Project Spraoi: Dietary Intake, Nutritional Knowledge, Cardiorespiratory Fitness and Health Markers of Irish Primary School Children

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Abstract: *Objective*: Examine dietary intake (DI), anthropometric measures, cardiorespiratory fitness (CRF) and nutritional knowledge (NK) of school children.

Design: Cross-sectional study. Food Diary, NK questionnaire and 550m walk/run test were used to assess DI, NK and CRF respectively. Blood pressure (BP) was also taken and body mass index (BMI) and waist to height ratio (WHtR) were calculated.

Setting: Two primary schools, Cork, Ireland.

Subjects: Six (n = 49, age 5.9 ± 0.6 years) and ten (n = 52, age 9.8 ± 0.5 years) year olds.

Results: Intakes of fruit and vegetables, fibre, calcium and iron were sub-optimal. Unhealthy snacks and saturated fat intakes were higher than recommended. A total of 24.4% of six year olds and 35.4% of ten year olds were classified as 'fast'. Furthermore, 45.9% of six and ten year olds had high-normal BP and 27.9% had high BP. NK was negatively correlated with sugar intake ($r = -0.321$, $p = 0.044$) in ten year olds. WHtR was negatively correlated with servings of vegetables in six year olds ($r = -0.377$, $p = 0.014$). For ten year olds, there was a positive correlation between WHtR and run score ($r = 0.350$, $p = 0.014$) and BMI and run score ($r = 0.482$, $p = 0.001$).

Conclusion: This study highlights, for the first time, DI, NK, CRF, BP and anthropometric data for Irish children and their potential combined effect on overall health. Study results suggest preventive initiatives are needed, in children as young as 6 years of age.

Keywords: Dietary Intake, Nutritional Knowledge, CRF, BP, Health Markers, Irish Children.

INTRODUCTION

There is currently a shortage of information on the nutritional status of primary school children in Ireland. Regular collection of such data is important as current dietary behaviours and practices observed in children may have harmful effects on their health [1]. Conditions such as overweight and obesity, type 2 diabetes mellitus, high blood pressure (BP) and heart disease have all been attributed to poor dietary habits [2,3]. The World Health Organization (WHO) assert that foods that are high in fat and sugars but low in vitamins, minerals and other important micronutrients are one of the primary causes driving the rising levels of childhood obesity [4]. Furthermore, the WHO advocate that adequate fruit and vegetable consumption in children may protect against many childhood illnesses, as they are important sources of a wide range of vital micronutrients [5]. There is very limited up to date research published on the dietary intake of children in Ireland, particularly in the Cork region. Of that which is available, the most recent National Children's Food Survey (NCFS) highlighted low fruit and vegetable intakes among Irish children aged five – twelve years [6].

Cardiorespiratory fitness (CRF) is a powerful marker of health in childhood [7,8], with high levels of childhood CRF associated with lower total adiposity(9,10) and reduced risk of developing cardiovascular disease (CVD) [8,10]. Worldwide, levels of CRF in children are decreasing, with children currently about 15% less fit than their parents were at the same age [11]. To date, only one study in Ireland has objectively investigated CRF in children and found that both BMI and waist circumference were inversely related to CRF [12]. However, detailed data on the CRF levels of primary school children remains low in Ireland.

Anthropometric data for children reflect general health status, dietary adequacy and growth and development [13]. A recent study by Gonclaves *et al*. [14]. (2014) highlighted the significant association between body mass index (BMI) and low CRF with CVD risk factors. As childhood obesity has an important influence on overall CVD risk [15] and is likely to track to later life [4], anthropometric

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measurements, BP and CRF provide valuable information at an early life stage. Anderson *et al*. [16] found that low levels of CRF, raised BMI, low levels of physical activity (PA) and unhealthy dietary patterns, may influence the development of unhealthy risk profiles in children. Waist-to-height ratio (WHtR) is considered an accurate anthropometric measure in identifying children with cardiovascular risk factors [17] and is a good predictor of adverse lipid profile among children [17]. In fact, waist circumference and WHtR have been shown to be better predictors of CVD risk factors in children than BMI [18].

Nutrition education is a key element to promoting lifelong healthy eating [19]. Improving nutritional knowledge (NK) among children may help them to make healthier food choices [20,21]. There is some evidence of a strong correlation between NK and dietary quality [22], which supports the inclusion of NK in health education campaigns but research of this kind, in Ireland, remains limited.

