level of parents was also obtained and responses could range from "less than 7 years" to "more than 16 years" of education, with a six-point scale response option.

2.6 | Diet quality

The DQ of parents and their children was assessed by the Healthy Diet Score (HDS). The HDS is a validated indicator developed for adults and was tested before over families at high-risk of T2D.[24] For this study, we adapted the scores for adults with the information available from the children. In this context, the component of oil and fats included only the cooking oil and fats, and the components of nuts and seeds were not included.[19] The dietary goals set in Feel4Diabetes intervention related to food behaviour and food choices were used as the basis for the HDS. The main components of the HDS include family meals, breakfast, whole-grain cereals, low-fat dairy products, red meat, vegetables, fruits and berries, nuts and seeds, oils and fats, sweet snacks, salty snacks, and sugary drinks.

For parents, a maximum score of 6 was given to the consumption of low-fat dairy products, nuts and seeds, salty snacks, and sweet snacks. A maximum score of 8 was given to the frequency of family meals as well as the consumption of oils and fats. The rest of the components got a maximum score of 10. For children, a maximum score of 4 was given to the cooking oils and fats component. A maximum score of 6 was given to sweet snacks, salty snacks and low-fat dairy. The frequency of family meals was given a maximum score of 8. The rest of the components got a maximum score of 10. The total score, calculated as the sum of the component scores, was ranging from 0 to 100 for parents, and from 0 to 86 for children, in which higher scores indicating better DQ. More information about HDS has been described in detail elsewhere.[19,24]

2.7 | Statistical analysis

Descriptive data on participants' characteristics are presented as percentages or means for categorical or continuous variables, respectively. The normal distribution of variables was checked by Kolmogorov–Smirnov test. Since sex interactions were observed in the associations between dietary habits and weight status among children, analyses were stratified by sex. Student's *t*-tests were used to compare means of continuous variables by sex, and Pearson's chi-square test was used in the case of categorical variables.

Multivariable regression models were used to examine the cross-sectional associations between family meals frequency and children BMI at baseline and T2, while adjusting for country, group (intervention-control), age and DQ of children, and parental characteristics (age, marital status, education level, employment, sex, DQ, BMI). Multivariable regression model was also used to study the longitudinal associations between the changes in the frequency of family meals from T0 to T2 and the changes over time in children's BMI. The model was adjusted for country, group (intervention-control), age and DQ of children, and parental characteristics (age, marital status, educational level, employment, sex, DQ, BMI) as well as family meals frequency and BMI of children at baseline.

Multilevel logistic regression was performed to predict the odds for children having overweight or obesity at T2 depending on family meals frequency at baseline, considering group (control vs. intervention) and country as levels to account for the study design, and adjusting for children's age, DQ, and BMI at baseline, and parental characteristics (age, marital status, education level, employment, sex, DQ, BMI change between baseline and T2). Out of the responses given in the Food frequency questionnaire (FFQ): (never, less than 1 time/week, 1–2 times/week, 3–4 times/week, 5–6 times/week, and daily), three categories of family meals frequency were created out of them and used as independent variables: "Never", "one to two times per week", and "three to seven times per week". BMI categories (normal weight, overweight, and obesity) were considered as dependent variables.

Finally, multilevel logistic regression models were also used to examine the prospective association between the following: (1) changes in family meals frequency over 2 years and children's BMI at T2, in which five categories of family meals frequency were created: (never, remained low, decreased, increased, remained high), and "never" was considered as a reference. While the BMI were categorized as follows: (normal weight, overweight/obesity). The group (control vs. intervention) and country were considered as levels, and the model was adjusted for children's age, DQ, and BMI at baseline, and parental characteristics (age, marital status, education level, employment, sex, DQ, BMI). (2) Changes in family meals frequency and changes in BMI from T0 to T2, in which the five categories of family meals frequency remained the same (never, remained low, decreased, increased, remained high). BMI change was categorized from better to worse as: normal weight at T0 and T2, overweight/obesity at T0 but normal weight at T2, normal weight at T0 but overweight/obesity at T2, overweight/obesity at T0 and T2. The model was adjusted for children's age and DQ, and parental characteristics (age, marital status, education level, employment, sex, DQ, BMI).

Statistical analyses were carried out using IBM-SPSS (Version 26.0. Armonk, NY: IBM Corp), except for the logistic regression model, which was conducted using Stata/SE 13 (Stata Corp LP, College Station, TX), with a $p < 0.05$ representing statistical significance for all tests.

3 | RESULTS

3.1 | Characteristics of study participants

Demographic and anthropometric characteristics of children and parents at T0 are presented in Table 1. Overweight/obesity was measured in 32% of the boys and 36% of the girls (sex difference: $p = 0.163$).

TABLE 1 Characteristics of the study participants at baseline (T0)

Characteristics	Parents	Children		
		Boys ($n = 480$)	Girls ($n = 509$)	p-value
Age (in years)	38.98 (5.24)	7.3(0.99)	7.4 (1.02)	0.968
Sex (female%)	72%	-	52%	-
Education level (% high education*)	73%	-	-	-
Employment status (% employed)	62%	-	-	-
Marital status (% married)	79%	-	-	-
Body weight (kg)	77.1 (17.1)	30.5 (7.9)	29.4 (7.8)	**0.020**
Height (cm)	165.9 (8.4)	131.2 (8.0)	130.3 (7.5)	**0.022**
BMI (kg/m^2)	27.8 (5.52)	17.65 (2.9)	17.59 (8.2)	0.287
BMI categories (%)				
Normal	37.5%	68.3%	63.1%	0.163
Overweight	35%	21%	25.1%	
Obesity	27.5%	10.6	11.6%	
BMI z-score	-	0.64 (1.1)	0.72 (1.1)	0.753
Family breakfast frequency	-			
Never or less than 3 times/week	59.1%	42.5%	34%	**0.036**
3–7 times/week	40.9%	57.5%	66%	
Family lunch frequency				
Never or less than 3 times/week	38.7%	50.5%	52.3%	0.261
3–7 times/week	61.3%	49.5%	47.7%	
Family dinner frequency				
Never or less than 3 times/week	19.2%	6.4%	6.9%	**0.018**
3–7 times/week	80.8%	93.6%	93.1%	
Healthy Diet Score (HDS)				
≤50	27.5%	38.4.7%	35.7%	**0.044**
>50	72.5%	61.6%	64.3%	

Note: $N = 989$ parents and children. This table provides mean (SD) for the continuous variables and frequency (%) for the categorical variables. Boldface indicates statistical significance between sexes at $p < 0.05$. *13–14 years of education or more. *Higher HDS indicates better diet quality. BMI, body mass index. BMI z-scores were calculated according to Cole et al.

3.2 | Cross-sectional associations between family meals frequency and BMI of children at baseline and follow-up

Family dinners frequency at baseline was inversely associated with children's BMI in boys ($\beta = -0.182$, $p = 0.021$) and girls ($\beta = -0.124$, $p < 0.001$), while no such associations were found for family breakfasts and/or lunches frequency (Table 2). The same holds true at T2, with the exception that a significant inverse association was also found between family breakfasts frequency and children's BMI for both boys and girls.

3.3 | Longitudinal associations between changes in family meals frequency and changes in children's BMI over time

When family meals frequency and BMI of children at baseline were included as covariables, it has been found that the increase in family breakfasts frequency was negatively associated with changes in BMI in girls ($\beta = -0.078$, $p = 0.035$) only (Table 3). No association was found with change in family lunches frequency and BMI change over time. Regarding family dinners frequency, the increase in family dinners frequency was inversely associated with changes in BMI of boys ($\beta = -0.102$, $p = 0.019$) and girls ($\beta = -0.198$, $p < 0.001$).

3.4 | Odds ratios of overweight/obesity status at T2 among children by baseline family meals frequency

The odds of having overweight/obesity are decreased for boys (OR = 0.76; 95% CI 0.52, 1.04) and girls (OR = 0.72, 95% CI 0.58, 0.93) who consumed family breakfasts three to seven times a week at baseline, compared to those who never had breakfasts with family (Table 4). In general, family lunches frequency was not associated with the odds of overweight/obesity among boys and girls. On the other hand, having three or more family-shared dinners per week at baseline

TABLE 2 Cross-sectional associations between family meals frequency and BMI of children at baseline (T0) and at 2nd follow-up (T2)

	Boys		Girls	
	β	*p*-value	*β*	*p*-value
Family meals frequency (T0)	**BMI of children (T0)**			
Breakfast	−0.073	0.063	−0.039	0.122
Lunch	0.024	0.202	−0.008	0.235
Dinner	**−0.182**	**0.021**	**−0.124**	**<0.001**
Family meals frequency (T2)	**BMI of children (T2)**			
Breakfast	**−0.217**	**0.033**	**−0.155**	**0.026**
Lunch	−0.094	0.301	−0.064	0.323
Dinner	**−0.191**	**0.004**	**−0.142**	**0.009**

Note: $N = 989$ parents and children. Boldface indicates statistical significance at $p < 0.05$. Regression analyses were adjusted for country, group (intervention-control), age and DQ of children, and parental characteristics (age, marital status, education level, employment, sex, DQ, BMI). In each shared meal occasion, the frequency was categorized as (never, 1–2 meals/week, and ≥3 meals/week). *β*, standardized coefficient. BMI, body mass index.

TABLE 3 Associations between changes in family meals frequency (T0–T2) and changes in BMI of children (T0–T2)

	Δ BMI of children			
	Boys		Girls	
	β	*p*-value	*β*	*p*-value
Δ Family meals frequency				
Breakfast	−0.051	0.066	**−0.078**	**0.035**
Lunch	−0.041	0.189	−0.085	0.214
Dinner	**−0.102**	**0.019**	**−0.198**	**<0.001**

Note: $N = 989$ parents and children. Boldface indicates statistical significance at $p < 0.05$. Regression analyses: adjusted for country, group (intervention-control), age of children and DQ, and parental characteristics (age, marital status, education level, employment, sex, DQ, BMI), with additional adjustments for family meals frequency and BMI of children at baseline. β, standardized coefficient; BMI, Body Mass Index.

was significantly associated with reduced odds of having overweight/obesity (OR = 0.65; 95% CI 0.41, 0.96) 2-years later in boys compared with those who never shared family dinners during childhood. In addition, girls who had family-shared dinners three to seven times a week at baseline had 34.6% decreased odds of having overweight and obesity 2-years later compared with girls who never had family-shared dinners at baseline.

