Self-reported Lifestyle Behaviours in Families With an Increased Risk for Type 2 Diabetes Across Six European Countries: the Feel4diabetes-study

Vicky Van Stappen (✉ vivstapp.vanstappen@ugent.be)

Department of Movement and Sports Sciences, Ghent University, 9000 Ghent, Belgium

<https://orcid.org/0000-0003-3097-7018>

Greet Cardon

Ghent University

Violeta Iotova

Medical University Varna

Nevena Chakarova

Medical University of Sofia

Imre Rurik

University of Debrecen

Jaana Lindström

Finnish institute of Health and Welfare

Jemina Kivelä

Finnish institute of Health and Welfare

Luis, Alberto Moreno

University of Zaragoza

Christina Mavrogrianni

Harokipio University

Yannis Manios

Harokopio University

Brondeel Ruben

Ghent University

Research

Keywords: Children, Parents, Physical activity, Sedentary behaviour, Dietary behaviours, Vulnerable

Posted Date: October 29th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-97223/v1>

Abstract

Background: The current study aimed to describe self-reported lifestyle behaviours by comparing them to current health guidelines in European Feel4Diabetes-families at risk for developing type 2 diabetes across six countries (Belgium, Finland, Spain, Greece, Hungary and Bulgaria).

Methods: Parents and their children were recruited through primary schools located in low socio-economic status areas. Parents filled out the FINDRISC-questionnaire, which was used for the risk assessment of the family. Sociodemographic factors and several lifestyle behaviours of both adults and children were assessed by parental questionnaires. To investigate families' lifestyle behaviours, to compare these levels to health guidelines and to assess potential differences between the countries, multilevel regression analyses were conducted.

Results: Most Feel4Diabetes-families at risk (parents and their children) did not comply with the guidelines regarding healthy behaviours, set by the WHO, European or national authorities; less than half of parents and children complied with the physical activity guidelines, less than 15% of them complied with the fruit and vegetable guideline, and only 40% of the children met the recommendations of five glasses of water per day. Clear differences in lifestyle behaviours in Feel4Diabetes-families at risk exist between the countries.

Conclusions: Countries are highly recommended to invest in policy initiatives to counter unhealthy lifestyle behaviours in families at risk, taking into account country-specific needs. For future research it is of great importance to focus on families at risk in order to counter the development of type 2 diabetes and reduce health inequity.

Trial registration: Name: Feel4Diabetes-study, trial registration number: 643708, data of registration 03/15/2015 (Retrospectively registered), URL: <https://clinicaltrials.gov/ct2/show/NCT02393872?term=643708&draw=2&rank=1>

Introduction

Diabetes is a serious public health problem in Europe and worldwide. The International Diabetes Federation (IDF) stated that diabetes affects 59.3 million European adults (8.9% of the population) aged 20–79 years - of which type 2 diabetes is the most common type - and the prevalence is estimated to rise to 68.1 million by 2045 (1). Although only a limited amount of information is available about the prevalence of type 2 diabetes in European children, type 2 diabetes is also increasingly diagnosed among this young population (2–5). The increased prevalence of type 2 diabetes in both children and adults results in a high cost spent on the treatment and management of diabetes and related complications (1). Therefore, efforts are needed to tackle this problem in both children and adults.

Type 2 diabetes is highly preventable through adopting a healthy lifestyle. Several lifestyle behaviours contribute to the development of type 2 diabetes, including insufficient levels of physical activity (PA),

high levels of sedentary behaviour and unhealthy dietary behaviours (6). Guidelines and recommendations for these behaviours have been developed for children and adults. PA guidelines set by the World Health Organisation (WHO) recommend children to engage in at least 60 minutes of moderate-to-vigorous PA (MVPA) per day (7) and adults to engage in at least 150 min of MVPA per week (corresponding to at least 30 minutes of MVPA during 5 days) (8). For sedentary behaviour, studies and national guidelines recommend for both children and adults to minimise the amount of time spent in prolonged sitting and to break up long periods of sitting as often as possible (9). Further, specifically for children it is recommended not to exceed two hours of recreational screen-time per day (10–12). Finally, the WHO recommends to consume at least 400 grams of fruit and vegetables, corresponding to five portions per day (for both children and adults) (13), and to limit the daily consumption of unhealthy snacks and soft drinks (not exceeding WHO recommendations for free sugar, < 10% of total energy intake) (14). In addition, recommendations based on previous research, suggest to consume breakfast on a daily basis (15) and the European Food Safety Authority recommends a daily water (fluid) intake of 1.6-2.0 litres of water per day for girls and women and boys and men respectively (16).

Several European studies have previously investigated the levels of physical activity (PA), sedentary behaviour and healthy dietary behaviours in primary schoolchildren and adults in a general population. Results indicated that between 5.0% and 47% of the European children (17) and between 7.0% and 96% of the European adults (18) met the recommended amount of PA per day, depending of assessment methods and country (17, 18). Furthermore, European adults reported a sitting time of 309 minutes/day on weekdays (19) and 25% of the girls and 33% of the boys exceeded the recommended daily screen-time limits (20). Regarding dietary behaviour, results of the European Energy-project showed that between 12.0 and 51.7% of children and between 11.8 and 56.1% of adults, depending of country and gender, skip breakfast (21). Furthermore, research has indicated that 76% and 94% of 11-year-old European children (22) and 86% of adults (23) did not reach the recommendations regarding fruit and vegetable intake. Moreover, a study conducted in six European countries showed that young children consumed on average between 0.25 and 0.85 litres of water per day (depending on gender and country) (24) and French, Italian and Spanish adults consumed on average between 0.60 and 0.72 litres of water per day (25), which is in both children and adults below the recommended amount. Finally, results of the IDEFICS-study revealed high intakes of total sugars and foods and drinks rich in added sugar in European 2-to 10-year-old children (25) and a high percentage (11–49%, depending of country) of European adults was found to exceed the WHO recommendation on free sugars intake, considering solely fluids (26). Even more alarming, in vulnerable subpopulations (e.g. children and parents with a low socio-economic status (SES)) higher levels of physical inactivity, high levels of sedentary behaviour and unhealthy dietary patterns have been reported and consequently they have a higher prevalence of overweight, obesity and type 2 diabetes compared to the general population (27, 28). In 2019, it was therefore recommended in the International Diabetes Federation Atlas (1) to prioritize families with a higher risk for developing type 2 diabetes in lifestyle interventions. However, up to now to our knowledge no research could be located that investigated the prevalence of the above mentioned lifestyle behaviours specifically in parents at increased risk for developing type 2 diabetes and their children.

Therefore, the aim of the current study was to assess the levels of several lifestyle behaviours (i.e. PA, sedentary behaviours and dietary behaviours) and compare these levels to health guidelines/recommendations in European families (parents and their primary schoolchildren) at risk for developing type 2 diabetes. As differences in prevalence of type 2 diabetes exist between European countries (1, 29), this study also investigated potential differences in lifestyle behaviours in these high-risk families between European countries.

Methods

Study background

Within the Feel4Diabetes-project a multi-level intervention was developed aiming to prevent type 2 diabetes in vulnerable families across six European countries (Belgium, Finland, Bulgaria, Hungary, Greece and Spain). These countries represent three socio-economic levels: High-income countries (Belgium and Finland), high-income countries under austerity measures (Greece and Spain) and low-to-middle-income countries (Bulgaria and Hungary). The Feel4Diabetes-intervention targets three main lifestyle behaviours, namely PA, sedentary behaviour and dietary behaviour. The Feel4Diabetes-study focused on all types of families with children on one hand; and on the other hand, on families with an increased risk for developing type 2 diabetes. This study uses the baseline data from the population at risk for developing type 2 diabetes. More detailed information can be found elsewhere (30).