Only a small number of Irish studies [12,23] have objectively assessed the dietary intake (DI), CRF or physical activity (PA) of primary school children, but these parameters have been examined in isolation. This study will be the first of its kind in Ireland to measure, in combination, the DI, NK and CRF status of Irish primary school children.

METHODOLOGY USED

Subject Participation

Data was collected in October 2014, a total of 101 children (six year olds, n=49 ten year olds, n=52) from two Cork schools participated (48.1% boys; 51.9% girls). The mean age for the 'Senior Infants Class' was 5.9 ± 0.6 years and 9.8 ± 0.5 years for 'Fourth Class' students; these participants will subsequently be referred to as six and ten year olds. Two schools were selected via convenience sampling for the purpose of a larger study, 'Project Spraoi', (http://www.cit.ie/projectspraoi) a primary school-based PA and nutrition intervention project, described in detail elsewhere [24] (http://www.isrctn.com/ISRCTN92611015). Inclusion criteria for schools included: mixed, middle/high socio economic status (SES), rural, medium sized [25], proximity of 20 km to the research Institute, willingness to implement the 'Project Spraoi' intervention and not currently participating in another PA and/or healthy eating intervention in their school [24]. Informed consent and parental consent were required from all children before participation. Ethical approval was obtained from Cork Institute of Technology Research Ethics Review Board in September 2013.

Dietary Analysis

DI and nutritional behaviours were examined via a four-day estimated food diary (two weekday and two weekend days) that was adapted from the Cork Children's Lifestyle Study (CCLaS) three day food diary [26]. Instructions to complete the food diary were provided to participants by the researcher in the classroom setting on each day of diary completion and in written format. Each day was broken into six meal sections; breakfast, morning snack, lunch, afternoon snack, dinner and evening snack. Ten year old children were advised to seek help from parents and teachers when filling in their food diary. Parents of the six-year-old children were asked to complete the food diary on behalf of their child. To encourage accurate recording of portion sizes, images from the Young Person's Food Atlas Primary [27] were included with the diary, which were then used for quantification by the researcher. Where no estimation was given, an age appropriate median portion size was assigned using the Irish Food Portion Sizes Database [28]. Number of unhealthy snacks (sweets, crisps, chocolate, ice-cream, cake, biscuits, bars and pastries) were estimated using the Irish Food Portion Sizes Database [28].

All foods and beverages were firstly entered into the Dietplan 7 (Forestfield Software Ltd, Horsham, UK, 2015) software package and subsequently exported to SPSS (Version 22) for analysis. Analysis examined fruit and vegetable intake, number of unhealthy snacks per day and macro- (protein, fat, saturated fat, carbohydrate) and micro- (sodium, calcium and iron) nutrient intake.

Identifying Under-Reporters

To identify under-reporters, each participant's basal metabolic rate (BMR, based on their age, sex and weight according to Schofield *et al*. [28] was multiplied by an assigned age and gender specific physical activity level (PAL), (Torun *et al*. [30]) to estimate total daily energy requirements. The minimum PAL cut off values were applied (males and females aged one-five years = 1.28, 1.39 for males aged six-eighteen years and 1.30 for females aged six-eighteen years). Each child's total energy intake was then compared to their estimated requirements and it was found that 54.5% of children were classified as under-reporters.

Nutrition Knowledge Questionnaire

All participants completed a validated questionnaire, titled 'Fit Kids 'r' Healthy Kids' [31] relating to their knowledge of healthy eating. The questionnaire was first piloted by the researcher in a primary school in Cork (n=23) to ensure its age appropriateness and relevance to an Irish setting. Minor changes were made to the pictures in the questionnaire and the Irish Food Pyramid (2012) [32] replaced the United States Department of Agriculture (USDA) food pyramid [33] used in the original questionnaire [31]. The questionnaire contained 15 multiple-choice questions that assessed knowledge on food groups, healthful foods and food functions.

Anthropometric and Blood Pressure Measurements

Height, body mass, BP, heart rate and waist circumference measurements were carried out, as detailed in Table **1**. Height and body mass values were used to calculate BMI and BMI Z scores [34]. International Obesity Task Force (IOTF) [35], age-adjusted cut off points were then applied to the data in order to assign BMI classifications (thinness, normal, overweight, obese) and to make international comparisons. Children were classified into BP categories (normal, high-normal and high) according to gender and age-specific BP cut-points [36]. Waist circumference and height measurements were used to calculate WHtR. Since, a WHtR higher than 0.50 is considered to be an indicator of central obesity in children [37,38], children were classified into two categories (WHtR <0.50 and WHtR ≥0.50).