3.5 | Associations between changes in family meals frequency (T0 to T2) and BMI categories at T2

Results from multilevel logistic regressions indicated that the increase in family meals frequency over time was associated with decreased odds of overweight/obesity among boys and girls at T2 (Table 5). Increased family breakfasts frequency over time was associated with lower odds of overweight/obesity in boys (OR = 0.78; 95% CI: 0.52–1.11) and girls (OR = 0.78; 95% CI: 0.55–1.01). However, no association was indicated between changes in family lunches frequency and the odds of overweight/obesity over time. Boys and girls that improved family-shared dinners over time showed lower odds of overweight/obesity at T2 (35% vs. 37.8%, respectively).

3.6 | Associations between changes in family meals frequency (T0 to T2) and BMI categories (at T0 and T2)

As shown in Table 6, an increase in the family meals frequency over time was associated with decreased odds of being in a higher outcome category of BMI over time. Specifically, boys and girls whose family breakfasts frequency increased were more likely to have lower BMI values (boys: OR = 0.68; 95% CI: 0.49–0.91; girls: OR = 0.69; 95% CI: 0.34–0.92) than those with a decreased frequency of family breakfasts. A similar association was found between a change in family dinner frequency and the odds of overweight/obesity in boys (OR = 0.57; 95% CI: 0.39–0.83) and girls (OR = 0.69; 95% CI: 0.42–0.91). On the other hand, no associations were observed between changes in the frequency of family lunches and BMI categories of children.

4 | DISCUSSION

The present study found that a high frequency of family meals consumption, especially breakfasts and/or dinners, but not lunch, is inversely associated with BMI in children cross-sectionally, at baseline and at follow-up. Also, having family-shared breakfasts and/or dinners three or more times per week at baseline was significantly associated with reduced odds of overweight/obesity at year 2 of follow-up. Moreover, the increase in the frequency of family breakfasts and/or dinners during a period of 2 years was associated with lower odds of overweight/obesity over time in boys and girls from families at high risk of developing T2D.

Results from this study suggest that girls tend to consume more meals with the family than boys. It is noteworthy that no previous research has assessed family meals frequency by children's sex, thus, a direct comparison could not be made. One explanation might be gender differences in dietary and social behaviours. Girls may for instance have more involvement in cooking with mothers and other food-related tasks including meals preparation and setting the dining table.[25] Moreover, according to Keller et al, girls enjoy more meals gathering with family and friends compared to boys, and these differences could be noticed in early childhood.[26] In this context, a cross-sectional study on UK children reported that boys were found to eat less with family, as they tend to eat more meals out, and they consumed more takeaway meals compared to girls.[27]

TABLE 4 Odds ratios of overweight/obesity status at (T2) among children by baseline family meals frequency (longitudinal)

	Overweight/obesity status (T2)			
	Boys		Girls	
Baseline family meals frequency	OR	(95% CI)	OR	(95% CI)
Breakfast				
Never	Ref.		Ref.	
One to two times per week	1.12	(0.79, 1.23)	1.06	(0.81, 1.22)
Three to seven times per week	0.76*	(0.52, 1.04)	0.72*	(0.58, 0.93)
Lunch				
Never	Ref.		Ref.	
One to two times per week	1.07	(0.73, 1.27)	1.13	(0.67, 1.78)
Three to seven times per week	1.11	(0.86, 1.57)	1.07	(0.48, 1.67)
Dinner				
Never	Ref.		Ref.	
One to two times per week	0.78*	(0.46, 0.98)	0.68*	(0.45, 0.96)
Three to seven times per week	0.65*	(0.41, 0.96)	0.53**	(0.31, 0.87)

Note: $N = 989$ parents and children. In the regression analysis, group (control vs. intervention) and country were considered as levels to account for the study design and adjusted for children's (BMI at baseline, age, and DQ), and parental characteristics (age, marital status, education level, employment, sex, DQ, and changes in BMI). OR, odds ratio; CI, confidence interval. Ref, reference category; BMI, body mass index. Statistical significance indicated at (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$). The category (never) was considered as a reference.

TABLE 5 Associations between changes in family meals frequency over time (T0–T2) and BMI of children at (T2)

	BMI of children at T2			
	Boys		Girls	
Δ Family meals frequency	OR	(95% CI)	OR	(95% CI)
Breakfast				
Never	Ref.		Ref.	
Remained low	1.03	(0.77, 1.29)	1.01	(0.88, 1.18)
Decreased	1.02	(0.75, 1.30)	1.04	(0.73; 1.27)
Increased	0.78*	(0.52, 1.11)	0.78**	(0.55, 1.01)
Remained high	0.91	(0.69, 1.22)	0.92	(0.61, 1.08)
Lunch				
Never	Ref.		Ref.	
Remained low	1.04	(0.79; 1.18)	1.01	(0.77, 1.19)
Decreased	1.03	(0.66, 1.31)	1.03	(0.71, 1.28)
Increased	0.88	(0.69; 1.18)	0.88	(0.63, 1.22)
Remained high	0.88	(0.55, 1.24)	0.77	(0.59, 1.17)
Dinner				
Never	Ref.		Ref.	
Remained low	1.08	(0.77, 1.31)	1.03	(0.71; 1.41)
Decreased	1.03	(0.81, 1.29)	1.07	(0.81, 1.35)
Increased	0.54*	(0.33, 0.83)	0.61**	(0.40, 0.97)
Remained high	0.79	(0.51, 1.35)	0.84	(0.59, 1.27)

Note: $N = 989$ parents and children. In the regression analysis, group (control vs. intervention) and country were considered as levels to account for the study design and adjusted for children's (BMI at baseline, age, and DQ), and parental characteristics (age, marital status, education level, employment, sex, DQ, and BMI). OR, odds ratio; CI, confidence interval; BMI, body mass index. Statistical significance indicated at (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$). The reference category is "never". BMI categories from better to worse (normal weight, overweight/obesity).

TABLE 6 Associations between changes in family meals frequency and changes in BMI over time (T0–T2)

	BMI categories (T0 to T2)			
	Boys		Girls	
Δ Family meals frequency	OR	(95% CI)	OR	(95% CI)
Breakfast				
Never	Ref.		Ref.	
Remained low	1.02	(0.83, 1.16)	1.01	(0.67, 1.21)
Decreased	1.03	(0.72, 1.31)	1.05	(0.65, 1.18)
Increased	0.68*	(0.49, 0.91)	0.69*	(0.34, 0.92)
Remained high	0.85	(0.66, 1.00)	0.64	(0.47, 0.92)
Lunch				
Never	Ref.		Ref.	
Remained low	1.04	(0.57; 1.22)	1.03	(0.77; 1.18)
Decreased	1.05	(0.77; 1.38)	1.02	(0.68, 1.20)
Increased	0.85	(0.53, 1.25)	0.68	(0.42, 1.07)
Remained high	1.02	(0.77, 1.24)	0.98	(0.71, 1.19)
Dinner				
Never	Ref.		Ref.	
Remained low	1.04	(0.83, 1.18)	1.07	(0.82, 1.18)
Decreased	1.02	(0.87, 1.23)	1.02	(0.81, 1.28)
Increased	0.57*	(0.39, 0.83)	0.69*	(0.42, 0.91)
Remained high	0.58**	(0.29, 0.86)	0.44**	(0.21, 0.77)

Note: $N = 989$ parents and children. In the regression analysis, group (control vs. intervention) and country were considered as levels to account for the study design and adjusted for children age, and DQ, and parental characteristics (age, marital status, education level, employment, sex, DQ, BMI). OR, odds ratio; CI, confidence interval; BMI, body mass index. Statistical significance indicated at (*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$). The reference category is "never". BMI categories from better to worse (normal weight at T0 and T2, overweight/obesity at T0 but normal weight at T2, normal weight at T0 but overweight/obesity at T2, overweight/obesity and T0 and T2).

Limited prior research has examined breakfasts, lunches, and dinners family meal patterns separately[28,29] among school children; therefore, these new findings add information to the pre-existing literature on family meals. In our study, family dinners were the most family-shared meals among most boys and girls. These findings are consistent with previous studies conducted among children and adolescents, which found similar proportions.[30,31] These results could be explained by the fact that family dinner is the only time of the day when the whole family can get together, especially on working days. While high proportions of school-age children usually consume a packed-lunch at school or lunch in the canteen of the school more than three times a week which explains the low frequency of shared lunches with family.[28,32]

Despite the substantial evidence that links the breakfasts to the overall diet and health of children, little is known about the benefits associated with family breakfasts frequency, particularly among younger children.[33] Evidence suggests that family dinner is the most commonly reported meal and researched family meal type,[34] while the frequency of both family breakfasts and dinners has been linked with improved dietary intake[18] and physical health among children.[35]

In this study, we found an inverse association between the frequency of family-shared breakfasts and/or dinners and BMI among children at follow-up. Similarly, previous studies found that more frequent family breakfasts[15,28,35] and dinners[11,28,35] were inversely linked to children's BMI outcomes.

The potential reason for this consistent result regarding the frequency of family dinners is due to the fact that family dinners frequency was already high compared to other meal occasions among both genders. Contrarily, some previous studies with children found no significant relationship between family meals and children's weight status.[36,37] Differences in results in this study compared to that of others could be due to the unadjusted analyses of these studies with uncontrolled confounders or methodological limitations.[14] Also, the sample population of this study was not a subset of the general population, but parents at risk of T2D. As it has been established previously,[38,39] parental BMI as an important predictor of children's BMI percentiles over time. Thus, the BMI of the parents was adjusted in all the analysis of this study. Besides, despite the family meals frequency, large family meal portion sizes and unhealthy meals preparation could also lead to higher weight in children.[36]

Our findings support the conclusions of several studies showing that having regular family-shared meals during childhood and adolescence is protective for overweight/obesity development over time.[12,40,41] In our sample of children, the increase in family meals

during childhood was inversely associated with changes in BMI of children even with considering family meals frequency and children's BMI at baseline as adjustment covariates.

