Project Spraoi: The Effectiveness of a Nutrition and Physical Activity Intervention on the Dietary Intake, Dietary Patterns, Nutritional Knowledge and Markers of Health of Irish Primary School Children

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Project Spraoi: The Effectiveness of a Nutrition and Physical Activity Intervention on the Dietary Intake, Dietary Patterns, Nutritional Knowledge and Markers of Health of Irish Primary School Children

Alison Merrotsy
Department of Sport, Leisure & Childhood Studies

A thesis submitted to Cork Institute of Technology in fulfilment of the requirement for the award of Doctor of Philosophy, May 2018

Supervisors: Dr Tara Coppinger, Ms. Jennifer Flack and Dr Aoife McCarthy
Declaration

I hereby declare that the work contained within this thesis is entirely my own work other than the counsel of my supervisors; Dr Tara Coppinger, Ms. Jennifer Flack and Dr Aoife McCarthy, of the Department of Sport, Leisure & Childhood Studies and the Department of Biological Sciences, Cork Institute of Technology and academic advisor Dr Séan Lacey, Department of Mathematics, Cork Institute of Technology. This work has not been submitted for any academic award, or part thereof, at this or any other educational establishment. Where the use has been made of the work of other people, it has been fully acknowledged and referenced.

Candidate:

________________________________________
Alison Merrotsy

________________________________________
Date
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<th>Term</th>
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<tbody>
<tr>
<td>AMDR</td>
<td>Acceptable Macronutrient Distribution Range</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
</tr>
<tr>
<td>BMI</td>
<td>Body Mass Index</td>
</tr>
<tr>
<td>BMR</td>
<td>Basal Metabolic Rate</td>
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<tr>
<td>BP</td>
<td>Blood Pressure</td>
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<tr>
<td>bpm</td>
<td>Beats per Minute</td>
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<tr>
<td>CHO</td>
<td>Carbohydrate</td>
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<tr>
<td>Cm</td>
<td>Centimetres</td>
</tr>
<tr>
<td>CRF</td>
<td>Cardiorespiratory Fitness</td>
</tr>
<tr>
<td>CVD</td>
<td>Cardiovascular Disease</td>
</tr>
<tr>
<td>DI</td>
<td>Dietary Intake</td>
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<tr>
<td>G</td>
<td>Gram</td>
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<td>HPS</td>
<td>Health Promoting Schools</td>
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<tr>
<td>IOTF</td>
<td>International Obesity Taskforce</td>
</tr>
<tr>
<td>KCA</td>
<td>K-Means Cluster Analysis</td>
</tr>
<tr>
<td>kcal</td>
<td>Kilocalorie</td>
</tr>
<tr>
<td>Kg</td>
<td>Kilograms</td>
</tr>
<tr>
<td>mg</td>
<td>Milligram</td>
</tr>
<tr>
<td>MVPA</td>
<td>Moderate to Vigorous Physical Activity</td>
</tr>
<tr>
<td>NCFS</td>
<td>National Children’s Food Survey</td>
</tr>
<tr>
<td>NK</td>
<td>Nutritional Knowledge</td>
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<tr>
<td>PA</td>
<td>Physical Activity</td>
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<tr>
<td>PAL</td>
<td>Physical Activity Level</td>
</tr>
<tr>
<td>SD</td>
<td>Standard Deviation</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organisation</td>
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<tr>
<td>WHtR</td>
<td>Waist to Height Ratio</td>
</tr>
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Abstract

Aim:
To implement and evaluate the effectiveness of a nutrition and physical activity (PA) intervention (Project Spraoi) on dietary intake (DI), dietary patterns (DP), nutritional knowledge (NK), cardiorespiratory fitness (CRF), blood pressure (BP) and markers of health of Irish children in one primary school in Cork. The relationship between DP and NK, CRF, BP and anthropometric data will also be examined.