Cardiorespiratory Fitness

CRF was measured using a validated 550m walk/run test [39,40]. A 110 metre rope was set up on a level grassed area outside. After the walk/run was explained, all children participated in a warm up lap. Then in groups of up to five, participants were asked to complete 5 laps as fast as they could. Times for each participant were recorded using stopwatches. Run scores were classified into fast ($\leq 50^{th}$ centile) and slow ($>50^{th}$ centile) categories based on the Waikato 2011 centile charts for time to complete 550m [41].

Data Analysis

Data was analysed using IBM SPSS (Version 22.0 for Windows). Descriptive statistics were used to explore and summarise the data. Normality was explored using descriptive statistics, histograms and Shapiro-Wilk tests were used to determine whether measurements were normally distributed. Levene's test was used to test the homogeneity of variances. Mean and standard deviations were calculated for all continuous variables, while frequencies and percentages were used to summarise categorical variables. Missing values were due to children being absent on the day of testing. All statistical testing was performed using a 5% level of significance. Independent samples *t*-tests and Fisher's Exact

Table 1: Details of Anthropometric and BP Measurements Undertaken (Adapted from Coppinger *et al*., 2016)

Measure	Assessment tool	Method notes
Height Unit : cm	Leicester portable height scales	Shoes were removed prior to measurement. Two measurements taken to the nearest 0.1cm. A third measurement was taken if the difference was >0.5cm.
Body Mass Unit: kg	Tanita WB100MZ portable electronic scale	Heavy outer clothing and shoes were removed prior to measurement. Two measurements taken to the nearest 0.1kg. A third measurement was taken if the difference was >0.5kg.
Waist circumference (WC) Unit: cm	Non-stretch Seca 200 measuring tape	Measured as the circumference of the narrowest point of the abdomen between the lower costal border and the top of the iliac crest, perpendicular to the long axis of the trunk. Two measurements taken to the nearest 0.1cm. A third measurement was taken if the difference was >0.5cm.
Waist to height ratio (WHtR) Unit: cm	Non-stretch Seca 200 measuring tape and Leicester portable height scales	WHtR is calculated by dividing waist circumference by height
Heart rate (HR) Unit: Beats per minute (BPM)	Omron M2 Basic Auto Blood Pressure Monitor	HR and BP were measured twice on the right arm in a seated position, with the cuff positioned 2cm above the elbow. Children were required to sit quietly prior to measurement. A third measurement for BP was taken if the difference was >10mmHg.
Blood Pressure (BP) Unit: mmHg	Omron M2 Basic Auto Blood Pressure Monitor	

probability test were used to explore statistically significant differences in measurements across gender. Pearson correlation coefficient and Spearman's rank correlation coefficient was used to analyse possible associations among variables. The criteria used by Cohen [42] for the correlations was used to indicate the strength of the correlation between the measurements; weak $0.1 \leq r < 0.3$, moderate $0.3 \leq r < 0.5$ and strong $r \geq 0.5$.

RESULTS

Dietary Intake Data

Dietary and nutrient intake data categorised by age and gender, are presented in Table **2**. Intakes of calcium and iron were below reference intakes for the 5-13 year age group [43]. Additionally, fibre intakes were sub-optimal for 10 year olds. Sodium intake was 249mg higher for ten year old males compared to ten year old females ($p = 0.020$). Calcium intake for ten year olds males was also 148.65mg higher compared to ten year old females ($p = 0.020$). There were no other significant differences in dietary intake by age or gender. Saturated fat intake was higher than the recommended <10% total energy, ranging from 14.3-17.7%.

Table **3** details the servings of fruits and vegetables, together with the number of unhealthy snacks consumed per day. While six year olds consumed significantly ($p = 0.039$) more total fruit and vegetables (2.26 ± 1.26 and 2.55 ± 1.72 servings/day for males and females, respectively) compared to ten year olds (1.73 ± 1.02 and 1.86 ± 0.95 servings/day for males and females, respectively), findings show that total fruit and vegetable intake was lower than recommended (5-7 servings/day) for both age groups. Number of unhealthy snacks was also higher than the recommendation to not consume unhealthy snacks every day [44], with six and ten year olds consuming 1.23 and 1.52 servings per day, respectively.

Nutritional Knowledge

The maximum possible score from the NK questionnaire data was 15. There was no statistical difference in mean scores between six year old boys and girls (9.25 ± 2.15 and 9.40 ± 2.16, respectively) and ten year old boys and girls (12.95 ± 1.26 and 12.28 ± 1.43, respectively). Ten year olds scored significantly higher, by 3.26 points, compared to the six year olds.