Besides, the longitudinal analysis found that having three or more family-shared breakfasts and/or dinner per week at baseline showed reduced odds of overweight/obesity at T2 among both boys and girls after adjusting for confounders. Moreover, our results found that the increase in the frequency of family breakfasts and/or dinners during a period of 2 years was associated with lower odds of overweight/obesity over time among both boys and girls. These results were consistent with those of previous studies indicating that children with normal weight tend to consume more frequent family breakfast and dinner than children with obesity.[11,35,36,42] Also, results of our study corroborate prior cross-sectional and longitudinal studies showing that family meals frequency is inversely associated with BMI of school-aged children.[13,28,33,34] The main explanation of these results could be related to the emotional connections among family members during family mealtime, which in return could improve children's food intake. Moreover, children may be exposed to parental modelling of healthful eating behaviours, and this could improve children's food choices and portion sizes.[5,33] In addition, these results could be also explained by the fact that parental presence at the meal table could be positively linked with improvement in consumption of healthier foods among children.[5] In detail, family meals are more likely to serve fruits and vegetables, and smaller serving sizes which can contribute to better children's health.[43] Another reason could be that at family meals, parents may have the opportunity to both instruct their children and model healthy eating behaviours.[42] Also, given the high prevalence of daily family-shared meals in our study, the positive emotions that children may experience during the family meal occasions over time could create a supportive environment for children to regulate their own eating, as suggested by previous research.[34,43]

It is noteworthy to mention that our study's participants showed high rate of unemployment (62%), despite the high percentage of education, therefore, parental employment status was also included for adjustment in the analysis. This probably may be due to the high percentage of women (72%) who participated, as they are the ones that usually are the "stay at home parent". When including this adjustment results did not change. On the other hand, in a large representative sample of Ohio adults surveyed in 2012, differences were found in family meals frequency relative to parental sociodemographic characteristics such as employment.[44] This is consistent with evidence from other studies.[45,46] In detail, studies have found that higher family meals frequency was shown in households in which one or more adult is unemployed either because of retirement, unemployment, or being a "stay-at-home parent".[44] Time constraints associated with employment, particularly when all adults in the household are employed, may make it more difficult for households to have family meals at home.[47]

The present study has some limitations. First, children's data were based on parental reports, and therefore, a bias must be considered. Second, as self-reported data were used, the possibility of socially desirable responding is also a limitation. Moreover, BMI could not be considered as an accurate tool to estimate person's body fat compared to other anthropometric measurements (i.e., skinfold thickness, and bioimpedance analysis). Furthermore, this study only focused on the frequency of specific meal occasions as no information was available on other features like food preparation methods. Finally, since the majority of participated parents were women, and the population were only families at high-risk of T2D, as well as the data used were only for those participants who had completed data on both (T0) and (T2), all these factors could limit the generalizability of our results. Also, because of the longitudinal nature of this study, the long-time gaps between follow-ups during the study phases could be considered as a limitation.

There are also several strengths in this study that need to be mentioned. To the best of our knowledge, the present study is the first to examine the long-term gender-specific effects of the frequency of all family meals occasions individually (i.e., breakfast, lunch, and dinner) on children's BMI. In addition, this study focuses on a specific vulnerable population namely families at high risk of developing T2D across six European countries. The anthropometric measurements were obtained by well-trained researchers using highly validated and standardized procedures to ensure and increase accuracy. Furthermore, the sample size had been selected from a wide geographical spread including six European countries, with large cultural and dietary diversity.

In conclusion, family breakfasts and/or dinners frequency are inversely associated with children's BMI in families at risk of T2D. Longitudinally, the increase over time of the frequency of family-shared dinners decreased the odds of having a higher BMI over time and after 2 years. Having a high frequency of family-shared dinners over time decreased the odds of being in a higher category of BMI after 2 years. Thus, the promotion of higher frequency of meals, especially breakfasts and/or dinners, together with the family could help in preventing the development of overweight/obesity among children. Family meals should be considered for future strategies that aim children BMI reduction as it could offer a promising entry point for positive changes, especially among T2D high-risk families.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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6. Discussion

In summary, results from this Thesis showed that parental dietary behaviors, intake and diet quality were associated with children's food consumption. In addition, family meals frequency was associated with children's consumption of selected food items besides children's obesity in families in which one or both of the parents were at risk of T2D.

6.1 Parental dietary behaviors, practices, and children's eating habits

Poor dietary habits that are established during early childhood persist into adulthood and could be linked to increased risk of chronic diseases such as obesity and its related complications such as T2D [113]. After evaluating the main factors linked to eating habits of children, parental dietary behaviors were found to affect children mainly because parents influence their children's food-related thoughts and preferences and shape the home food environment in terms of accessibility and availability [114]. On the other hand, the influence of parental practices differs by age and it is thought to be strongest during early ages regardless of demographics including sex, age, country, and SES [12].

Although studies examining the direct role of parental influence on children's eating habits are limited, recent evidence showed that some parental feeding practices are preferable among others in developing positive eating habits during childhood [22]. For instance, previous studies found that the authoritative parenting style, which presents both demanding and responsive, is linked more with improved eating habits among children compared to other parenting styles (i.e., authoritarian and permissive). Also, children raised in authoritative households tend to have better food choices and healthier BMI [22,23,115].

In the narrative review included in this Doctoral Thesis, it was observed that family environment, as well as parental dietary behaviors and practices are associated with eating habits of children. While role modeling and moderate restriction were the most recommended parental practices, in which more parental encouragement and less excessive pressure might improve their children's eating habits.

Parents are critical role models for their children in many regards, and specifically in helping their children to build good eating habits that they will carry with them for the rest of their life. Since eating is a social experience, children develop their eating habits by imitating their parents in terms of diet quality and quantity [30]. Consistent with existing evidence, similarity between parents and children were observed in terms of types of food consumed and dietary composition [6,11,16-18]. In detail, healthy parental diet patterns were associated with reduced consumption of soft drinks [5], decreased fat intake [7], and improved FV consumption [7]. However, most of these studies did not conclude causality. It has been found that active encouragement and the provision of healthy food items was associated with healthier eating habits in children [25], along with

decreased consumption of cakes, chocolates, and savoury dishes [45]. Previous evidence suggests that pressuring practices aiming for healthy eating could have an inverse effect and increase the consumption of unhealthy and energy-dense foods in children [25]. Therefore, encouragement plus moderate restriction were the most favourable feeding practices for supporting positive food-related behaviors, in which children have the right to make decisions in combination with their parents [26].

6.2 Parental food consumption, diet quality and children's food consumption

In this Doctoral Thesis, it has been observed that the intake of both parents and children did not meet the recommended servings of healthy food items (i.e., FV, grains, fish, and seafoods). On the other hand, half of parents and children participating in the study were exceeding the recommended servings of sweets. Our results are in line with recently published studies on food intake assessment indicating that families from a general population did not meet dietary recommendations of healthy food items in the U.S [116], UK [117], and Asia [118].

Previous studies have shown that parental dietary intake is strongly linked with food consumption of children [119,120]. This could be explained by the fact that children tend to imitate parents' dietary behaviors, intake, and food choices since parents are considered as role models [119]. The results of our study found that parental food consumption is positively linked with children's food consumption in families at risk of T2D. For instance, high parental intake of FV was associated with improved consumption of FV in both boys and girls. Some previous studies [119,120] had analyzed similar associations, but focused only on healthy populations, specific gender, age, and ethnicity. Our study stands out for the incorporation of the vulnerable group of families at high risk of T2D across six European countries, as well as a detailed analysis of the diet of both parents and children (gender-specific) including multiple food groups, which allows to assess the food in a more global way. However, few studies have shown inconclusive results in this regard as some of them have not found significant relationships [121,122]. Among the possible causes that the literature has put forward to explain these differences in results could be related to methodological limitations, uncontrolled confounders, or unadjusted analyses [123].

Through measuring DQ scores, like HDS, our findings showed that mothers have better DQ compared to fathers. These results were confirmed by a previous randomized controlled study in Europe indicating that women tend to have higher DQ scores [124], and this could be due to the higher awareness and better nutrition knowledge that women have compared to men [66]. Additionally, in our findings, significant associations were found between parental DQ and children's food consumption. In detail, a better DQ of parents was positively related to the children's consumption of whole grains, and FV, and inversely associated with snacks intake. Similar results were found by previous research indicating that parental DQ was linked with healthier food consumption in children,

regardless the DQ indicators used [45,109]. Furthermore, same results were confirmed by a multi-centric cross-sectional study on European families [26]. Though, our study is the first to examine this relation between parental DQ and children's food consumption among vulnerable groups of families at high risk of T2D in Europe. These associations were in line with that of Davison et al. [45], which investigated the associations between DQ of parents and children's food intake in New Zealand. The Davison et al. study found similar results to ours, except that the children's intake of FV was not associated with improved DQ of parents, and the difference in results could be due to different DQ indicators used (i.e., DQI Vs. HDS in our study).

6.3 Family meals frequency, children's food consumption and obesity

This Doctoral Thesis has focused on assessing the relationship between family meals frequency and food consumption in European children aged 6-8 years. After adjusting for confounders, it was found that having a high frequency of family-shared meals is positively associated with a healthier food consumption of children (i.e., FV, grains, milk and milk products), and inversely associated with the intake of salty-snacks among both boys and girls. These results were consistent with those reported in previous studies [74,125,126]. However, some studies found no relation between frequency of shared meals with family and children's intake of selected food items [127-129]. The differences in results could be due to the culture-specific meal patterns, different study populations, and the meal occasion being investigated, as well as adjusted vs. unadjusted analysis.

Evidence suggests that family meals affect the food intake and dietary habits of children, which in turn impact thier diets and health, therefore, mealtimes could have the potential to be used as settings for health promotion [57]. Given that children with increased risk of T2D had higher probability of developing unhealthy lifestyle patterns [104], it is important to consider whether the frequency of family meals affect children's food intake and health in European families at high risk of T2D. Consequently, manuscripts III and IV aimed to investigate the associations between family meals frequency and children's food consumption and obesity in families at high risk of T2D across six European countries.