Procedure

Primary schoolchildren and their parents were recruited via schools located in vulnerable areas. Within low-to-middle income countries (Bulgaria and Hungary), all areas were considered vulnerable; whereas in Belgium, Finland, Greece and Spain recruitment only took place in low SES areas. To select the low SES areas, all municipalities in the selected provinces were divided into tertiles based on socioeconomic indices retrieved from official sources and authorities (i.e. literacy or unemployment rates) (31–34). Municipalities within the highest tertile (i.e. municipalities with the lowest SES indices) were included in the study. Within the selected areas, schools were randomly contacted and in total 236 primary schools (response rate = 40.2%) confirmed their participation in the Feel4Diabetes-study. In January 2016, children from the first three grades of primary school and their parents were invited to participate in the study. By signing the informed consent form and filling out two questionnaires (FINnish Diabetes Risk Score (FINDRISC)-questionnaire and Energy Balance Related Behaviour (EBRB)-questionnaire), families confirmed their participation. The FINDRISC-questionnaire was used to identify families with an increased risk for developing type 2 diabetes (based on the diabetes risk score – see ‘Measurements’ section). In addition, the high-risk families received two additional questionnaires (i.e. the high-risk questionnaires - one for the child and one for the parent) for a more in-depth evaluation of the behaviours. The parents filled out the demographic and lifestyle-related questions for both their children and themselves. In total, 11,396 families confirmed their participation to the project, of which 4,484 families (39.3%) were identified as high-risk families for developing type 2 diabetes (defined as one or both parents having

FINDRISC value denoting moderate or high type 2 diabetes risk)(35). Finally, height and weight were measured by researchers in the school (children) and local municipality centers or home setting (parents). Measurements were conducted by trained researchers, using standardized protocols and calibrated equipment (36).

Measurements

Before applying the questionnaire to the main study, its reliability was assessed in a pilot study using a two-way random effect single measure intra-class correlation coefficient (ICC). Reliability addressed the question of how consistent the answers were from one occasion to the next in the same subject. Parents were asked to complete the questionnaire twice, within a 1–2 week interval. The ICC's were classified as excellent (> 0.81), good ($0.61 - 0.50$), moderate ($0.41 - 0.60$) and poor (< 0.40) (37).

Diabetes risk score. The FINDRISC-questionnaire is a validated tool to assess individuals' risk for developing type 2 diabetes. It includes eight questions on age, Body Mass Index (BMI), waist circumference, PA, daily consumption of fruit, berries or vegetables, history of antihypertensive drug treatment, history of high blood glucose and family history of diabetes (38). The Diabetes Risk score is calculated as the sum of these individual scores and varied from 0 to 26 points, with higher scores indicating a higher risk for developing type 2 diabetes (39). A family was selected as a high-risk family if at least one of the parents met the cut-off score of 9 points. Further, the highest FINDRISC-score within the family was assessed based on the highest FINDRISC-score of mother or father, or of both parents.

Physical activity. Moderate-to-vigorous physical activity (MVPA) was measured by the following questions in the EBRB-questionnaire: "On how many days during the last week did you (parent) spent MVPA for a total of at least 30 minutes per day?" and "On how many days during the last week did your child spent in MVPA for a total of at least 1 hour per day?". This question was asked separately for weekdays and weekend days (ICC range 0.367-0.700). To assess the percentage of children and parents meeting the WHO Europe PA guidelines, the number of days meeting the PA guidelines on weekdays and weekend days were summed. The levels of PA in a whole week were dichotomized into not meeting the WHO guideline (< 7 days a week for children and < 5 days a week for parents) and meeting the guideline (7 days a week for children and ≥ 5 days a week for parents).

Sedentary behaviour. Parents' total sitting time on weekdays in parents and screen-time behaviour during the week in children were assessed in respectively the high-risk questionnaire and the EBRB-questionnaire. Total sitting time in parents was assessed using the question: "During the last 7 days, how many hours did you (parent) spend sitting on a weekday?" (ICC = 0.584). Furthermore, children's screen-time behaviour was assessed by the following question: "About how many hours per day does your child usually devote to screen-activities (excluding school)?". This question was asked separately for weekdays and weekend days (ICC = 0.647 and 0.694). Answer options were 0 h/d, < 0.5 h/d, 0.5 h/d to < 1 h/d, 1 h/d to < 2 h/d, 2 h/d to < 3 h/d, 3 h/d to < 4 h/d, 4 h/d to < 5 h/d, 5 h/d to < 6 h/d, 6 h/d to < 7 h/d, 7 h/d to > 7 h/d. Afterwards, these categorical values were recoded into numerical values according to the midpoint method (e.g. 2 h/d to < 3 h/d was recoded into 150 minutes/day) and the time spend on screen-

time activities on weekdays and weekend days were summed. To determine the percentage of children meeting the recommendation of less than two hours of recreational screen-time per day (based on recent studies and set by national authorities), the total time spend on screen-time activities were dichotomized into not meeting the guideline (≥ 120 minutes of screen-time activities per day) and meeting the guideline (< 120 minutes of screen-time activities per day).

Dietary behaviour. Consumption of water, soft drinks and juices containing sugar, fruit and vegetables, unhealthy snacks (sweets and salty snacks/fast-food) and breakfast were assessed in the EBRB-questionnaire. The general question asked in the questionnaire was: "Please indicate how often you (parent) and your child consume: Water, soft drinks and juices containing sugar, fruit/berries (fresh or frozen), fruit and berries (canned or dried), vegetables, sweets, salty snacks/fast-food" (ICC range: 0.371–0.827). Answer options were: Less than 1 per week, 1–2 per week, 3–4 per week, 5–6 per week, 1 or 2 per day, 3 or 4 per day, 5 or 6 per day, more than 6 per day. Afterwards, these categorical values were recoded into numerical values according to the midpoint method (e.g. 5–6 portions per week was recoded into 0.79 portion per day, 3 or 4 portions per day was recoded into 3.5 portions per day). The portion size, defined with a household unit, was provided under the question. The consumption of water and soft drinks/juices containing sugar was expressed in glasses, one glass contains a content of 2.5 dl. One portion of fruit and vegetables equals the content of about 1/2 cup (2.5 dl) or the size of a tennis ball. One portion of sweets equals a chocolate bar, half a cup of sweets, cookies or ice-cream and one portion of salty/snacks fast food equals a small hamburger, a small bag of chips or a slice of pizza. To assess the total consumption of fruit and vegetable per day, the daily consumption of fruit/berries (fresh or frozen), fruit and berries (canned or dried) and vegetables were summed. Further, outliers (defined as values above three standard deviations from the mean) were capped, and reassigned the value of the mean plus three standard deviations, a method conducted within previous research (40). The daily breakfast consumption was measured by the following questions. "On how many days do you/does your child usually eat breakfast?". This question was asked separately for weekdays and weekend days (ICC range 0.088–0.281). The amount of days consuming breakfast on weekdays and weekend days were summed. Within the Feel4Diabetes-study, families were recommended to drink at least 5 glasses of water per day. To assess the percentage of parents and children meeting these recommendations, the amount of water consumption was dichotomized into not meeting the recommendation (< 5 glasses of water per day) and meeting the recommendation (≥ 5 glasses of water per day). Further, to assess the percentage of parents and children meeting the WHO guidelines regarding fruit and vegetable consumption (at least 5 portions per day), the amount of fruit and vegetable intake was dichotomized into not meeting the guideline (< 5 portions of fruit and vegetables per day) and meeting the guideline (≥ 5 portions of fruit and vegetables per day). Finally, to assess the percentage of parents and children consuming breakfast on a daily basis (recommendation based on previous research), the breakfast consumption in a whole week was dichotomized into not meeting the guideline (< 7 days a week) and meeting the guideline (7 days a week).

Sociodemographic variables. Parents reported their birthdate, sex and educational level (years of education), as well as their child's birthdate and sex. Age was calculated based on parents' and children's

birthdate and measurement dates. Family SES was categorised as follows: low (both parents having no higher education i.e. ≤ 14 years of education), medium (at least one of the parents having no higher education), high (both parents having a higher education i.e. > 14 years of education) (41). In European education systems more than 14 years of education implies attendance of higher education (e.g., bachelor program).