Anthropometric and Blood Pressure Data

Anthropometric and BP data categorised by age and gender, are presented in Table **4**. Descriptive

Table 2: Dietary and Nutrient Intakes for 6 and 10 Year Old Irish Primary School Children

	6 year olds		10 year olds	
	Males	**Females**	**Males**	**Females**
Fibre (g) RI = Age + 5g [4]	11.09 ± 2.94	11.39 ± 4.09	11.16 ± 2.91	10.73 ± 2.44
Calcium (mg) RI = 800-1300mg[4]	695.47± 209.63	721.07 ± 237.80	706.89 ± 238.85*	558.24 ± 170.30*
Iron (mg) RI = 8-11mg[4]	6.84 ± 1.60	7.29 ± 1.99	7.24 ± 1.83	6.33 ± 1.69
Sodium (mg)(<1600mg) (FSAI,2011)	1441.1 ± 269.58	1385.26 ± 439.87	1588.00 ± 395.36*	1338.92 ± 325.49*
Protein (%) AMDR =10-30%[5]	15.29 ± 1.75	15.38 ± 2.76	15.06 ± 2.74	14.93 ± 2.39
Fat (%) AMDR = 20-35%[4]	34.31 ± 3.95	35.68 ± 4.92	36.22 ± 4.37	34.88 ± 4.24
Saturated Fat (%) AMDR = <10%[4]	14.70 ± 3.49	17.17 ± 1.25	15.85 ± 3.44	14.30 ± 2.41
Carbohydrate (%) DRV = 45-60% (EFSA,2010)	48.74 ± 4.35	47.19 ± 5.71	47.21 ± 4.70	48.52 ± 4.23
Sugar (%)	21.26 ± 5.03	20.29 ± 6.21	18.68 ± 4.29	20.32 ± 5.19
Total Energy (kcals)	1308.26 ± 147.20	1281.53 ± 362.48	1437.16 ± 274.51	1311.40 ± 342.25

Data represents mean ± standard deviation. * Difference is significant at the 0.05 level, for males versus females in the same age group.

Table 3: Servings of Fruit and Vegetables and Number of Unhealthy Snacks of Irish Primary School Children

	6 year olds		10 year olds	
	Males	**Females**	**Males**	**Females**
Fruit intake (servings/day)	1.31 ± 0.78	1.42 ± 1.01	1.01 ± 0.77	1.04 ± 0.78
Vegetable intake (servings/day)	0.90 ± 0.64	1.13 ± 0.79	0.72 ± 0.55	0.77 ± 0.43
Total fruit/veg (servings/day)	2.26 ± 1.26*	2.55 ± 1.72*	1.73 ± 1.02*	1.86 ± 0.95*
Number of unhealthy snacks (servings/day)	1.21 ± 0.67	1.26 ± 0.79	1.40 ± 0.95	1.63 ± 0.91

Data represents mean ± standard deviation. Measurements were statistically insignificant across gender ($p > 0.05$).
*Denotes significant difference at the 0.05 level between six year olds and ten year olds.

Table 4: Anthropometric and BP Data for Irish Primary School Children

	6 year olds		10 year olds	
	Males	**Females**	**Males**	**Females**
Height (cm)	117.33 ± 4.78	115.59 ± 5.66	139.87 ± 4.59	140.41 ± 6.01
Weight (kg)	22.60 ± 3.18	21.58 ± 2.49	34.47 ± 5.79	34.73 ± 5.93
BMI (kg/m^2)	16.36 ± 1.53	16.13 ± 1.31	17.36 ± 2.47	17.53 ± 2.27
BMI Z score	0.57 ± 0.96	0.29 ± 0.68	0.35 ± 1.03	0.10 ± 0.88
WHtR	0.45 ± 0.03	0.45 ± 0.03	0.43 ± 0.03	0.42 ± 0.03
Systolic BP (mmHg)	104.31 ± 8.89	103.44 ± 9.32	105.72 ± 12.90	105.52 ± 12.33
Diastolic BP (mmHg)	61.56 ± 8.99	61.52 ± 9.82	63.57 ± 10.44	64.70 ± 9.59
Heart rate (bpm)	85.63 ± 9.21	88.66 ± 12.35	79.46 ± 10.67	81.04 ± 14.89

Data represents mean ± standard deviation. BP: Blood Pressure; BMI: Body Mass Index; WHtR: Waist to Height Ratio.

analysis of baseline data revealed that 85 (84.2%) children were normal weight, 11 (10.9%) were overweight, 4 (4.0%) were obese and 1 (1.0%) was underweight, based on IOTF classifications [35]. When categorised by age and gender, a total of 5 (21.0%) six year old boys and 3 (12%) six year old girls were overweight or obese. Among ten year old children, 3 (13.0%) boys and 4 (13.7%) girls were overweight or obese.