In addition, this Doctoral Thesis attempted to fill a gap in the literature by being the first to assess the mediation effects of parental DQ on the association between the frequency of family meals occasions individually (i.e., breakfast, lunch, dinner) and children's food intake in European families at high risk of T2D. In our analysis, the association between family meals frequency and food consumption of children was found to be partially mediated by parental DQ. However, a direct comparison with previous studies could not be made due to the limited research focusing on the role of parental DQ in relation to family meals frequency and because our study focused on a specific population. Nevertheless, our results were in agreement with previous research indicating that high

parental DQ affect the food intake of children because of its unique role in establishing and maintaining healthy food intake and eating habits among children [46,47].

Some studies have linked the frequency of family meals with obesity in children, though, very limited studies examined the longitudinal relation between them. Therefore, one of the objectives of this Doctoral Thesis was to assess the long-term association between family meals frequency and children's obesity in families at high risk of T2D in Europe. Our results indicated an inverse association between the frequency of family breakfast and/or dinner and BMI changes over time in both boys and girls. Moreover, lower odds of overweight/obesity at follow-up were observed in children who consumed a minimum of three times family breakfast and/or dinner a week at baseline. In addition, an increase in family breakfast and/or dinner frequency over a two-year period was associated with decreased odds of overweight/obesity in both, boys and girls, at follow-up. On the other hand, no long-term association was found between the frequency of family lunch and overweight/obesity in children.

Our findings support the conclusions of previous research suggesting that high family meals frequency, especially during early childhood, could be a protective factor against the development of obesity [71,79,130]. Among the specific reasons that have tried to explain the improved children's food intake in relation to family meals frequency is the emotional connection between family members during mealtime, as well as being exposed to parental modelling of healthful eating habits [75,131]. Moreover, as suggested by previous research, the supportive environment for children is created during family mealtimes, in which more healthy food items and more suitable portion sizes are being served [80,132,133].

6.4. Strengths and limitations

The main limitations included in this Doctoral Thesis were: 1) children's data were based on parental report and therefore, a bias must be considered; 2) the food frequency and eating behaviour questionnaire used in this study is not able to adequately determine absolute food intakes compared to other methods (i.e., 24-hour dietary recall), and it did not quantify energy intake of children, also it did not focus on the food preparation methods; 3) the cross-sectional nature of manuscript II and III does not allow for causality inferences; 4) waist circumference was only measured in adults participated in the Feel4Diabetes-study; and 5) body mass index was used to measure adiposity in children, which is not an accurate way to measure body fat compared to other measurements (i.e., bioimpedance analysis, and skinfold thickness). However, the major strengths of this this Doctoral Thesis were: 1) the focus on a specific vulnerable population namely European families at high risk of type 2 diabetes; 2) the large sample of families across six European countries with a large cultural and dietary diversity; 3) the anthropometric measurements following highly validated and standardized procedures to ensure and increase accuracy; 4) manuscript II and III were the first to assess the associations between parental food

consumption, diet quality, family meals frequency and children's food consumption in European families at high risk of developing type 2 diabetes; and 5) manuscript IV was also the first in measuring the longitudinal effect of each type of family meals (i.e., breakfast, lunch, and dinner) individually on children's body composition.

6.5. Public health implications

The results obtained in this Doctoral Thesis give a better insight for the promotion of healthy dietary habits of children in European families at high risk of T2D. Examining the unhealthy eating habits among those vulnerable groups and their association with increased risk of obesity and T2D, is one of the key points valued in this Doctoral Thesis. The data obtained are useful tools for designing strategies that promote healthy food consumption and dietary habits among children that could help in preventing obesity and cardiometabolic diseases such as T2D.

The narrative review (manuscript I), was a starting point to identify the parental dietary behaviors and practices that could affect children's eating habits. These behaviors and practices could be the entry points for interventions to reduce the risk of dietary related diseases such as obesity and T2D. Among these behaviors and practices, the ones that were in favour of healthy eating were role modeling, encouragement along with moderate restriction. On the other hand, the ones that increased the consumption of unhealthy food items were pressuring and highly restricted parental feeding practice. It is essential to know the potential effects of parents on their children in terms of dietary habits and practices that trigger an increase in unhealthy dietary habits. This knowledge could help to develop specific health promotion programs, future dietary interventions and policies that effectively focus on parental child-feeding behaviors as modifiable risk factors.

In relation to the associations between parental dietary intake and DQ on children's food consumption (manuscript II), our results contribute to the current knowledge and filling in gap of the literature by focusing on European families at high risk of T2D. The main results obtained is that the quality of the parents' diet influences the type of foods consumed by their children in families at risk of T2D, who presumably have already a poor DQ. This suggests that enhancing DQ in these families could have not only a direct impact on parents but also on children, thereby lowering their risk of T2D.

Evidence suggests the importance of family meals frequency in establishing and maintaining healthy food intake of children; however, all previous research included only healthy populations. Our findings (manuscript III) suggested that frequent family-shared breakfast and/or dinner are associated with healthier children's food consumption and better parental DQ. However, the association between family meals frequency and children's food intake was partially mediated by parental DQ. These findings recommend promoting more frequent family meals that could have positive impacts on children and

parent. Accordingly, this can act as a promising point for behavioral changes and thereby help in preventing obesity and T2D.

In the present Doctoral Thesis, the association between family meals frequency and obesity in children was also studied (manuscript IV). Prior to our study, this relationship has been examined but not for long-term, only on healthy populations, and without analysing each meal occasion individually. Our results found that high frequency of family meals over time, especially breakfast and/or dinner, is related to a reduced odds of overweight and obesity among children. These results would help in encouraging higher frequencies of family meals that could provide a promising entry point for positive changes in term of decreasing obesity and its related complications such as T2D.

In summary, the main public health implications of this Doctoral Thesis suggest that parental behaviors and practices, including diet quality and family meals, can affect children's food consumption and obesity even in children from families at risk of T2D across European countries.
Taking into account previous results and those presented in this Doctoral Thesis, public health interventions should pay special attention to children from families with greater risk of developing T2D. Also, the future strategies that aim for obesity prevention should focus on parents as well, as they have a significant effect on children especially during early ages. Interventions, policies, family- and school-based programs aimed at children should focus more on parents' child-feeding behaviors and practices, the diet quality of parents and their children, as well as important dietary behaviors such as the frequency of family meals. These steps could have positive future impacts on health, help to protect against chronic diseases such as obesity and T2D, and address health disparities especially among vulnerable groups of families at high risk of T2D. Besides, due to their potential to improve dietary-related outcomes for parents and children, and to produce health benefits over time, these interventions can produce a considerable return on direct medical costs annually along with the additional health care costs attributable to obesity and obesity-related comorbidities [134].

7. Main thesis contributions

Manuscript I. Unhealthy parental dietary behaviors and practices could trigger poor eating habits during childhood and may persist into adulthood. Current evidence shows that early modifications in eating habits of children could promote health and reduce the risk of type 2 diabetes. Parental encouragements, role modelling and moderate restriction are parental practices that most positively influence children's eating habits. It is necessary for parental child-feeding behaviors to receive more attention as modifiable risk factors in research studies, future dietary interventions, and policies.

Manuscript II. The present study assessed the parental dietary intake and diet quality and their effects on children's food consumption in European families at risk of type 2 diabetes. This study found that the intake of both parents and their children failed to meet the recommended servings of healthy foods according to the European dietary guidelines. Moreover, healthier food intake along with higher diet quality of parents involved in improving the food consumption of their children in both boys and girls.

Manuscript III. Different studies have evaluated the impact of family meals frequency on children's food consumption. However, they considered only healthy populations and did not analyze each meal occasion separately (i.e., breakfast, lunch, dinner). This study fill gaps in the literature by assessing the effect of family meals frequency on parent's food intake and diet quality, examine the relation between family meals frequency and children's food consumption. Moreover, it considered the mediation effect of parental diet quality on the association between family meals frequency and the food consumptions of European children in 1,964 families at high risk of type 2 diabetes. In addition, improvements in food consumption of children, parental food intake and diet quality were indicated with increased frequency of family meals especially breakfast and/or dinner. Also, the association between the frequency of family meals and children's food consumption was partially mediated by parental diet quality.

Manuscript IV. Several studies have analyzed the relationship between family meals frequency and children's BMI, but without taking into consideration the analysis of each meal occasion separately, the sex-differences, or specific populations at cardiometabolic risk. This study included the assessment of the frequency of each family meal occasion individually, focused on families at high risk of type 2 diabetes in six European countries and investigated the longitudinal associations between family meals frequency and children's BMI, over a period of two-years follow-up. This study showed that higher family meals frequency especially breakfast and/or dinner, at baseline and over a period of 2-years in families at high risk of type 2 diabetes, is associated with decreased odds of overweight/obesity in both boys and girls.

7. Aportaciones principales de la Tesis Doctoral

Artículo I. Los comportamientos y prácticas dietéticas de los padres que no son saludables pueden originar malos hábitos alimenticios durante la infancia y pueden persistir en la edad adulta. La evidencia actual muestra que las modificaciones tempranas en los hábitos alimentarios de los niños podrían promover la salud y reducir el riesgo de diabetes tipo 2. Los estímulos de los padres, el ejemplo a seguir y la restricción moderada son las prácticas de los padres que influyen más positivamente en los hábitos alimenticios de los niños. Es necesario que los comportamientos de alimentación de los padres en relación con los niños, reciban más atención como factores de riesgo modificables en estudios de investigación, futuras intervenciones dietéticas y políticas de salud.

Artículo II. El presente estudio evaluó la ingesta dietética de los padres y la calidad de la dieta y sus efectos sobre el consumo de alimentos de los niños, en familias europeas con riesgo de diabetes tipo 2. Este estudio encontró que la ingesta tanto de los padres como de sus hijos no cumplió con las porciones recomendadas de alimentos saludables de acuerdo con las Pautas dietéticas europeas. Además, la ingesta de alimentos más saludables junto con una mayor calidad de la dieta de los padres implicados en la mejora del consumo de alimentos de sus hijos, tanto en niños como en niñas.