Statistical analyses

Descriptive statistics for the sample demographics were computed using SPSS statistics 24.0 for Windows (SPSS Inc., Chicago, IL). Besides, in order to have more insight into the strength of the relationship between parents' lifestyle behaviours and their FINDRISC-score and between children's lifestyle behaviours and highest FINDRISC-score within the family a correlation analysis was conducted in SPSS statistics 24.0 for Windows (SPSS Inc., Chicago, IL).

Parents' and children's lifestyle behaviours and the percentages of parents and children meeting the recommendations/guidelines across all countries were investigated. In addition, there was examination of potential differences between countries. Therefore, multilevel regression analyses were conducted using MLwiN 2.28 (Centre for Multilevel Modelling, University of Bristol, UK). Multilevel modelling (three-level: child; class, school) was used to take clustering of children in classes, in schools into account. For all analyses, statistical significance level was set at $p < 0.01$.

Results

Descriptive data

In total 2,499 high-risk parents (88.8% mothers/stepmothers, mean age 40.05 ± 5.47 years) and 2,506 children (51.1% girls, mean age 8.12 ± 1.01 years) provided data on EBRB-Questionnaire at baseline. Parents' FINDRISC-score ranged between 0 and 22 points, with an average of 9.63 ± 4.56 points. Furthermore, the highest FINDRISC-score within the family ranged between 9 and 24 points, with an average of 12.41 ± 2.94 points. Families were assigned to the high-risk group based the FINDRISC-score of the mother (41.7%), the father (35.3%) or both (22.8%). Descriptive data across all countries, and separately for the six countries can be found in Table 1.

Besides, the correlations were investigated between parents' lifestyle behaviours and their FINDRISC-score (correlation coefficient ranged between 0.037 and 0.098), and between children's lifestyle behaviours and the highest FINDRISC-score within the family (correlation coefficients ranged between 0.009 and 0.079]. The correlation coefficients can be found in Additional File 1.

Table 1

Descriptive data of the study sample: Children and parents from high-risk families in the Feel4Diabetes-study

Children							
	Belgium N = 420	Finland N = 354	Spain N = 569	Greece N = 494	Bulgaria N = 408	Hungary N = 261	All countries N = 2,506
Mean age (SD) in years	8.02 (0.93)	8.70 (0.95)	7.84 (0.96)	7.76 (0.89)	8.25 (0.93)	8.65 (1.03)	8.12 (1.01)
% girls	48.1	53.4	49.9	51.0	50.4	56.3	51.1
% Overweight/obese (> 25 kg/m ²)	21.1	26.6	30.5	38.1	25.1	34.6	29.4
% low family SES	35.6	27.1	5.7	55.9	18.6	67.2	32.8
% medium family SES	30.1	31.1	28.4	26.7	33.7	18.9	28.6
% high family SES	34.2	41.8	65.9	17.4	47.8	13.9	38.6
Highest FINDRISC score within the family	11.9 (2.68)	12.58 (2.85)	12.05 (2.87)	12.76 (3.05)	12.47 (3.13)	13.02 (2.90)	12.41 (2.94)
	[9–22]	[9–21]	[9–22]	[9–22]	[9–24]	[9–22]	[9–24]
Mean (SD)							
Range [min-max]							
Parents							
	Belgium N = 420	Finland N = 354	Spain N = 568	Greece N = 594	Bulgaria N = 404	Hungary N = 259	All countries N = 2,449
Mean age (SD) in years	38.73 (5.50)	40.11 (5.19)	41.51 (5.13)	41.18 (5.04)	39.25 (4.50)	37.60 (6.40)	40.05 (5.47)
% mother/stepmother	86.1	87.3	86.3	90.0	94.7	89.0	88.8
% overweight/obese (> 25 kg/m ²)	61.6	84.3	72.4	66.2	51.8	83.9	66.4
% low individual SES	43.1	30.9	7.8	64.1	24.1	71.3	38.0

Children							
Parents' FINDRISC-score	9.65 (4.22)	10.70 (4.30)	9.64 (4.40)	10.14 (4.46)	7.62 (4.89)	10.26 (4.51)	9.63 (4.56)
mean (SD)	[0–21]	[0–21]	[0–22]	[0–22]	[0–21]	[0–20]	[0–22]
Range [min-max]	32.1	22.1	32.1	31.0	51.3	28.0	33.1
% of parents with FINDRISC-score < 9 points							

Self-reported lifestyle behaviours across and between the participating countries

Moderate-to-vigorous physical activity

Descriptive data (means and standard deviations) of moderate-to-vigorous physical activity in parents and children can be found in Table 2. Furthermore, within the table, differences between the countries were indicated (p-values).

Table 2

Lifestyle behaviours for parents and children from high-risk families across six European countries.

	Belgium	Finland	Spain	Greece	Bulgaria	Hungary	All countries	P-value
Moderate-to-vigorous physical activity								
CHILDREN								
Days per week $\geq$ 60 minutes per day (SD)	4.96 (0.08)	5.76 (0.09)	5.19 (0.08)	4.73 (0.08)	5.17 (0.08)	5.78 (0.11)	5.20 (0.04)	< 0.001
Meeting guidelines (%)	27.7	40.3	31.2	17.1	27.6	43.3	29.7	< 0.001
PARENTS								
Days per week $\geq$ 60 minutes (mean $\pm$ SD)	4.10 (0.12)	4.32 (0.12)	3.37 (0.10)	3.36 (0.11)	3.69 (0.12)	5.04 (0.15)	3.85 (0.05)	< 0.001
Meeting guidelines (%)	48.0	49.3	37.7	37.0	38.1	65.2	43.7	< 0.001
Sedentary time								
Screen-time in CHILDREN								
Minutes per day mean (SD)	108.80 (3.24)	113.60 (3.52)	88.63 (2.91)	106.22 (2.93)	118.52 (3.25)	125.74 (4.11)	108.09 (1.36)	< 0.001
Meeting guidelines (%)	61.8	62.6	74.6	67.7	58.5	54.9	64.5	< 0.001
Sitting time during weekdays in PARENTS								
Hours per day mean (SD)	5.91 (0.22)	5.44 (0.26)	4.95 (0.19)	4.66 (0.18)	4.96 (0.19)	5.29 (0.29)	5.13 (0.09)	< 0.001
Drinking water								
CHILDREN								
Glasses per day	2.92 (0.09)	2.36 (0.09)	4.67 (0.08)	4.54 (0.08)	4.21 (0.08)	4.27 (0.10)	3.90 (0.04)	< 0.001

INVALID: No valid cases because of missing question

	Belgium	Finland	Spain	Greece	Bulgaria	Hungary	All countries	P-value
Meeting guidelines (%)	17.7	12.9	55.1	51.1	44.8	51.7	39.8	< 0.001
PARENTS								
Glasses per day	3.76 (0.10)	4.34 (0.10)	5.00 (0.09)	4.60 (0.09)	4.73 (0.10)	4.71 (0.13)	4.55 (0.04)	< 0.001
Meeting guidelines (%)	41.0	50.4	67.2	58.5	60.0	65.3	57.3	< 0.001
Fruit and vegetable consumption								
CHILDREN								
Portions per day	2.58 (0.08)	2.46 (0.09)	2.60 (0.7)	1.95 (0.08)	2.78 (0.08)	2.15 (0.11)	2.43 (0.04)	< 0.001
Meeting guidelines (%)	8.0	11.2	10.1	6.9	11.9	8.9	9.4	0.03
PARENTS								
Portions per day	2.76 (0.09)	3.04 (0.10)	2.81 (0.08)	2.03 (0.09)	2.96 (0.09)	2.00 (0.12)	2.62 (0.04)	< 0.001
Meeting guidelines (%)	14.9	17.7	15.8	7.7	14.1	10.9	13.5	< 0.001
Consumption of soft drinks or juices containing sugar								
CHILDREN								
Glasses per day	0.51 (0.05)	0.33 (0.05)	0.32 (0.04)	0.13 (0.04)	0.30 (0.04)	1.16 (0.06)	0.40 (0.02)	< 0.001
PARENTS								
Glasses per day	0.52 (0.05)	0.17 (0.05)	0.25 (0.04)	0.14 (0.04)	0.29 (0.05)	1.07 (0.06)	0.35 (0.02)	< 0.001
Consumption of sweets								
CHILDREN								
Portions per day	1.13 (0.04)	0.36 (0.05)	0.73 (0.04)	0.72 (0.04)	0.84 (0.04)	1.37 (0.05)	0.83 (0.02)	< 0.001
PARENTS								
INVALID: No valid cases because of missing question								