Descriptive analysis of baseline data revealed that 93 (93.0%) children had a WHtR < 0.50 while 7 (7.0%) children had a WHtR ≥ 0.50. When categorised by age and gender, a total of 3 (13.0%) six year old boys and 2 (8.0%) six year old girls had a WHtR ≥ 0.50. Among ten year old children, 1 (4.3%) boy and 1 (3.4%) girl had a WHtR ≥ 0.50.

BP centiles, as detailed by Jackson *et al*. [36] were used to categorise children as normal, high-normal and high BP. Descriptive analysis of baseline data revealed that 34 (69.4%) six year old children had normal BP, 9 (18.4%) had high-normal and 6 (12.2%) had high BP. In ten year olds, 29 (56.9%) had normal BP, 14 (27.5%) had high-normal and 8 (15.7%) had high BP. Mean resting heart rates for both age groups were within the normal centiles for age and gender [36].

Cardiorespiratory Fitness

Percentages of children assigned to the fast or slow category, by age and gender, are presented in Table **5**. Only 24.4% of six year olds were classified as fast, while 75.6% were classified as slow. However, this percentage increased for ten year olds, with 35.4% classified as fast and 64.6% classified as slow. A

Table 5: Fast & Slow Run Categories of Irish Primary School Children

	6 year olds			10 year olds		
	Males	**Females**	**All**	**Males**	**Females**	**All**
Fast Category (≤50th Centile)	6 (26.1%)	5 (22.7%)	11 (24.4%)	9 (39.1%)	8 (32%)	15 (35.4%)
Slow Category (>50th Centile)	17 (73.9%)	17 (77.3%)	34 (75.6%)	14 (60.9%)	17 (68%)	31 (64.6%)
All	23 (100.0%)	22 (100.0%)	45 (100.0%)	23 (100.0%)	25 (100.0%)	46 (100.0%)

Table 6: Relationships between Dietary Intake, Nutritional Knowledge, Anthropometric Measurements, BP and CRF for 6 Year Olds

Measurements	BMI	SBP	DBP	Pulse	WHtR	Run Score	Nut. Score	Fibre	Sat Fat	Trans fat	Na	Ca	Iron	Fruit	Veg	Fruit & Veg	Unhealthy Snacks	% Fat	% CHO	% Pro	% Sugar
BMI	1	.222^	-.006^	-.088^	.660**^	-.012^	-.075^	-.001^	.050^	.051^	.244^	-.044^	-.192^	-.089^	-.467**^	-.338^	.127^	-.059^	.097^	-.096^	-.057^
SBP		1	.469**ɣ	.074ɣ	-.010ɣ	-.193ɣ	.096ɣ	.121ɣ	-.151ɣ	.008ɣ	.120ɣ	.001ɣ	.038ɣ	-.127^	-.085^	-.158^	.042ɣ	-.038ɣ	.038ɣ	-.032ɣ	-.109ɣ
DBP			1	.042ɣ	.210ɣ	.126ɣ	-.074ɣ	-.201ɣ	-.320ɣ	-.332ɣ	-.207ɣ	-.134ɣ	-.124ɣ	-.359^	-.316^	-.357^	-.054ɣ	.013ɣ	.014ɣ	-.042ɣ	-.190ɣ
Pulse				1	-.084ɣ	-.003ɣ	-.092ɣ	.022ɣ	.037ɣ	-.030ɣ	-.070ɣ	.032ɣ	.094ɣ	.032^	-.011^	-.019^	-.039ɣ	.131ɣ	-.038ɣ	-.184ɣ	.041ɣ
WHtR					1	.113ɣ	-.282ɣ	-.159ɣ	-.009ɣ	-.040ɣ	-.110ɣ	-.071ɣ	-.274ɣ	.076^	-.377**^	-.168^	.156ɣ	-.150ɣ	.266ɣ	-.271ɣ	.138ɣ
Run Score						1	.009ɣ	-.116ɣ	-.135ɣ	-.256ɣ	-.454*ɣ	-.187ɣ	-.007ɣ	.034^	-.164^	-.059^	-.301ɣ	-.248ɣ	.234ɣ	-.064ɣ	.136ɣ
Nut Knowledge							1	-.066ɣ	-.102ɣ	-.112ɣ	-.058ɣ	.070ɣ	.015ɣ	.188^	.319^	.310^	-.081ɣ	-.160ɣ	-.047ɣ	.430*ɣ	.139ɣ
Fibre								1	.344**ɣ	.220ɣ	.503**ɣ	.311ɣ	.572**ɣ	.661	.548^	.475^	.536^	-.203ɣ	.228ɣ	-.260ɣ	.119ɣ
Saturated Fat									1	.718**ɣ	.652**ɣ	.526**ɣ	.523**ɣ	.112^	.064^	.048^	.364*ɣ	.464**ɣ	-.300ɣ	-.224ɣ	-.108ɣ
Trans fat										1	.591**ɣ	.699**ɣ	.418*ɣ	.074^	.157^	.102^	.357*ɣ	.450**ɣ	-.365*ɣ	-.024ɣ	-.035ɣ
Sodium											1	.539**ɣ	.389*ɣ	.029^	.124^	.069^	.253ɣ	.264ɣ	-.251ɣ	.031ɣ	-.249ɣ
Calcium												1	.506**ɣ	.243^	.180^	.226^	.122ɣ	.194ɣ	-.239ɣ	.172ɣ	-.054ɣ
Iron													1	.345*^	.399*^	.402*^	.166ɣ	.099ɣ	-.075ɣ	-.084ɣ	-.012ɣ
Fruit														1	.560**^	.863**^	.310^	-.352*^	.288^	-.045^	.511**^
Vegetables															1	.874**^	.340*^	-.088^	-.065^	.203^	.265^
Fruit & Vegetables																1	.342*^	-.255^	.117^	.143^	.407*^
Unhealthy Snacks																	1	.039ɣ	.003ɣ	-.056ɣ	.284ɣ
% Fat																		1	-.899**ɣ	.111ɣ	-.662**ɣ
% CHO																			1	-.528**ɣ	.648**ɣ
% Protein																				1	-.166ɣ
% Sugar																					1ɣ