Artículo III. Diferentes estudios han evaluado el impacto de la frecuencia de las comidas en familia en el consumo de alimentos de los niños. Sin embargo, estos estudios consideraron solo poblaciones sanas y no analizaron cada comida por separado (desayuno, almuerzo, cena). Este estudio llena los vacíos en la literatura al evaluar el efecto de la frecuencia de las comidas en familia en la ingesta de alimentos de los padres y la calidad de su dieta, y examina la relación entre la frecuencia de las comidas en familia y el consumo de alimentos de los niños. Además, valoró el efecto de mediación de la calidad de la dieta de los padres en la asociación entre la frecuencia de las comidas en familia y el consumo de alimentos de los niños europeos, en 1964 familias con alto riesgo de diabetes tipo 2. Además, se observaron mejor consumo de alimentos de los niños, mejor ingesta de alimentos de los padres y mejor calidad de la dieta, en relación con una mayor frecuencia de comidas en familia, especialmente el desayuno y/o la cena. Además, la asociación entre la frecuencia de las comidas familiares y el consumo de alimentos de los niños estuvo parcialmente mediada por la calidad de la dieta de los padres.

Artículo IV. Varios estudios han analizado la relación entre la frecuencia de las comidas en familia y el IMC de los niños, pero sin tener en cuenta el análisis de cada comida por separado, las diferencias por sexo o poblaciones específicas con riesgo cardiometabólico. Este estudio incluyó la evaluación de la frecuencia de cada comida en familia de forma individual, se centró en familias con alto riesgo de diabetes tipo 2 en seis países europeos

e investigó las asociaciones longitudinales entre la frecuencia de las comidas en familia y el IMC de los niños, durante un período de dos años de seguimiento. Este estudio mostró que una mayor frecuencia de las comidas en familia, especialmente el desayuno y/o la cena, al inicio del estudio y durante un período de 2 años, se asocia con una menor probabilidad de sobrepeso/obesidad tanto en niños como en niñas, en familias con alto riesgo de diabetes tipo 2.

8. Conclusions

Manuscript I. The current evidence indicates that the family environment has an active role in establishing and promoting eating habits in children. Besides, parental feeding practices and behaviors that influence children's dietary habits cannot be considered separately because they are reciprocally interacting. Some practical recommendations can be made: (1) parents should avoid excessive pressure or restriction that can negatively affect children's food acceptance; (2) parents should focus more on encouraging their children through positive and active social modelling with moderated restrictions only; (3) intervention programs should promote some strategies aimed at parents' unhealthy eating and provide parents with detailed guidance on feeding their children; (4) childhood obesity prevention program should focus more on parents' child-feeing behaviors while designing thier policies.

Manuscript II. According to the European dietary guidelines, the intake of the majority of parents and children were below minimum recommendations for all healthy foods in families at high risk of type 2 diabetes. Also, better parental food consumption and diet quality are associated with healthier children's food intake in both boys and girls.

Manuscript III. Family meals frequency, especially breakfast and/or dinner, is associated with improved children's consumption of healthy food items. Moreover, parental food consumption and diet quality are related with family meals frequency. Also, parental diet quality partially mediated the association between family meals frequency and children's food consumption among boys and girls in families at high risk of type 2 diabetes.

Manuscript IV. Higher family meals frequency, especially dinner is inversely associated with children's BMI at baseline and 2-years follow up period. Also, consuming three and more family breakfast and/or dinner at baseline is associated with decreased odds of overweight/obesity at the second year of follow-up. Furthermore, the increase in the frequency of family breakfast and/or dinner over time is associated with lower odds of overweight/obesity during a period of 2 years in families at high risk of type 2 diabetes.

8. Conclusiones

Artículo I. La evidencia actual indica que el entorno familiar tiene un importante papel en el establecimiento y promoción de hábitos alimentarios en los niños. Además, las prácticas y comportamientos de alimentación de los padres, que influyen en los hábitos alimentarios de los niños, no pueden considerarse por separado porque interactúan recíprocamente. Se pueden hacer algunas recomendaciones prácticas: (1) los padres deben evitar presiones o restricciones excesivas que puedan afectar negativamente la aceptación de los alimentos por parte de los niños; (2) los padres deben centrarse más en alentar a sus hijos a través de modelos sociales positivos y activos, solamente con restricciones moderadas; (3) los programas de intervención deben promover algunas estrategias dirigidas a la alimentación poco saludable de los padres y proporcionar a los padres una guía detallada sobre la alimentación de sus hijos; (4) los programas de prevención de la obesidad infantil deben centrarse más en los comportamientos de alimentación de los padres en relación con los de los niños al diseñar sus políticas de salud.

Artículo II. De acuerdo con las guías dietéticas europeas, la ingesta de la mayoría de los padres e hijos, en familias con alto riesgo de diabetes tipo 2, estaba por debajo de las recomendaciones mínimas de todos los alimentos saludables. Además, un mejor consumo de alimentos por parte de los padres y la calidad de su dieta se asocian con una ingesta más saludable de los niños y niñas.

Artículo III. La frecuencia de las comidas en familia, especialmente el desayuno y la cena, se asocia con un mayor consumo de alimentos saludables por parte de los niños. Además, el consumo de alimentos de los padres y la calidad de su dieta están relacionados con la frecuencia de las comidas en familia. Además, la calidad de la dieta de los padres medió parcialmente la asociación entre la frecuencia de las comidas en familia y el consumo de alimentos de los niños y niñas, en familias con alto riesgo de diabetes tipo 2.

Artículo IV. La mayor frecuencia de las comidas en familia, especialmente la cena, se asocia inversamente con el IMC de los niños al inicio del estudio y en el período de seguimiento de 2 años. Además, consumir tres o más desayunos o cenas familiares al inicio del estudio, se asocia con una menor probabilidad de sobrepeso/obesidad en el segundo año de seguimiento. Además, el aumento en la frecuencia del desayuno o cena en familia a lo largo del tiempo, se asocia con menor probabilidad de sobrepeso/obesidad durante un período de 2 años, en familias con alto riesgo de diabetes tipo 2.

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Appendix

Factor de impacto de las revistas y ranking en “ISI Web o Knowledge – Journal Citation Reports (JCR)” dentro de sus áreas temáticas correspondientes.

Impact factor and ranking of each Journal in “ISI Web o Knowledge – Journal Citation Reports (JCR)” within their subject categories for [published manuscripts].

	Journal	Impact factor	Quartile
Manuscript I	**Nutrients** Ranking in 2021 ISI JCR: 15/90 (Nutrition & Dietetics)	6.706	Q1
Manuscript II	**Public Health Nutrition** Ranking in 2021 ISI JCR: 42/90 (Nutrition & Dietetics)	4.539	Q2
Manuscript III	**European Journal of Pediatrics** Ranking in 2021 ISI JCR: 24/184 (Pediatrics)	3.860	Q1
Manuscript IV	**Pediatric Obesity** Ranking in 2021 ISI JCR: 27/130 (Pediatrics)	3.910	Q1

Anexos [Annexes]

Food frequency and eating behaviour questionnaire

PARTICIPANT CODE: _____ **DATE:** _____/ _____/ _____

RESEARCHER'S NAME: _____

ADULT' S QUESTIONNAIRE

1a. Who is answering this questionnaire?

- ❑1 *mother*
- ❑2 *stepmother/ female carer*
- ❑3 *father*
- ❑4 *stepfather/ male carer*
- ❑5 *grandfather, of mother side*
- ❑6 *grandfather, of father side*
- ❑7 *grandmother, of mother side*
- ❑8 *grandmother, of father side*

of the participating child

1b. Where is this questionnaire completed?

- ❑1 *at home*
- ❑2 *during the measurements/sessions with a Researcher*

2. When were you born?

_ _/_ _/ _ _ _ _ (Day/Month/Year)

3. What is your highest level of education completed?

- ❑1 6 years or less
- ❑2 7-9 years
- ❑3 10-12 years
- ❑4 13-14 years
- ❑5 15-16 years
- ❑6 >16 years

4. To which racial or ethnic group(s) do you most identify?

- ❑1 Caucasian/White
- ❑2 Black
- ❑3 Asian/Pacific Islanders
- ❑4 Latino or Hispanic
- ❑5 Chinese, Japanese, or other South East Asian
- ❑6 Arabic or North African
- ❑7 Mixed
- ❑8 Other Please specify9 :…….

5. What is your marital status?

- ❑1 single
- ❑2 married or cohabiting
- ❑3 separated or divorced
- ❑4 widowed
- ❑5 other

6. What is your main occupation over the last 6 months?

- ❑1 stay at home parent
- ❑2 work full-time
- ❑3 work part-time
- ❑4 unemployed
- ❑5 full-time education
- ❑6 retired
- ❑7 something else (please state:
  ……)

7. What is your smoking status?

Never Smoked	Former Smoker	Current Smoker
❑1	❑2	❑3

8. If you are a current smoker, how many cigarettes do you, on average, smoke per day?

……. Cigarettes/day

9. How much sleep do you usually get at night:

1. On weekdays: …… hours/night
2. On weekend days: …… hours/night

10. Has a physician ever told you that you have diabetes?

❑1 no

❑2 yes, gestational diabetes

❑3 yes, diabetes, at the age of _____

11. If you have been diagnosed with diabetes, what treatment are you on now (you can select several options)?

❑1 nothing

❑2 diet modifications

❑3 tablets

❑4 insulin

12. Do you currently use drugs for high blood pressure prescribed by a physician?

❑1 no ❑2 yes

13. Do you currently use drugs for high blood cholesterol prescribed by a physician?

❑1 no ❑2 yes

EATING HABBITS

14. How often do you consume the following <u>main meals</u>

a) on **WEEK DAYS**?					b) on **WEEKEND** days?		
	none	1–2 times per week	3–4 times per week	every day (5)	none	1	2
1. Breakfast	❑1	❑2	❑3	❑4	❑1	❑2	❑3
2. Lunch	❑1	❑2	❑3	❑4	❑1	❑2	❑3
3. Dinner/Supper	❑1	❑2	❑3	❑4	❑1	❑2	❑3