	Belgium	Finland	Spain	Greece	Bulgaria	Hungary	All countries	P-value
Portions per day	0.99 (0.04)	0.48 (0.05)	0.64 (0.04)	0.53 (0.04)	0.67 (0.04)	1.10 (0.06)	0.70 (0.02)	< 0.001
Consumption of salty snacks, fast food								
CHILDREN								
Portions per day	0.30 (0.04)	0.12 (0.04)	INVALID	0.19 (0.04)	0.45 (0.04)	0.97 (0.05)	0.36 (0.02)	< 0.001
PARENTS								
Portions per day	0.24 (0.03)	0.10 (0.03)	0.21 (0.03)	0.12 (0.03)	0.29 (0.03)	0.61 (0.04)	0.24 (0.01)	< 0.001
Breakfast consumption								
CHILDREN								
Days per week	6.39 (0.07)	6.80 (0.07)	6.86 (0.06)	6.44 (0.06)	6.53 (0.06)	6.41 (0.08)	6.58 (0.03)	< 0.001
Meeting guidelines (%)	82.5	92.4	95.9	82.9	83.1	82.3	86.9	< 0.001
PARENTS								
Days per week	5.88 (0.11)	6.71 (0.12)	6.45 (0.10)	4.99 (0.10)	4.30 (0.11)	5.10 (0.14)	5.60 (0.05)	< 0.001
Meeting guidelines (%)	71.8	89.1	85.3	52.9	40.0	56.7	66.5	< 0.001
INVALID: No valid cases because of missing question								

Children. Across the participating countries, children spent 5.20 days per week being moderate-to-vigorous physically active for at least 60 minutes per day and 29.7% of children complied with the PA guideline (being moderate-to-vigorous physically active for at least 60 minutes, 7 days per week). Significant differences exist between the countries ($p < 0.001$). Children from Hungary and Finland were significantly more physically active (respectively 5.78 and 5.76 days/week) compared to the other countries ($p < 0.001$), while children from Greece and Belgium spent the lowest number of days being at least 60 min physically active (respectively 4.73 and 4.96 days/week) ($p < 0.001$). Further, in Hungary and Finland a significantly higher percentage of children (respectively 43.3% and 40.3%) complied with the PA guidelines compared to the other participating countries ($p < 0.01$). On the other hand, the lowest number of children complied with the PA guidelines was found in Greece (17.1%; $p < 0.01$).

Parents. Overall, parents spent 3.85 days per week being moderate-to-vigorous physically active for at least 30 minutes per day and in total 43.7% complied with the PA guideline (being moderate-to-vigorous physically active for at least 30 minutes, 5 days per week). Significant differences exist between the participating countries ($p < 0.001$). Hungarian parents had the highest number of days in which they were physically active (5.04 days/week) compared to the other countries ($p < 0.01$). In Greece, Spain and Bulgaria, parents had the lowest number of days in which they were physically active (respectively 3.36, 3.37 and 3.69 days/week). The highest percentage of parents complying with the PA guidelines was found in Hungary (64.2%) ($p < 0.01$), while the lowest percentages of parents complying with the guidelines were found in Spain (37.7%), Greece (37.0%) and Bulgaria (38.1%) ($p < 0.01$).

Sedentary behaviour

Descriptive data (means and standard deviations) of subjectively measured sedentary behaviour in children and parents can be found in Table 2. Furthermore, within the table, differences between the countries were indicated (p-values).

Children. Children across the participating countries spent on average 108.09 minutes in front of screens and 64.5% complied with the screen-time guideline (less than 120 min/day). Significant differences exist between the countries. Spanish children spent 88.63 minutes in front of screens, which is the lowest amount of time compared to the other participating countries ($p < 0.001$). The highest amounts were found in Hungarian and Bulgarian children (respectively 125.74 and 118.52 min/day) ($p < 0.01$). The percentage of children meeting the screen-time guideline ranged between 74.6% in Spanish children and 54.9% in Hungarian children. A significantly higher number of Spanish and Greek children complied with the screen-time guideline compared to the other countries ($p < 0.001$).

Parents. Overall, parents spent on average 5.07 hours in sitting time during the day. Significant differences exist between the participating countries ($p < 0.001$). More specifically, Belgian parents had a significantly higher amount of sitting time (5.91 hours/day) compared to Greek (4.6 hours/day), Spanish (4.94 hours/day) and Bulgarian (4.96 hours/day) parents ($p < 0.01$). Furthermore, no differences exist between the other countries. No differences exist between the other countries.

Dietary behaviour

Drinking water. Descriptive data (means and standard deviations) of drinking water in children and parents can be found in Table 2. Furthermore, within the table, differences between the countries were indicated (p-values).

Children. Across the countries, children consumed on average 3.90 glasses of water per day and 39.8% complied with the guideline regarding water consumption (drinking at least 5 glasses per day). Significant differences exist between the participating countries ($p < 0.001$). More specifically, Spanish and Greek children consumed the highest amount of water (respectively 4.67 and 4.54 glasses/day) compared to the other countries ($p < 0.01$). The lowest amount of water consumption was found in

children from Finland, who consumed 2.36 glasses per day ($p < 0.001$). The highest percentages of children meeting the guidelines regarding water consumption were found in Spain (55.1%), Greece (51.1%) and Hungary (51.7%) ($p < 0.001$), while only 12.9% of Finnish children and 17.7% of Belgian children complied with the guideline ($p < 0.001$).

Parents. Overall, parents consumed on average 4.55 glasses of water per day and 57.3% complied with the guideline regarding water consumption (drinking at least 5 glasses per day). Significant differences exist between the participating countries ($p < 0.001$). In Spain, Hungary and Bulgaria, parents consumed respectively 5.00, 4.71 and 4.73 glasses per day, which is significantly higher compared to the other countries ($p < 0.01$), while Belgian parents consumed the lowest amount of water (3.76 glasses/day) ($p < 0.001$). In Spain, Bulgaria and Hungary, respectively 67.2%, 60.0% and 65.3% of the parents complied with the guidelines of water consumption, which is significantly higher compared to the other countries ($p < 0.01$). The lowest amount of parents meeting the guideline was found in Belgium (41.0%) ($p < 0.01$).

Fruit and vegetable consumption. Descriptive data (means and standard deviations) of fruit and vegetable consumption in children and parents can be found in Table 2. Furthermore, within the table, differences between the countries were indicated (p-values).

Children. Across the countries, children consumed on average 2.43 portions of fruits and vegetables per day and differences were found between the countries ($p < 0.001$). Children in Bulgaria, Spain, Belgium and Finland consumed more fruit and vegetables compared to the other countries ($p < 0.01$), respectively 2.78, 2.60, 2.58 and 2.46 portions fruit and vegetables per day. Greek and Hungarian children consumed the lowest amount of fruit and vegetables per day (respectively 1.95 and 2.15 portions/day). Across the countries 9.4% of children complied with the guideline of at least 5 portions of fruit and vegetables per day. No significant differences were found between the participating countries.

Parents. Across the participating countries, parents consumed on average 2.63 portions of fruit and vegetables per day and 13.5% complied with the guideline of at least 5 portions of fruit and vegetables per day. Further, significant differences exist between the participating countries ($p < 0.001$). Parents from Finland, Bulgaria, Spain and Belgium consumed the highest proportions of fruit and vegetables per day (respectively 3.04, 2.96, 2.81 and 2.76 portions/day) compared to Hungarian and Greek parents who consumed respectively 2.03 and 2.00 portions of fruit and vegetables per day ($p < 0.001$). The percentage of parents meeting the fruit and vegetable guidelines ranged between 17.7% in Finnish parents and 7.7% in Greek parents. In Greece and Hungary (10.9%), a significantly lower proportion of parents complied with guidelines compared to the other countries ($p < 0.01$).