*Correlation is significant at the 0.05 level, **Correlation is significant at the 0.01 level. ^: Spearman's Rank Order Correlation. ɣ: Pearson's product-moment correlation. BP: Blood Pressure; BMI: Body Mass Index; WHtR: Waist to Height Ratio. Na: sodium, Ca: calcium, CHO: Carbohydrates, Pro: protein.

Table 7: Relationships between Dietary Intake, Nutritional Knowledge, Anthropometric Measurements, BP and CRF for 10 Year Olds

Measurements	BMI	SBP	DBP	Pulse	WHtR	Run Score	Nut. Score	Fibre	Sat Fat	Trans fat	Na	Ca	Iron	Fruit	Veg	Fruit & Veg	Unhealthy Snacks	% Fat	% CHO	% Pro	% Sugar
BMI	1	.083^	.197^	-.157^	.554**^	.482**^	.083^	.011^	-.023^	-.053^	.025^	-.030^	.073^	.058^	-.079^	.002^	.059^	.305^	-.224^	-.060^	-.233^
SBP		1	.667**ɣ	-.070ɣ	.159^	-.206ɣ	-.130^	-.026ɣ	.304*ɣ	.149ɣ	.136^	.302*^	.029ɣ	.010^	.106ɣ	.102ɣ	.192ɣ	.254ɣ	-.036ɣ	-.327*ɣ	-.013ɣ
DBP			1	.019ɣ	.260^	-.016ɣ	-.066^	-.093ɣ	.281ɣ	.154ɣ	.086^	.279^	.068ɣ	-.179^	.015ɣ	-.083ɣ	.216ɣ	.331*ɣ	-.106ɣ	-.342*ɣ	-.008ɣ
Pulse				1	-.017^	.033ɣ	-.141^	-.095ɣ	-.044ɣ	.132ɣ	-.143^	-.202^	-.041ɣ	.026^	.316*ɣ	.183ɣ	-.154ɣ	-.026ɣ	.057ɣ	-.045ɣ	.010ɣ
WHtR					1	.350*^	.240^	-.052^	-.007^	.138^	.082^	.095^	.022^	-.300^	.018^	-.296^	-.037^	.166^	-.196^	.052^	-.361*^
Run Score						1	.156^	-.100ɣ	-.440**ɣ	-.479**ɣ	-.371*^	-.312*^	-.236ɣ	-.037^	-.101ɣ	-.105ɣ	.047ɣ	-.097ɣ	.056ɣ	.019ɣ	-.024ɣ
Nutrition Knowledge							1	.054^	-.089^	-.089^	-.019^	.084^	-.116^	-.186^	-.140^	-.225^	-.026^	.046^	-.229^	.281^	-.321*^
Fibre								1	.431**ɣ	.356**ɣ	.471**^	.575**^	.661**ɣ	.474**^	.178ɣ	.462**ɣ	.388*ɣ	-.069ɣ	.148ɣ	-.184ɣ	.228ɣ
Saturated Fat									1	.809**ɣ	.708**^	.651**^	.571**ɣ	.130^	.110ɣ	.159ɣ	.411**ɣ	.632**ɣ	-.394ɣ	-.317ɣ	.023ɣ
Transfat										1	.632**^	.641**^	.515ɣ	.148^	.292ɣ	.256ɣ	.074ɣ	.495ɣ	-.437ɣ	-.023ɣ	-.088ɣ
Sodium											1	.585**^	.545**^	-.018^	.096^	.059^	.202^	.410**^	-.255^	-.167^	-.032^
Calcium												1	.642**^	.179^	.189^	.230^	.274^	.232^	-.286^	.097^	.021^
Iron													1	.208^	.018ɣ	.173ɣ	.198ɣ	.150ɣ	-.059ɣ	-.139ɣ	.046ɣ
Fruit														1	.060^	.858**^	.282^	-.333*^	.387*^	-.079^	.452**^
Vegetables															1	.567**ɣ	-.229ɣ	.086ɣ	-.149ɣ	.115ɣ	-.062ɣ
Fruit & Vegetables																1	.151ɣ	-.276ɣ	.269ɣ	-.023ɣ	.359*ɣ
Unhealthy Snacks																	1	.130ɣ	.138ɣ	-.445**ɣ	.513**ɣ
% Fat																		1	-.820**ɣ	-.213ɣ	-.419**ɣ
% CHO																			1	-.381*ɣ	.616**ɣ
% Protein																				1	-.358*ɣ
% Sugar																					1