15. How often do you consume the following <u>snacks</u>

a) on **WEEK DAYS**?					b) on **WEEKEND** days?		
	none	1–2 times per week	3–4 times per week	every day (5)	none	1	2
1. Morning snack	❑1	❑2	❑3	❑4	❑1	❑2	❑3
2. Afternoon snack	❑1	❑2	❑3	❑4	❑1	❑2	❑3
3. Evening snack	❑1	❑2	❑3	❑4	❑1	❑2	❑3
4. Other snacks	❑1	❑2	❑3	❑4	❑1	❑2	❑3

16. How often do you consume the following foods/ food groups in your BREAKFAST.

❑1 I never eat breakfast. Please continue to the next question

Foods/ Food groups		**Times/week**				
		Less than 1	**1-2**	**3-4**	**5-6**	**7**
2. Fruits and berries		❑1	❑2	❑3	❑4	❑5
3. Vegetables		❑1	❑2	❑3	❑4	❑5
4. Breakfast cereals	a. Non whole grain breakfast cereals (e.g. corn flakes or rice crispies, coco pops)	❑1	❑2	❑3	❑4	❑5
	b. Whole grain breakfast cereals, müsli	❑1	❑2	❑3	❑4	❑5
5. Bread	a. White bread, tortillia, melba toast, rusk, etc.,	❑1	❑2	❑3	❑4	❑5
	b. Whole grain bread, tortillia, melba toast, rusk, etc.	❑1	❑2	❑3	❑4	❑5
6. Milk or milk products	a. Unsweetened (e.g. natural yogurt)	❑1	❑2	❑3	❑4	❑5
	b. Sweetened (e.g. yogurt, chocolate milk)	❑1	❑2	❑3	❑4	❑5
Foods/ Food groups		**Times/week**				

	Less than 1	1-2	3-4	5-6	7
7. Cheese	❑1	❑2	❑3	❑4	❑5
8. Meat or meat products (e.g. cold cuts, bacon, sausages)	❑1	❑2	❑3	❑4	❑5
9. Sweet or salty pastries (e.g. pancake, cookie, cake, croissant, cheese pie)	❑1	❑2	❑3	❑4	❑5
10. Eggs (boiled, fried, scrambled, omelet)	❑1	❑2	❑3	❑4	❑5
11. Water	❑1	❑2	❑3	❑4	❑5
12. Soft drinks and juices containing sugar	❑1	❑2	❑3	❑4	❑5
13. Coffee	❑1	❑2	❑3	❑4	❑5
14. Tea	❑1	❑2	❑3	❑4	❑5

17. What is the main reason that you usually skip breakfast?

❑1 I never skip breakfast

I do not have enough time.	I do not like the breakfast products available at home.	I am not hungry in the morning.	I just cannot eat early in the morning.	No specific reason	Other reason
❑2	❑3	❑4	❑5	❑6	❑7

18. How often do you have the following meals with others, with family, friends or colleagues?

	never	less than 1 time/ week	1-2 times/ week	3-4 times/ week	5-6 times/ week	daily
1. breakfast	❑1	❑2	❑3	❑4	❑5	❑6
2. lunch	❑1	❑2	❑3	❑4	❑5	❑6
3. dinner	❑1	❑2	❑3	❑4	❑5	❑6

Regarding Questions 19 - 32, consider your usual consumption over the last month:

19. How many servings of milk and milk products (e.g. yogurt) do you consume per day?
One serving is **half a cup (120 mL= 124gms)**. Count also milk in tea, coffee or with cereal. Do not count cheese.
Mark 0 if you eat on average less than one serving per day.

1. _____ servings of low-fat or fat-free milk and milk products
2. _____ servings of full fat milk and milk products

20. How much bread and other cereals do you eat per day?
A roll (60 g) equals [1 slice (15 g) - 1 cup = 30gm) of bread.
Mark 0 if you eat on average less than one serving per day.

1. _____ slice(s) of whole grain bread
2. _____ slice(s) of non-whole grain (i.e. white) bread
3. _____ cup(s) of porridge (e.g. rye, oat or wheat flake porridge)
4. _____ cup(s) of whole grain breakfast cereals, muesli
5. _____ cup(s) of non-whole grain breakfast cereals (e.g. corn flakes or rice crispies)

21. What kind of fat spread do you usually use with your bread?
Choose only one option.

- ❑1 Vegetable oil (olive, rapeseed etc.)
- ❑2 Soft margarine with 70-80% fat
- ❑3 Reduced-fat margarine 28-60% fat
- ❑4 Butter-vegetable oil mixture
- ❑5 Butter
- ❑6 I do not usually have fat spread on bread

22. How many servings of fruits or berries do you eat?
For fresh or frozen fruits, one serving is a tennis ball (medium) sized fruit (e.g. apple) or two small fruits (e.g. apricots) or half a cup of chopped fruit or berries. **(Please see Appendix 3 and 4)**
For canned fruits, one serving is half a cup of canned fruits. **(Please see Appendix 3)**
For dried fruits, one serving is a quarter of a cup (62.5 mL) of dry fruits and berries. **(Please see Appendix 3) (1 serving apple = 90gm)**

- ❑1 Less than one serving per week = 0gm
- ❑2 1-2 servings per week
- ❑3 3-4 servings per week
- ❑4 5-6 servings per week / 7
- ❑5 1-2 servings per day
- ❑6 3-4 servings per day
- ❑7 5 or more servings per day X7

23. How many servings of raw or cooked vegetables do you eat?
One serving is half a cup of vegetables or at the size of a tennis ball tomato, broccoli or leafy vegetables **(Please see Appendix 3) (1 serving half cup= 125ml= 80gm)**

- ❑1 Less than one serving per week = 0gm
- ❑2 1-2 servings per week
- ❑3 3-4 servings per week
- ❑4 5-6 servings per week
- ❑5 1-2 servings per day
- ❑6 3-4 servings per day
- ❑7 5 or more servings per day

24a. How many times per week do you eat legumes (e.g. lentils, beans, peas)?
_____ time(s) per week
24b.What is your average portion size? (Please see Appendix 3)
Please consider the legumes cooked and drained, without soup

- ❑1 Less than half a cup (100 g) = 0gm
- ❑2 Half a cup (100 g)
- ❑3 1 cup = 200
- ❑4 1.5 cup
- ❑5 2 cups
- ❑6 2.5 cups
- ❑7 3 cups
- ❑8 More than 3 cups= 4cups

25a. How many times per week do you eat red meat (e.g. pork, beef, veal, lamb) or processed meat (e.g. hamburger or sausages)?

_____ time(s) per week

25b.What is your average portion size?

- ❑1 Less than 1 pack of cards (100-120 g) = 0g
- ❑2 1 pack of cards (100-120 g) = 110g
- ❑3 1.5 pack of cards
- ❑4 2 packs of cards
- ❑5 2.5 packs of cards
- ❑6 3 packs of cards
- ❑7 3.5 packs of cards
- ❑8 4 packs of cards
- ❑9 more than 4 packs of cards= 5 packs

26a. How many times per week do you eat white meat (e.g. poultry, rabbit)?

_____ time(s) per week

26b. What is your average portion size?

- ❑1 Less than 1 pack of cards (100-120 g) = 0g
- ❑2 1 pack of cards (100-120 g) = 110g
- ❑3 1.5 pack of cards
- ❑4 2 packs of cards
- ❑5 2.5 packs of cards
- ❑6 3 packs of cards
- ❑7 3.5 packs of cards
- ❑8 4 packs of cards
- ❑9 more than 4 packs of cards= 5 packs

27a. How many times do you eat fish and seafood?

_____ time(s) per week

27b. What is your average portion size?

- ❑1 Less than 1 pack of cards (100-120 g)= 0g
- ❑2 1 pack of cards (100-120 g) = 110g
- ❑3 1.5 pack of cards
- ❑4 2 packs of cards
- ❑5 2.5 packs of cards
- ❑6 3 packs of cards
- ❑7 3.5 packs of cards
- ❑8 4 packs of cards
- ❑9 more than 4 packs of cards= 5 packs

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28. How many servings of salty snacks/fast food do you eat?

One serving is: 1 small bag of chips, 1 slice of pizza, 1 cheese pie or other dough-based snacks **(Please see Appendix 2) (1 serving= 150gm)**

- ❑1 One or less than one serving per week = 150gm
- ❑2 2 servings per week
- ❑3 3-4 servings per week
- ❑4 5-6 servings per week
- ❑5 1-2 servings per day
- ❑6 3-4 servings per day
- ❑7 5 or more servings per day

29. How many servings of sweets, biscuits, ice cream, cakes, pastries times do you eat
One serving is 1 small chocolate bar (40 g) or half a cup of sweets, cookies or 1 scoop of ice cream **(Please see Appendix 1) (1 serving= 40 gm)**

- ❑1 One or less than one serving per week = 40gm
- ❑2 2 servings per week
- ❑3 3-4 servings per week
- ❑4 5-6 servings per week
- ❑5 1-2 servings per day
- ❑6 3-4 servings per day
- ❑7 5 or more servings per day

30. How many servings of nuts or seeds do you eat?
One serving is about 2 tablespoons or 30 g

- ❑1 Less than one serving per week
- ❑2 1-2 servings per week
- ❑3 3-4 servings per week
- ❑4 5-6 servings per week
- ❑5 1-2 servings per day
- ❑6 3-4 servings per day
- ❑7 5 or more servings per day

---

31. What of the following fats and oils do you use daily? Think about fats and oils used with vegetables (raw or boiled) and/or in cooked dishes (added during or after cooking).
Choose one or more options.

- ❑1 Olive or rapeseed oil
- ❑2 Other vegetable oil (e.g. sunflower oil)
- ❑3 Margarine
- ❑4 Butter
- ❑5 Butter-oil mixture
- ❑6 Cream, sour cream
- ❑7 Mayonnaise, French dressing etc.
- ❑8 I do not use any of these fats daily

32. How much of the following beverages do you drink per week?

Mark 0, if you don't drink the following beverages or if you drink on average less than one serving per week.