Consumption of soft drinks and juices containing sugar. Descriptive data (means and standard deviations) of the consumption of soft drinks and juices containing sugar in children and parents can be found in Table 2. Furthermore, within the table, differences between the countries were indicated (p-values).

Children. Children across the participating countries consumed on average 0.40 glasses of soft drinks or juices containing sugar per day and significant differences exist between the countries. In Greece, children consumed the lowest amount of soft drinks or juices containing sugar per day (i.e. 0.13 glasses/day) ($p < 0.001$), while in Hungary, children consumed the highest amount of soft drinks or juices containing sugar per day (i.e. 1.16 glasses/day) ($p < 0.001$).

Parents. Parents across the participating countries consumed on average 0.35 glasses of soft drinks or juices containing sugar per day and significant differences exist between the countries. Hungarian parents consumed a significantly higher amount of soft drinks or soft drinks containing sugar (1.07 glasses per day) compared to parents in Greece (0.14 glasses/day), Finland (0.17 glasses/day), Spain (0.25 glasses/day), Bulgaria (0.29 glasses/day) and Belgium (0.52 glasses/day) ($p < 0.001$).

Consumption of sweets. Descriptive data (means and standard deviations) of the consumption of sweets in children and parents can be found in Table 2. Furthermore, within the table, differences between the countries were indicated (p-values).

Children. Children across the countries consumed on average 0.83 portions of sweets per day and significant differences could be detected between the countries ($p < 0.001$). In Finland, children consumed a significantly lower number of sweets (0.36 portions/day) compared to the other countries ($p < 0.001$). The highest consumption of sweets was found in Hungary, with an average of 1.37 portions per day ($p < 0.001$).

Parents. Parents across the countries consumed on average 0.70 portions of sweets per day and significant differences exist between the countries ($p < 0.001$). Parents from Finland and Greece consumed the lowest number of sweets per day (respectively 0.48, 0.53 portions/day), while in Hungary (1.10 portions/day) and Belgium (0.99 portions/day), parents consumed the highest number of sweets per day ($p < 0.001$).

Consumption of salty snacks and fast food. Descriptive data (means and standard deviations) of salty snacks and fast food in children and parents can be found in Table 2. Furthermore, within the table, differences between the countries were indicated (p-values).

Children. Children across the participating countries consumed on average 0.36 portions of salty snacks/fast food per day and differences exist between the countries ($p < 0.001$). In Finland and Greece, children consumed the lowest number of salty snacks and fast food (respectively 0.12 and 0.19 portions/day) ($p < 0.01$), while in Hungary, children consumed 0.97 portions of salty snacks and fast food, which is the highest number compared to the other countries ($p < 0.001$). From Spanish children, no data are available, due to a question missing in the local survey.

Parents. Parents across the countries consumed on average 0.34 portions of salty snacks and fast food per day and significant differences were found between the countries ($p < 0.001$). Finnish and Greek parents consumed the lowest number of salty snacks and fast food (respectively 0.10 and 0.12

portions/day) compared to the other countries ($p < 0.01$), while the highest number, 0.61 portions per day, was found in Hungarian parents ($p < 0.001$)

Breakfast consumption. Descriptive data (means and standard deviations) of breakfast consumption in children and parents can be found in Table 2. Furthermore, within the table, differences between the countries were indicated (p-values).

Children. Children across the countries consumed breakfast on 6.58 days per week and in total 86.9% complied with the daily breakfast guideline (consuming breakfast, 7 days/week). Significant differences exist between the countries ($p < 0.001$). The highest number of days in which children consumed breakfast were found in Spain (6.86 days/week) and Finland (6.79 days/week), while the lowest numbers were found in Belgium (6.39 days/week), Greece (6.44 days/week), Hungary (6.41 days/week) and Bulgaria (6.53 days/week) ($p < 0.01$). The highest percentages of children complying with the daily breakfast guideline were found in Spain (95.9%) and Finland (92.4%), while the lowest percentages were found in Hungary (82.3%), Belgium (82.5%), Greece (82.9%) and Bulgaria (83.1%) ($p < 0.001$).

Parents. Overall, parents consumed breakfast on average 5.60 days per week and in total 66.5% of all parents complied with the guideline of daily breakfast consumption. Significant differences exist between the participating countries ($p < 0.001$). The highest numbers of days in which parents consumed breakfast were found in Finland (6.71 days/week) and Spain (6.45 days/week) compared to the other countries ($p < 0.001$). In contrast, Bulgarian parents consumed breakfast on 4.30 days per week, which was significantly lower compared to the other countries ($p < 0.001$). The percentages of parents meeting the breakfast guidelines were the highest in Finland (89.1%) and Spain (85.3%), while the lowest percentage was found in Bulgaria (40.0%) ($p < 0.001$).

A more detailed description (p-values) of lifestyle behaviours between the participating countries can be found in Additional File 2.

Discussion

The aim of the current study was to assess several lifestyle behaviours (PA, sedentary behaviour and dietary behaviours) in families at risk for developing type 2 diabetes, and to compare the behaviours to health guidelines. Further, potential differences in at risk families' lifestyle behaviours between six Feel4Diabetes European countries were investigated.

Overall, some alarming results were found for both parents and children: less than 30% of the children met the PA guideline, only 40% of the children met the guideline of at least 5 glasses of water per day and less than 10% of the children met the guideline regarding fruit and vegetable intake. In addition, less than 45% of the parents met the PA guideline and only 14% of the parents met the guidelines regarding fruit and vegetable intake. On the other hand, results also showed some more positive results: almost 87% of the children and 68% of the parents met the recommendations regarding daily breakfast consumption, 64% of the children met the guideline of screen-time, and both parents and children managed to keep the

consumption of soft drinks or juices containing sugar, sweets, salty snacks/fast food relatively low. These results point out that behaviour change programmes in the selected Feel4Diabetes families at increased risk for type 2 diabetes primarily need to focus on the promotion of physical activity, fruit and vegetable intake and on drinking water. To obtain the adherence to health guidelines, additional efforts to promote daily breakfast consumption and to limit the consumption of unhealthy snacks seem less necessary in this target group.

Despite research showing that people with normal blood glucose levels generally have healthier behaviours compared to people with prediabetes (42, 43), results of this European sample of families at increased risk seems to be quite comparable with results of studies conducted in the general population. More specifically, similar figures were found for adults and children in meeting the guidelines regarding PA, sedentary behaviour and several dietary behaviours (19, 22, 23, 44, 45). Less positive outcomes for health behaviours could be expected in families at increased risk to develop type 2 diabetes, since they have been selected based on the FINDRISC-questionnaire, which includes questions on these behaviours. However, these questions only counts for 3 of 26 points (11.5%) of the total FINDRISC-score, so they only minimally influence the total FINDRISC-score. Further, results showed that the correlations between parents' lifestyle behaviours and their FINDRISC-score, and the correlations between children's lifestyle behaviours and families' FINDRISC-score are overall weak. This is actually not surprising since the prediction model to assess the probability to develop type 2 diabetes within 10 year (conducted to develop the FINDRISC-questionnaire) showed that questions on physical activity and fruit and vegetable consumption did not add much to the predictive power. Even though they had no impact on the score, these two lifestyle behaviours were included in the FINDRISC-score to emphasize the importance of lifestyle behaviours in preventing type 2 diabetes (38). Despite the comparable lifestyle outcomes between the general population and the at risk population, this study population needs extra attention in future lifestyle interventions in order to prevent the development of type 2 diabetes.