*Correlation is significant at the 0.05 level, **Correlation is significant at the 0.01 level. ^: Spearman's Rank Order Correlation. ɣ: Pearson's product-moment correlation. BP: Blood Pressure; BMI: Body Mass Index; WHtR: Waist to Height Ratio. Na: sodium, Ca: calcium, CHO: Carbohydrates, Pro: protein.

Fisher's Exact Test indicated no significant difference in fast/slow run category between six year old boys and girls (p = 1.000) and ten year old boys and girls (p = 0.764).

Correlations between DI, NK, Anthropometric Measurements, BP and CRF

Relationships between dietary intake, nutritional knowledge, anthropometric measurements, BP and CRF for six and ten year olds are outlined in Tables **6** and **7**. Using Spearman's rank correlation coefficient, there was a strong, positive correlation between BMI and WHtR for six year olds (r = 0.660, p < 0.01) and ten year olds (r = 0.554, p < 0.01). There was also a medium, positive correlation between BMI and run score in seconds for ten year olds (r = 0.482, p = 0.01). WHtR was negatively correlated with servings of vegetables in six year olds (r = -0.377, p = 0.01), while in ten year olds, there was a positive correlation between WHtR and run score (r = 0.350, p = 0.05). WHtR in ten year olds was also negatively correlated to sugar (r = -0.361, p = 0.05) as a percentage of dietary intake.

Servings of fruit for six year olds was positively correlated with servings of vegetables (r = 0.560, p = 0.001) and sugar intake (r = 0.511, p = 0.002) and negatively correlated with fat intake (r = -0.352, p = 0.041). Servings of fruit for ten year olds was positively correlated with sugar (r = 0.452, p = 0.004) and fibre (r = 0.474, p = 0.002) and negatively correlated with percentage fat (r = -0.333, p = 0.039). NK was positively correlated with percentage protein (r = 0.430, p = 0.011) in six year olds and negatively correlated with percentage sugar (r = -0.321, p = 0.044) in ten year olds. Run score in ten year olds was negatively correlated with saturated fat (r = -0.440, p = 0.004), trans fat (r = -0.479, p = 0.002), sodium (r = -0.371, p = 0.017) and calcium (r = -0.312, p = 0.047) intakes.