1. _____ glass(es) of water (1 glass=250 mL)
2. _____ cup(s) of tea (1 cup=250 mL)
3. _____ cup(s) of coffee (1 cup=250 mL)
4. _____ glass(es) of soft drink with sugar (1 glass = 250 mL)
5. _____ glass(es) of soft drink without sugar, e.g. Coca Cola Light (1 glass = 250 mL)
6. _____ glass(es) of fruit juice freshly squeezed or prepacked without sugar (1 glass = 250 mL)
7. _____ glass(es) of juice containing sugar (1 glass =250 mL)
8. _____ glass(es) of beer/cider (1 beer glass = 330 mL)
9. _____ glass(es) of wine (1 wine glass = 125 mL)
10. _____ glass(es) other spirits (1 glass = 40 mL)

33. What do you think about your weight?

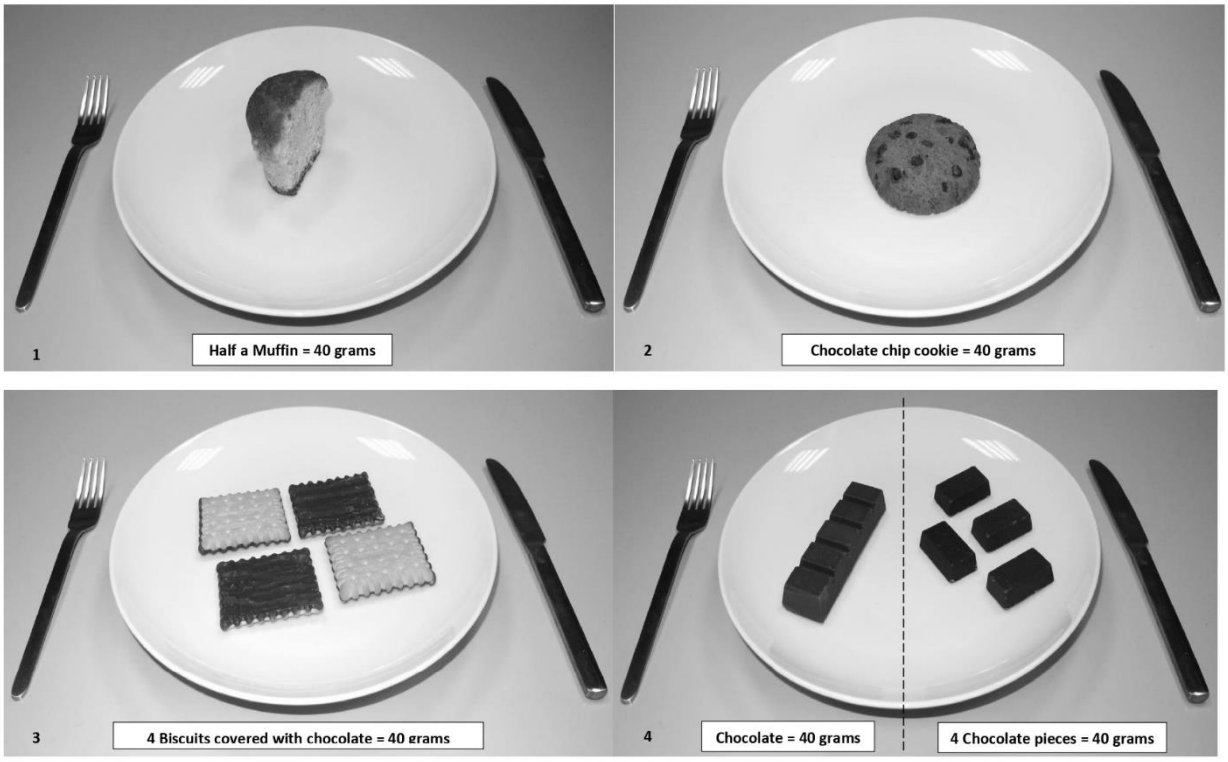
My weight is way too low	My weight is a bit too low	My weight is not too low, not too high	My weight is a bit too high	My weight is way too high
❑1	❑2	❑3	❑4	❑5

34. In your opinion, what is the minimum recommended consumption of fruits, berries and vegetables for adults per day?

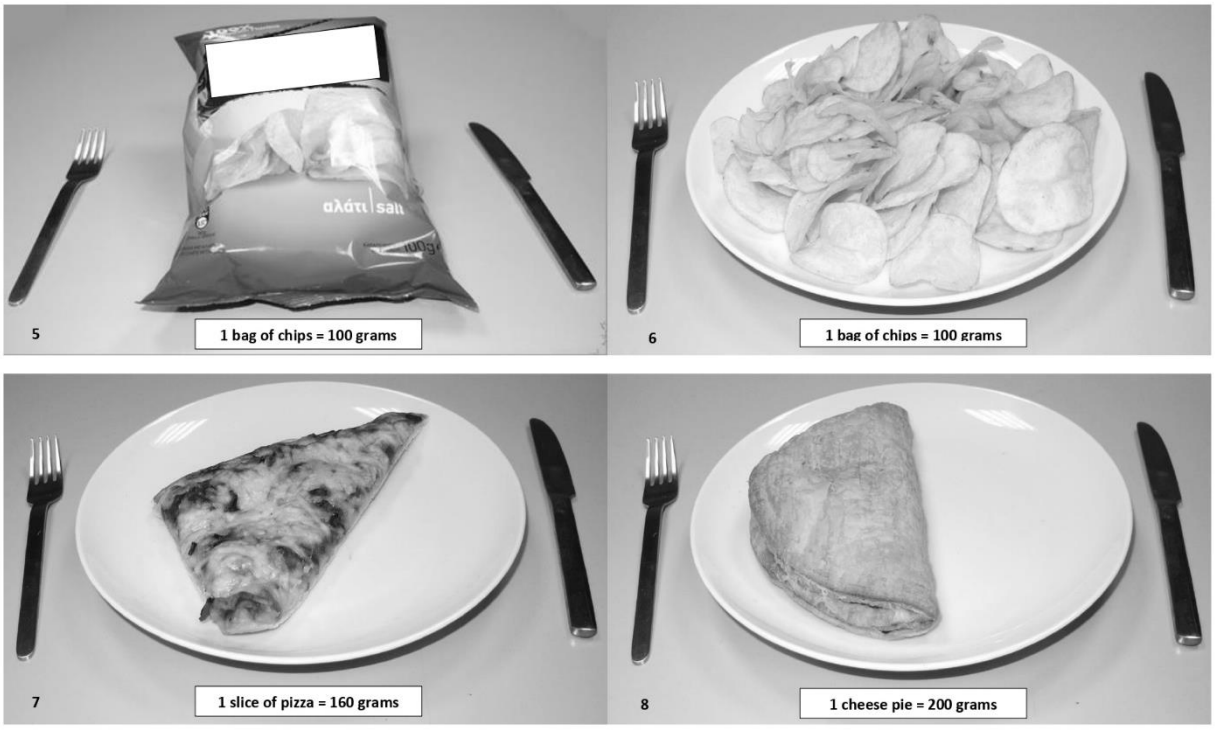
1 serving	2 servings	3 servings	4 servings	5 servings	6 servings	7 servings	8 servings	I don't know
❑1	❑2	❑3	❑4	❑5	❑6	❑7	❑8	❑9

Food frequency questionnaire (Appendix of portion sizes)

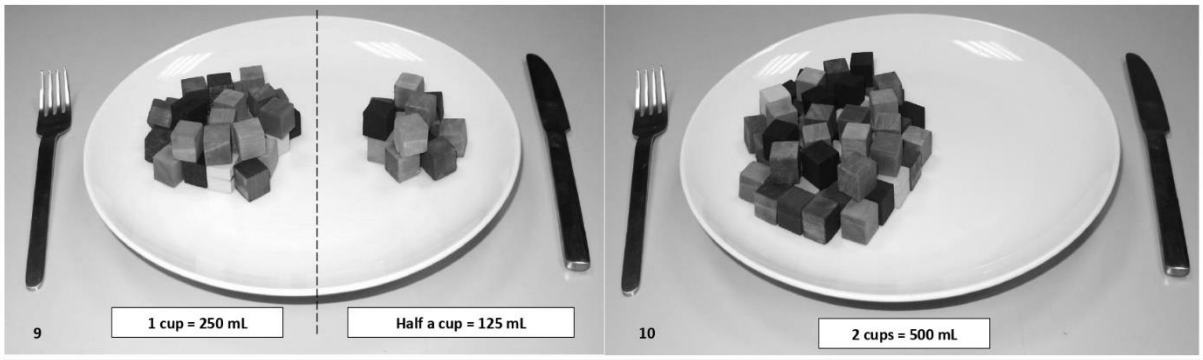
Appendix 1 (Sweets/Desserts)



Appendix 2 (Salty snacks)



Appendix 3



Appendix 4

11 1 medium sized fruit = 90 grams (1 tennis ball)

12 2 small fruits = 90 grams

Energy balance-related behaviors questionnaire

This consent form needs to be completed by one of the parents
Please complete the consent form and questionnaire and return the sealed envelope to your school

Logo of your Institute

CERTIFICATE OF CONSENT

I read the information form and the information supplied is clear to me. If I have more questions, I know whom to contact. I agree to participate in the programme and I give my permission for the measurement of my child's weight and height. I have been informed that the programme is free of charge and if I decide to withdraw (I and/or my child) from the programme anytime now or in the future I can do so without giving any reason.

Name and surname of the child (in BLOCK letters)

Name and surname of parent/ caregiver (in BLOCK letters)

Date: ……/……/2016
Telephone number during working hours: ……
Telephone number evening: ……
What is the best time and days we can reach you by telephone?
……

Home address

Street …… City …….. Postal Code ……..

Signature parent/ caregiver

Name & signature of researcher

PARTICIPANT CODE: _____ DATE: _____/ _____/ _____

A. This part of the questionnaire should be completed by both mother/stepmother and father/stepfather living with the child. If you don't have a spouse/partner, please provide this information only for yourself.