Similar to cross-European health behaviour differences in the general population (41, 46, 47), results of the present study showed clear cross-European differences in several lifestyle behaviours in high risk families. The cross-European differences, found in all included lifestyle behaviours, are possibly due to political, geographical and cultural differences. In our study, Hungarian children and parents and Finnish children at increased risk had significantly higher physical activity levels compared to similar participants in the other countries (Belgium, Spain, Greece and Bulgaria). This might partially be explained by differences in the total hours of mandatory physical education in primary schools: Hungarian schools provide five hours of physical education per week, whereas schools in the other countries provide 2 to 3 hours of physical education per week (46). Furthermore, countries differ in provided action plans in the health sectors, schools, workplaces to promote physical activity, and in national awareness campaigns on PA (46). Regarding sedentary behaviours, parents at risk for developing type 2 diabetes living in Belgium and Finland (Northern and Central European countries) had higher levels of sedentary time compared to Greece, Spain, Bulgaria and Hungary (Southern European countries), which is in line with the study of Bennie et al. (2013), conducted in 32 European countries in a general population. These differences might be explained by wealth inequalities, which could influence several domains of

sedentary behaviours (i.e. parents' occupation, transport, leisure-time and household activities), differences in climate, and/or cultural differences; which has also been reported in previous research (19). Finally, within this study, clear differences were found in water consumption between Northern and Central European countries, compared to Southern European countries, which could also be found in the study of De Craemer et al. (2015), conducted in preschool children in the general population. This might be explained by higher outside temperatures, resulting in a higher thirst to quench (48). In conclusion, clear cross-European differences exist in health behaviours in families at risk for developing type 2 diabetes, which are similar compared to cross-European differences reported in the general population.

Finally, based on the results of this study country-specific recommendations could be provided to enhance lifestyle behaviours in families at risk for developing type 2 diabetes. In Belgium, further efforts are needed to improve the levels of MVPA, especially in children as only 28% of them met the PA guidelines. Furthermore, in Belgium, it is highly recommended to reduce children's screen-time, to improve children's breakfast consumption and to increase the consumption of water in both parents and their children. In Finland, improvements are needed in children's screen time activities and children's water consumption. However, the recommendation regarding the increase of water consumption should be put into perspective as Finnish children are recommended to drink low-fat milk during meals and to drink water when thirsty, instead of soft drinks and juices containing sugar (49). Within the current study, no data is available on the consumption of low-fat milk in Finnish children. In Spain, the levels of PA in parents should be improved as only 38% met the PA guidelines. In Greece, the levels of children's and parents PA as well as the breakfast consumption should be promoted; as well as the consumption of fruit and vegetable should be increased as only 7% of the Greek children and 8% of Greek parents met the recommended amount of five portions fruit and vegetables per day. In Bulgaria, further efforts are needed to improve the levels of parents' MVPA, to reduce children's screen-time activities and to promote the consumption of daily breakfast in both children and parents. Finally, in Hungary, more promotion is needed to reduce sedentary time in children and regarding dietary behaviours, improvements are needed in children's breakfast consumption and in the consumption of soft drinks or juices containing sugar, sweets, salty snacks/fast food and fruit and vegetables in both parents and children. So, countries should investigate in policy initiatives and strategies to counter unhealthy lifestyle behaviours in their inhabitants, especially in people with an increased risk for type 2 diabetes.

For future research, it is recommended to deliver effective universal interventions (targeting the general population), with a special focus on targeted interventions in individuals/families with an increased risk for developing type 2 diabetes – known as proportionate universalism – in order to reduce health inequity (50). Second, the FINDRISC-questionnaire, used as a tool to select families at risk for developing type 2 diabetes, is a unique and promising approach in health research to identify families' risk for type 2 diabetes. It is a fast, inexpensive way to raise awareness in parents of their families' risk (38) and parents have a profound influence on their children's lifestyle behaviours through their own behaviours (51–53), so lifestyle changes in parents might have a positive effect on children's lifestyle behaviours. Third, within the current study, a low percentage of fathers (11%) engaged in the current study, which is in line with results of the review of Morgan et al. (2017) (54). Yet it is of great importance to involve them in health

research as recent research shows a strong correlation between weight status and lifestyle behaviours of fathers and their children (55–58) and because a growing number of fathers are involved in the health care of their children (59). Therefore, recruitment strategies in which fathers are explicitly invited to participate, or by communicating the benefits of the research for fathers and their families should be used in further research (60).

A first strength of the study is the large sample across six European countries, representing high income countries, low-to-middle income countries and countries under austerity measures. Another strength is the focus on a population at risk for developing type 2 diabetes. By using the FINDRISC-questionnaire, at risk families could be detected in a fast, inexpensive and non-invasive way. On the other hand, families' lifestyle behaviours were self-reported, potentially causing response bias (e.g. social-desirability bias) (61), which is a limitation of the current study.

Conclusion

Results revealed that most Feel4Diabetes families at risk (parents and their children) did not comply with the guidelines regarding healthy behaviours set by the WHO, European or national authorities. Despite the fact that no clear differences in lifestyle behaviours exist between the at risk group in the current study and the general population (revealed from previous research), it is still of great importance to focus on this subgroup in future lifestyle interventions in order to counter the development of type 2 diabetes and to reduce health inequity. Countries should investigate in policy initiatives to counter unhealthy lifestyle behaviours in families at risk for developing type 2 diabetes and because of the observed differences between countries, it is recommended to develop interventions taking into account the needs within a specific country.

Declarations

Ethical approval and Consent to participate

Ethical approval was granted by the Ethical Committee in all countries. More specifically, in Belgium the study was approved by the Medical Ethics Committee of the Ghent University Hospital; in Bulgaria, by the Ethics Committee of the Medical University of Varna and the Municipalities of Sofia and Varna, as well as the Ministry of Education and Science local representatives; in Finland, by the hospital district of Southwest Finland ethical committee; in Greece, by the Bioethics Committee of Harokopio University and the Greek Ministry of Education; in Hungary by the National Committee for Scientific Research in Medicine; and in Spain, the study was approved by the Clinical Research Ethics Committee and the Department of Consumers' Health of the Government of Aragón.

Informed consent was obtained from all individual participants included in the study

Consent for publication

Not applicable.

Availability of supporting data

All data related to this research are available in the text and tables.

Competing interests

The authors declare that they have no conflict of interest

Funding

The Feel4Diabetes-study has received funding from the European Union's Horizon 2020 research and innovation programme [Grant Agreement: n° 643708]. The content of this article reflects only the authors' views and the European Community is not liable for any use that may be made of the information contained therein.

Authors' contribution

Conceptualization VVS, GC, RB; Data Curation VVS, GC, VI, NC, IR, JL, JK, LAM, CM, YM; Methodology VVS; Formal Analysis VVS; Investigation VVS; Writing-Original Draft Preparation VS; Writing-Review & Editing VVS, GC, RB, VI, NC, IR, JL, JK, LAM, CM, YM; Supervision GC, RB; Project Administration YM; Funding Acquisition YM; All authors read and approved the final manuscript.

Acknowledgments

The Feel4Diabetes-study group consists of - Coordinator: Yannis Manios; **Steering Committee:** Yannis Manios, Greet Cardon, Jaana Lindström, Peter Schwarz, Konstantinos Makrilakis, Lieven Annemans, Winne Ko; **Harokopio University (Greece)** Yannis Manios, Kalliopi Karatzi, Odysseas Androutsos, George Moschonis, Spyridon Kanellakis, Christina Mavrogianni, Konstantina Tsoutsouloupoulou, Christina Katsarou, Eva Karaglani, Irimi Qira, Efsthios Skoufas, Konstantina Maragkopoulou, Antigone Tsiafita, Irimi Sotiropoulou, Michalis Tsolakos, Effie Argyri, Mary Nikolaou, Eleni-Anna Vampouli, Christina Filippou, Kyriaki Apergi, Amalia Filippou, Gatsiou Katerina, Efstratios Dimitriadis; **Finnish Institute for Health and Welfare (Finland)** Jaana Lindström, Tiina Laatikainen, Katja Wikström, Jemina Kivelä, Päivi Valve, Esko Levälähti, Eeva Virtanen, Tiina Pennanen, Seija Olli, Karoliina Nelimarkka; **Ghent University (Belgium)** *Department of Movement and Sports Sciences:* Greet Cardon, Vicky Van Stappen, Nele Huys *Department of Public Health:* Lieven Annemans, Ruben Willems *Department of Endocrinology and Metabolic Diseases:* Samyah Shadid; **Technische Universität Dresden (Germany)** Peter Schwarz, Patrick Timpel; **University of Athens (Greece)** Konstantinos Makrilakis, Stavros Liatis, George Dafoulas, Christina-Paulina Lambrinou, Angeliki Giannopoulou; **International Diabetes Federation European Region (Belgium)** Winne Ko, Ernest Karuranga ; **Universidad De Zaragoza (Spain)** Luis Moreno, Fernando Civeira, Gloria Bueno, Pilar De Miguel-Etayo, Esther M^a Gonzalez-Gil, María L. Miguel-Berges, Natalia Giménez-Legarre; Paloma Flores-Barrantes, Aleli M. Ayala-Marín, Miguel Seral-Cortés, Lucia Baila-Rueda, Ana Cenarro, Estíbaliz