DISCUSSION

The study examined DI, anthropometric measures, CRF and NK of Cork primary school children. A total of 84.2% of children were normal weight, 10.9% were overweight, 4% were obese and 1% were thin. These values are significantly lower than those found by Keane *et al*. [45], who found that over one quarter of Cork primary school children were overweight (20.9%) or obese (6.2%), and the NCFS [46] where percentages of overweight and obesity were 20% for boys and 25% for girls aged five to twelve years. This may be related to the SES of schools used in our research, as the two schools included in this study were not from low SES backgrounds. In contrast, the earlier research by Keane *et al*. [45] and the NCFS [46], included schools from low SES backgrounds, which may explain their higher percentages of overweight and obesity [47]. This is supported by research reported in the Growing Up in Ireland study [48] that found 19% of boys and 18% of girls from professional households to be overweight or obese, which increased to 29% of boys and 38% of girls from semi- and un- skilled social class households [49].

Results of the present study show that children are consuming below the WHO recommendation for fruit and vegetables of 400g or 5 servings per day [5]. These results are similar to those previously reported [23,46]. Furthermore, our study demonstrated that low fruit and vegetable intake was associated with higher WHtR. Although causal relationships were not the focus of this current study, studies with similar findings demonstrate that reduced fruit and vegetable consumption is linked to poor health and increased risk of noncommunicable diseases (NCDs) [4].

Micronutrient intakes, including calcium and iron were lower than recommended (Food Safety Authority of Ireland [43]. Calcium is essential for the development and strengthening of bones and teeth in children and a reduced intake of calcium during periods of growth can negatively influence bone development, leading to rickets and children not achieving their potential height [50]. Iron is also an essential nutrient and low intake may lead to iron deficiency anaemia in children, which can result in behavioural problems, loss of appetite, lethargy and failure to grow at the expected rate [51]. Fibre intake (10 year olds) was lower than recommended in dietary guidelines [43]. Inadequate fibre intake can increase the risk of constipation [52]. Furthermore, research has shown that diets high in fibre have lower energy density and may therefore help in moderating obesity [53]. High fibre diets may also lower the risk of metabolic syndrome, Type 2 Diabetes and BP in children [54]. Saturated fat intake and number of unhealthy snacks per day were also higher than recommended by the European Food Safety Authority [55].

The WHO [56] guidelines recommend children's daily intake of free sugars should be less than 10% of their total energy intake. A further reduction to below 5% (25 grams/6 teaspoons) per day is recommended to provide additional health benefits [57]. The total percentage sugar intake in this study includes both

added sugars and naturally occurring sugars and while a direct comparison was not possible, the high intake of 20% suggests that children's diets are higher in added sugars than is recommended, particularly given the low intakes of fruit and vegetables. Such eating habits are likely to contribute to the rising levels of child obesity [58] and can also lead to increased risk of Type 2 diabetes and CVD [56]. Additionally, research indicates a positive relationship between intake of free sugars and dental caries in children [59]. The inverse correlation between sugar intake and WHtR is in contrast to other research highlighting that higher sugar intake is associated with increased body weight [60]. Our results also demonstrate an inverse correlation between sugar intake and NK, suggesting that improving NK may help to reduce sugar intake.

High BP in children is a cause for concern as it is a risk factor for CVD [61]. BP values from this study are similar to those found for nine and ten year olds in the CCLaS [45]. However, our results showed 15.7% of ten year olds had high BP, compared to 8% of children who took part in the CCLaS [45]. Children with elevated BP are likely to become adults with high BP and therefore early intervention is key [62].

Our results highlight that greater NK is associated with some healthy dietary intakes (higher protein intake (six year olds) and lower sugar intake (ten year olds). However, it has previously been suggested that primary school children's DI may be more reflective of parental choices rather than their own choices [63]. Research conducted in Ireland by Walsh & Nelson [64] revealed that parents were a major influence in their children's diets. Thus, improving children's NK should also take into consideration parental influences and further research should explore this association.

The mean baseline run scores were higher (slower) when compared to baseline scores recorded in New Zealand [65]. Such a finding is positive, since Rush *et al*. [66] report that ability to run faster is associated with more favourable nutritional status and body composition. Our results suggest similar associations; run score was positively correlated with BMI and WHtR and negatively correlated with calcium. The promotion of CRF should therefore be included as a core component of any future health promotion intervention efforts amongst school children.

CONCLUSION

Irish school children consume diets that are high in saturated fat and low in essential nutrients and fruit and vegetables, while also displaying low levels of CRF. Given the associations between these dietary intakes and CRF values and sub-optimal health, and the finding that a greater NK is associated with some healthy dietary intakes, future preventive initiatives should include both nutrition education and CRF components, and be delivered to children as young as 6 years of age. Furthermore, as many of the risk factors for childhood obesity do not occur in isolation, it is also important that future research in Ireland further examines the relationships identified between these variables.

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CONFLICT OF INTEREST

None.

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