Mother's or stepmother's information

1. Please indicate:

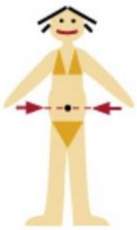
❑1 Mother
❑2 Stepmother

1. Age
❑1 Under 45 years
❑2 45-54 years
❑3 55-64 years
❑4 Over 64 years

2. Weight: …… kg

3. Height: ……. m

4. Waist circumference measured below the ribs (usually at the level of the navel)
❑1 Less than 80 cm
❑2 80-88 years
❑3 More than 88 cm



5. Do you usually have daily at least 30 minutes of physical activity at work and/or during leisure time (including normal daily activity)?
❑1 Yes
❑2 No

6. How often do you eat vegetables, fruit or berries?
❑1 Every day
❑2 Not every day

7. Have you ever taken medication for high blood pressure on regular basis?
❑1 No
❑2 Yes

Father's or stepfather's information

2. Please indicate:

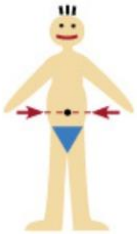
❑1 Father
❑2 Stepfather

1. Age
❑1 Under 45 years
❑2 45-54 years
❑3 55-64 years
❑4 Over 64 years

2. Weight: …… kg

3. Height: ……. m

4. Waist circumference measured below the ribs (usually at the level of the navel)
❑1 Less than 94 cm
❑2 94-102 cm
❑3 More than 102 cm



5. Do you usually have daily at least 30 minutes of physical activity at work and/or during leisure time (including normal daily activity)?
❑1 Yes
❑2 No

6. How often do you eat vegetables, fruit or berries?
❑1 Every day
❑2 Not every day

7. Have you ever taken medication for high blood pressure on regular basis?
❑1 No
❑2 Yes

8. Have you ever been found to have high blood glucose (e.g. in a health examination, during an illness, during pregnancy)?
❑1 No
❑2 Yes

9. Have any of the members of your immediate family or other relatives been diagnosed with diabetes (type 1 or type 2)?
❑1 No
❑2 Yes: parent, brother, sister or own child
❑3 Yes: grandparent, aunt, uncle or first cousin (but no own parent, brother, sister or child)

8. Have you ever been found to have high blood glucose (e.g. in a health examination, during an illness)?

❑1 No
❑2 Yes

9. Have any of the members of your immediate family or other relatives been diagnosed with diabetes (type 1 or type 2)?
❑1 No
❑2 Yes: parent, brother, sister or own child
❑3 Yes: grandparent, aunt, uncle or first cousin (but no own parent, brother, sister or child)

Demographic information

Mother/Stepmother

10. Completed Education
❑ 6 years or less
❑ 7-9 years
❑ 10-12 years
❑ 13-14 years
❑ 15-16 years
❑ >16 years

11. Current Occupation
❑1 Stay at home parent
❑2 Work full time
❑3 Work part time
❑4 Unemployed
❑5 Full time student
❑6 Retired
❑7 Something else

Father/Stepfather

10. Completed Education
❑ 6 years or less
❑ 7-9 years
❑ 10-12 years
❑ 13-14 years
❑ 15-16 years
❑ >16 years

11. Current Occupation
❑1 Stay at home parent
❑2 Work full time
❑3 Work part time
❑4 Unemployed
❑5 Full time student
❑6 Retired
❑7 Something else

B. This part of the questionnaire needs to be completed by the primary caregiver of the child. Where "child" is mentioned, please respond only about the child who is participating in this study

Instructions for completing this part of the questionnaire

- ✓ Please read the questions and the answering options carefully before answering them.
- ✓ Please complete the questionnaire using **a blue or black pen.**
- ✓ Please answer the open-ended questions with a clear handwriting.
- ✓ Most of the questions can be answered by placing a clear **X** in the answer box. Mark only one box per question unless multiple answers can be given. This will be indicated next to the question.
- ✓

Example:

From Monday to Friday, how many times do you usually eat breakfast?
❑1 I never eat breakfast on weekdays
❑2 1 day
☒3 2 days
❑4 3 days
❑5 4 days
❑6 5 days

- ✓ If you wish to change an answer, leave the incorrect answer box marked, X‘ and make the correct answer box completely black.

Example:

From Monday to Friday, how many times do you usually eat breakfast?
❑1 I never eat breakfast on weekdays
❑2 1 day
☒3 days
■ 3 days
❑5 4 days
❑6 5 days

---

1. My child is a: ❑1 Boy ❑2 Girl

2. When was your child born? _ _ /_ _ / _ _ _ _ (Day/Month/Year)

3. Who is answering this questionnaire?

❑1 *mother*
❑2 *stepmother/ female carer*
❑3 *father*
❑4 *stepfather/ male carer*
❑5 *grandfather, of mother side*
❑6 *grandfather, of father side*

❑7 *grandmother, of mother side*
❑8 *grandmother, of father side*
of the participating child

4. When were you born?
_ _ /_ _ / _ _ _ _ (Day/Month/Year)

5. What is the birth year of all the children living in this household (excluding the child participating in this study)?

Child 1	Child 2	Child 3	Child 4	Child 5	Child 6	Child 7	Child 8	Child 9	Child 10

6. Do you have another child in this school?

❑1 Yes ❑2 No

7a. If yes, in which grade …….1 and which class? …….2

7b. If you have a third child in the same school, in which grade …….1 and which class? …….2

8. Considering the total income in this household, how difficult or easy is it to cover your costs?
❑1 Very difficult ❑2 Difficult ❑3 Fairly difficult ❑4 Fairly easy ❑5 Easy ❑6Very easy

9. Please indicate how often <u>you</u> and <u>your child</u> usually consume the following foods/drinks. One cup/glass is 2,5 dl.
For every foodstuff, please indicate your weekly OR daily consumption of the following portions of foods or beverages.

YOU$_a$	less than 1 time/ week	1 or 2 times/ week	3 or 4 times/ week	5 or 6 times/ week	1 or 2 times/ day	3 or 4 times/ day	5 or 6 times/ day	more than 6 times /day
1. Water (1 glass or 1 cup)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
2. Fruits and berries, fresh or frozen (1 tennis ball sized fruit or 2 small fruits or half a cup of chopped)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
3. Fruits and berries, canned (half a cup) or dried (a quarter of cup)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
4. Fruit juices, freshly-squeezed or prepacked **without** sugar (1 glass or 1 cup)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
5. Soft drinks and juices **containing** sugar (1 glass or 1 cup)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
6. Soft drinks, diet (light) (1 glass or 1 cup)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
7. Coffee (1 cup)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
8. Vegetables (half a cup or at the size of a tennis ball of tomato, broccoli, leafy vegetables etc)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
9. Sweets (1 chocolate bar or half a cup of sweets, cookies or ice-cream)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
10. Salty snacks/fast food (e.g.1 small hamburger, 1 small bag of chips, 1 slice of pizza)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$

YOUR CHILD$_b$	less than 1 time/ week	1 or 2 times/ week	3 or 4 times/ week	5 or 6 times/ week	1 or 2 times/ day	3 or 4 times/ day	5 or 6 times/ day	more than 6 times /day
1. Water (1 glass or 1 cup)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
2. Fruits and berries, fresh or frozen (1 tennis ball sized fruit or 2 small fruits or half a cup of chopped)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
3. Fruits and berries, canned (half a cup) or dried (a quarter of cup)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
4. Fruit juices, freshly-squeezed or prepacked **without** sugar (1 glass or 1 cup)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
5. Soft drinks and juices **containing** sugar (1 glass or 1 cup)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
6. Soft drinks, diet (light) (1 glass or 1 cup)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
8. Vegetables (half a cup or at the size of a tennis ball of tomato, broccoli, leafy vegetables etc)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
9. Sweets (1 chocolate bar or half a cup of sweets, cookies or ice-cream)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$
10. Salty snacks/fast food (e.g.1 small hamburger, 1 small bag of chips, 1 slice of pizza)	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$	❑$_6$	❑$_7$	❑$_8$

10. On how many days do you and child usually eat breakfast.
During weekdays, "breakfast" is anything you usually eat and drink within 2 hours after getting up in the morning. This can be done at home, on the way to work or at work.
During weekends "breakfast" is anything you drink and/or eat before 11 a.m.

YOU$_a$

On how many days do <u>you</u> usually eat breakfast?

WEEKDAYS$_1$
❑$_1$ never/rarely
❑$_2$ 1 day
❑$_3$ 2 days
❑$_4$ 3 days
❑$_5$ 4 days
❑$_6$ 5 days

WEEKENDDAYS$_2$
❑$_1$ never/rarely
❑$_2$ 1 day (Saturday or Sunday)
❑$_3$ 2 days (Saturday and Sunday)

YOUR CHILD$_b$

On how many days does <u>your child</u> usually eat breakfast?

WEEKDAYS$_1$
❑$_1$ never/rarely
❑$_2$ 1 day
❑$_3$ 2 days
❑$_4$ 3 days
❑$_5$ 4 days
❑$_6$ 5 days

WEEKENDDAYS$_2$
❑$_1$ never/rarely
❑$_2$ 1 day (Saturday or Sunday)
❑$_3$ 2 days (Saturday and Sunday)

11. Having in mind previous week, how often you and your child consumed the following foods/ food groups as part of your and his/her BREAKFAST

YOU$_a$

		Frequency (<u>times/last week</u>)				
Food groups		**0**	**1-2**	**3-4**	**5-6**	**7**
1	**Fruits, berries and vegetables**	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$
2	**Freshly squeezed juices or pre-packed without sugar**	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$
3	**Soft drinks and juices containing sugar**	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$
4	**Milk or milk products, unsweetened (e.g. cheese, natural yogurt)**	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$
5	**Milk or milk products, sweetened (e.g. yogurt, pudding, chocolate milk)**	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$
6	**Sweet or salty pastries (e.g. pancake, cookie, cake, croissant, cheese pie)**	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$
7	**Low fiber cereal and cereal products (e.g. white bread or rusk any type, refined (not whole grain) breakfast cereals, such as coco pops)**	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$
8	**Whole grain cereal and cereal products (e.g. brown bread, porridge, muesli, whole grain breakfast cereal)**	❑$_1$	❑$_2$	❑$_3$	❑$_4$	❑$_5$

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