Jarauta, Rocío Mateo-Gallego; **Medical University of Varna (Bulgaria)** Violeta Iotova, Tsvetalina Tankova, Natalia Usheva, Kaloyan Tsochev, Nevena Chakarova, Sonya Galcheva, Romyana Dimova, Yana Bocheva, Zhaneta Radkova, Vanya Marinova, Yuliya Bazdarska, Tanya Stefanova; **University of Debrecen (Hungary)** Imre Rurik, Timea Ungvari, Zoltán Jancsó, Anna Nánási, László Kolozsvári, Csilla Semánova, Éva Bíró, Emese Antal, Sándorné Radó; **Extensive Life Oy (Finland)** Remberto Martinez, Marcos Tong

Authors' information

¹ Department of Movement and Sports Sciences, Ghent University, 9000 Ghent, Belgium ² Research Foundation Flanders (FWO), Egmontstraat 5, 1000 Brussels, Belgium ³ Clinic of Paediatric Endocrinology, Medical University Varna, 9002 Varna, Bulgaria ⁴ Clinical Center of Endocrinology, Medical University of Sofia, 1431 Sofia, Bulgaria ⁵ Debreceni Egyetem (UoD), University of Debrecen, 4002 Debrecen, Hungary ⁶ Finnish Institute for Health and Welfare, 00271 Helsinki, Finland ⁷ Growth, Exercise, Nutrition and Development (GENUD), University of Zaragoza, 50009 Zaragoza, Spain ⁸ Department of Nutrition and Dietetics, School of Health Science & Education, Harokopio University, 176 76 Athens, Greece

References

1. International Diabetes Federation. IDF DIABETES ATLAS. 2019.
2. Kiess W, Bottner A, Raile K, Kapellen T, Muller G, Galler A, et al. Type 2 diabetes mellitus in children and adolescents: a review from a European perspective. *Horm Res*. 2003;59 Suppl 1:77-84.
3. Candler T, Mahmoud O, Lynn R, Majbar A, Barrett T, Shield J. Continuing rise of Type 2 diabetes incidence in children and young people in the UK. *Diabetic Medicine*. 2018;35(6):737-44.
4. Association AD. Type 2 Diabetes in Children and Adolescents. 2000.
5. Barkai L, Kiss Z, Rokszin G, Abonyi-Tóth Z, Jermendy G, Wittmann I, et al. Changes in the incidence and prevalence of type 1 and type 2 diabetes among 2 million children and adolescents in Hungary between 2001 and 2016—a nationwide population-based study. *Archives of Medical Science: AMS*. 2020;16(1):34.
6. Williams ED, Tapp RJ, Magliano DJ, Shaw JE, Zimmet PZ, Oldenburg BF. Health behaviours, socioeconomic status and diabetes incidence: the Australian Diabetes Obesity and Lifestyle Study (AusDiab). *Diabetologia*. 2010;53(12):2538-45.
7. WHOEurope. Recommended levels of physical activity for children aged 5 - 17 years [Available from: http://www.who.int/dietphysicalactivity/factsheet_young_people/en/].
8. World Health Organization. Global recommendations on physical activity for health: World Health Organization; 2010.
9. Dunstan DW, Howard B, Healy GN, Owen N. Too much sitting—a health hazard. *Diabetes research and clinical practice*. 2012;97(3):368-76.
10. Vlaams Instituut Gezond Leven. Vlaamse gezondheidsaanbevelingen sedentair gedrag (lang stilzitten) en lichaamsbeweging. 2017.

11. Tremblay MS, Leblanc AG, Janssen I, Kho ME, Hicks A, Murumets K, et al. Canadian sedentary behaviour guidelines for children and youth. *Appl Physiol Nutr Metab*. 2011;36(1):59-64; 5-71.
12. Tremblay MS, Carson V, Chaput J-P, Connor Gorber S, Dinh T, Duggan M, et al. Canadian 24-hour movement guidelines for children and youth: an integration of physical activity, sedentary behaviour, and sleep. *Applied Physiology, Nutrition, and Metabolism*. 2016;41(6):S311-S27.
13. WHOEurope. Fruit and Vegetables for Health, Report of a Joint FAO/WHO Workshop.
14. World Health Organization. Information note about intake of sugars recommended in the WHO guideline for adults and children. WHO: Geneva, Switzerland. 2015.
15. Rampersaud GC, Pereira MA, Girard BL, Adams J, Metz J. Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents. *J Am Diet Assoc*. 2005;105(5):743-60; quiz 61-2.
16. Tetens I. European Food Safety Authority: EFSA: Panel on Dietetic Products, Nutrition, and Allergies (NDA); Scientific Opinion on Dietary reference values for water. *EFSA J*. 2010;8:1459.
17. Van Hecke L, Loyen A, Verloigne M, Van der Ploeg HP, Lakerveld J, Brug J, et al. Variation in population levels of physical activity in European children and adolescents according to cross-European studies: a systematic literature review within DEDIPAC. *Int J Behav Nutr Phy*. 2016;13(1):70.
18. Loyen A, Van Hecke L, Verloigne M, Hendriksen I, Lakerveld J, Steene-Johannessen J, et al. Variation in population levels of physical activity in European adults according to cross-European studies: a systematic literature review within DEDIPAC. *Int J Behav Nutr Phys Act*. 2016;13:72.
19. Bennie JA, Chau JY, van der Ploeg HP, Stamatakis E, Do A, Bauman A. The prevalence and correlates of sitting in European adults-a comparison of 32 Eurobarometer-participating countries. *Int J Behav Nutr Phy*. 2013;10(1):107.
20. Santaliestra-Pasias AM, Mouratidou T, Verbestel V, Bammann K, Molnar D, Sieri S, et al. Physical activity and sedentary behaviour in European children: the IDEFICS study. *Public Health Nutr*. 2014;17(10):2295-306.
21. Brug J, van Stralen MM, te Velde SJ, Chinapaw MJ, De Bourdeaudhuij I, Lien N, et al. Differences in weight status and energy-balance related behaviors among schoolchildren across Europe: the ENERGY-project. *Plos One*. 2012;7(4):e34742.
22. Yngve A, Wolf A, Poortvliet E, Elmadfa I, Brug J, Ehrenblad B, et al. Fruit and vegetable intake in a sample of 11-year-old children in 9 European countries: The Pro Children Cross-sectional Survey. *Ann Nutr Metab*. 2005;49(4):236-45.
23. Eurostat. 1 in 7 persons aged 15 or over eats at least 5 portions of fruit or vegetables daily... 2016 [Available from: <https://ec.europa.eu/eurostat/documents/2995521/7694616/3-14102016-BP-EN.pdf/1234ac94-27fd-4640-b9be-427a42d54881>].
24. Guelinckx I, Iglesia I, Bottin J, De Miguel-Etayo P, Gonzalez-Gil E, Salas-Salvado J, et al. Intake of water and beverages of children and adolescents in 13 countries. *European journal of nutrition*. 2015;54(2):69-79.

25. Svensson Å, Larsson C, Eiben G, Lanfer A, Pala V, Hebestreit A, et al. European children's sugar intake on weekdays versus weekends: the IDEFICS study. *European journal of clinical nutrition*. 2014;68(7):822.
26. Guelinckx I, Ferreira-Pêgo C, Moreno LA, Kavouras SA, Gandy J, Martinez H, et al. Intake of water and different beverages in adults across 13 countries. *European journal of nutrition*. 2015;54(2):45-55.
27. Fernandez-Alvira JM, Bammann K, Pala V, Krogh V, Barba G, Eiben G, et al. Country-specific dietary patterns and associations with socioeconomic status in European children: the IDEFICS study. *Eur J Clin Nutr*. 2014;68(7):811-21.
28. Lampinen EK, Eloranta AM, Haapala EA, Lindi V, Vaisto J, Lintu N, et al. Physical activity, sedentary behaviour, and socioeconomic status among Finnish girls and boys aged 6-8 years. *European journal of sport science*. 2017;17(4):462-72.
29. Tamayo T, Rosenbauer J, Wild S, Spijkerman A, Baan C, Forouhi N, et al. Diabetes in Europe: an update. *Diabetes research and clinical practice*. 2014;103(2):206-17.
30. Manios Y, Androutsos O, C. L, Cardon G, J. L, Annemans L, et al. A school- and community-based intervention to promote healthy lifestyle and prevent type 2 diabetes in vulnerable families across Europe: design and implementation of the Feel4Diabetes-study. *Public Health Nutrition*. 2018.
31. VDAB. VDAB-Arvastat: Vlaamse overheid; 2015 [Available from: https://arvastat.vdab.be/arvastat_basisstatistieken_werkloosheid.html].
32. The Hellenic Statistical Authority. Hellenic Statistical Authority (ELSTAT) 2015 [Available from: <https://www.statistics.gr/>].
33. Statistics Finland's PxWeb databases [cited 2019 October]. Available from: http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__vrm__vaerak/?rxid=6b89654c-24b1-4509-816f-80b00b6e497f
34. Instituto Aragonés de Estadística (IAEST) [Available from: <https://www.aragon.es/en/organismos/departamento-de-economia-planificacion-y-empleo/direccion-general-de-economia/instituto-aragones-de-estadistica-iaest>].
35. Manios Y, Mavrogianni C, Lambrinou C-P, Cardon G, Lindström J, Iotova V, et al. Two-stage, school and community-based population screening successfully identifies individuals and families at high-risk for type 2 diabetes: the Feel4Diabetes-study. *BMC Endocrine Disorders*. 2020;20(1):1-11.
36. Androutsos O, Anastasiou C, Lambrinou C-P, Mavrogianni C, Cardon G, Van Stappen V, et al. Intra- and inter-observer reliability of anthropometric measurements and blood pressure in primary schoolchildren and adults: the Feel4Diabetes-study. *BMC Endocrine Disorders*. 2020;20(1):1-6.
37. Anastasiou CA, Fappa E, Zachari K, Mavrogianni C, Van Stappen V, Kivelä J, et al. Development and reliability of questionnaires for the assessment of diet and physical activity behaviors in a multi-country sample in Europe the Feel4Diabetes Study. *BMC Endocrine Disorders*. 2020;20(1):1-7.
38. Lindstrom J, Tuomilehto J. The diabetes risk score: a practical tool to predict type 2 diabetes risk. *Diabetes Care*. 2003;26(3):725-31.

39. Saaristo T, Peltonen M, Lindstrom J, Saarikoski L, Sundvall J, Eriksson JG, et al. Cross-sectional evaluation of the Finnish Diabetes Risk Score: a tool to identify undetected type 2 diabetes, abnormal glucose tolerance and metabolic syndrome. *Diabetes & vascular disease research*. 2005;2(2):67-72.
40. Pérez CE. Fruit and vegetable consumption. *Health Rep*. 2002;13(3):23-31.
41. De Craemer M, Lateva M, Iotova V, De Decker E, Verloigne M, De Bourdeaudhuij I, et al. Differences in Energy Balance-Related Behaviours in European Preschool Children: The ToyBox-Study. *Plos One*. 2015;10(3).
42. Graham E, Gariépy G, Burns RJ, Schmitz N. Demographic, lifestyle, and health characteristics of older adults with prediabetes in England. *Preventive medicine*. 2015;77:74-9.
43. Buckley C, Madden J, Balanda K, Barron S, Fahy L, Harrington J, et al. Pre-diabetes in adults 45 years and over in Ireland: the Survey of Lifestyle, Attitudes and Nutrition in Ireland 2007. *Diabetic medicine*. 2013;30(10):1198-203.
44. Santaliestra-Pasías AM, Mouratidou T, Verbestel V, Bammann K, Molnár D, Sieri S, et al. Physical activity and sedentary behaviour in European children: the IDEFICS study. *Public health nutrition*. 2014;17(10):2295-306.
45. Ramsay SA, Bloch TD, Marriage B, Shriver LH, Spees CK, Taylor CA. Skipping breakfast is associated with lower diet quality in young US children. *European journal of clinical nutrition*. 2018;72(4):548-56.
46. World Health Organization. Physical Activity Factsheets for the 28 European Union Member States of the Who European Region. WHO Regional Office for Europe Copenhagen; 2018.
47. Miller LJW, L. These are the World's Healthiest Nations 2019 [cited 2020 January, 7th]. Available from: <https://www.bloomberg.com/news/articles/2019-02-24/spain-tops-italy-as-world-s-healthiest-nation-while-u-s-slips>.
48. De Craemer M, Lateva M, Iotova V, De Decker E, Verloigne M, De Bourdeaudhuij I, et al. Differences in energy balance-related behaviours in European preschool children: the ToyBox-study. *Plos One*. 2015;10(3):e0118303.
49. Food and Agriculture Organization of the United Nations. Food-based dietary guidelines - Finland [Available from: <http://www.fao.org/nutrition/education/food-dietary-guidelines/regions/countries/Finland/en>].
50. Marmot M, Bell R. Fair society, healthy lives. *Public health*. 2012;126 Suppl 1:S4-S10.
51. Morgan PJ, Young MD, Lloyd AB, Wang ML, Eather N, Miller A, et al. Involvement of Fathers in Pediatric Obesity Treatment and Prevention Trials: A Systematic Review. *Pediatrics*. 2017;139(2).
52. Edwardson CL, Gorely T. Parental influences on different types and intensities of physical activity in youth: A systematic review. *Psychol Sport Exerc*. 2010;11(6):522-35.
53. Patrick H, Nicklas TA. A review of family and social determinants of children's eating patterns and diet quality. *Journal of the American College of Nutrition*. 2005;24(2):83-92.
54. Morgan PJ, Young MD. The Influence of Fathers on Children's Physical Activity and Dietary Behaviors: Insights, Recommendations and Future Directions. *Curr Obes Rep*. 2017;6(3):324-33.

55. Neshteruk CD, Nezami BT, Nino-Tapias G, Davison KK, Ward DS. The influence of fathers on children's physical activity: a review of the literature from 2009 to 2015. *Preventive medicine*. 2017;102:12-9.
56. Fuemmeler BF, Anderson CB, Mâsse LC. Parent-child relationship of directly measured physical activity. *Int J Behav Nutr Phy*. 2011;8(1):17.
57. Scaglioni S, De Cosmi V, Ciappolino V, Parazzini F, Brambilla P, Agostoni C. Factors influencing children's eating behaviours. *Nutrients*. 2018;10(6):706.
58. Latomme J, Huys N, Cardon G, Morgan PJ, Lateva M, Chakarova N, et al. Do physical activity and screen time mediate the association between European fathers' and their children's weight status? Cross-sectional data from the Feel4Diabetes-study. *The international journal of behavioral nutrition and physical activity*. 2019;16(1):100.
59. Yogman M, Garfield CF, Child CoPAo, Health F. Fathers' roles in the care and development of their children: the role of pediatricians. *Pediatrics*. 2016;138(1).
60. Davison KK, Charles JN, Khandpur N, Nelson TJ. Fathers' perceived reasons for their underrepresentation in child health research and strategies to increase their involvement. *Maternal and child health journal*. 2017;21(2):267-74.
61. Rosenman R, Tennekoon V, Hill LG. Measuring bias in self-reported data. *International journal of behavioural & healthcare research*. 2011;2(4):320.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Additionalfile1.pdf](#)
- [Additionalfile2.pdf](#)