Design: Cross-sectional and longitudinal study. Food diary, NK questionnaire and 550m walk/run test were used to assess DI, DP, NK and CRF, respectively. BP, body mass index (BMI) and waist to height ratio (WHtR) were also 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: Study One: Intakes of fruit, vegetables, fibre, calcium, iron, unhealthy snacks and saturated fat were sub-optimal. Only 24.4% of six year olds and 35.4% of ten year olds were classified as ‘fast’. Nearly half (45.9%) of all participants had high-normal BP. 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).

Study Two: There was a significant improvement (p < 0.05) in systolic and diastolic BP, WHtR and NK for ten year olds and a significant improvement for fibre intake in six year old males (p = 0.024) after the Project Spraoi intervention. Percentage energy from protein in ten year old females from the intervention group (p = 0.021) also significantly improved.

Study Three: At baseline, three out of four dietary patterns identified for six and ten year olds were unfavourable and there was no significant difference in dietary patterns at baseline and post-intervention. There were also statistically insignificant differences in nutritional knowledge, BMI, WHtR, CRF and BP with respect to dietary patterns at baseline and post-intervention.

Conclusion: Project Spraoi was effective in improving nutritional knowledge, WHtR, BP and some aspects of dietary intake (fibre, protein) in older Irish primary school children in one intervention school in Cork, Ireland. This study also highlights, for the first time, the relationship between DP and nutritional knowledge, CRF, BP and anthropometric data for Irish children.
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- To the staff and all the children from Upper Glanmire NS and Cloghroe NS, without whom there would be no study!

- To my parents and family, for their love, support and encouragement all the way from Australia and to my father-in-law, Michael, for your invaluable babysitting.

- To my children, Emmi, Hayden & Elyssa, thank you for your extreme patience and understanding and for occupying yourselves many an afternoon/weekend so I could get work done!

- Finally, to Donal, for embarking on this journey with me, for your love, support and encouragement, I could not have done it without you!
Publications

Original Research Papers


Literature Review


Conference Proceedings


Chapter 1: Introduction
1.1 Background

Overweight and obesity are now the most common childhood disorders in Europe (World Health Organisation (WHO), 2018), and can cause social, psychological and physiological health problems in youth, obesity later in life and poor health outcomes as an adult (Waters et al., 2011). Previous Irish statistics have shown that 1 in 4 children are overweight or obese (Layte & McCrory, 2011). Environmental and lifestyle factors are recognised as the primary drivers of the condition; with poor diet, physical inactivity and sedentary behaviour also contributing (Perry et al., 2012).

Current work in Ireland focusing on overweight and obesity at a policy level includes, but is not limited to, the Irish Obesity Policy and Action Plan (Department of Health, RoI, 2016), Health Promoting Schools Framework (2013) and the National Physical Activity Plan (Get Ireland Active, 2016). The Growing up in Ireland study (Layte & McCrory, 2011) and the Childhood Obesity Surveillance Initiative (COSI) (Bel-Serrat et al., 2017) have been used to help inform childhood obesity policy. Research has shown that Irish children have poor nutritional habits in comparison to their European counterparts (Joyce et al., 2009) and are increasingly consuming foods high in sugar, salt and fat (Fitzgerald, 2010). Yet, up-to-date evidence is limited (Keane, 2014) and no research to date has simultaneously investigated the dietary behaviours, CRF, BP, nutritional knowledge and health markers of Irish children, over time.

The school environment has the potential to make important differences in children’s health and school-based interventions demonstrate more convincing evidence of their effectiveness in reducing BMI than other traditional initiatives (Sobel-Golberg et al., 2012). Furthermore, evidence shows that combined dietary and PA interventions are the most successful in improving multiple health behaviours (Mead et al., 2017). The primary school-based nutrition
and PA intervention presented in this thesis, Project Spraoi, is the first initiative in Ireland that targets both nutrition and PA in primary schools, and has been evaluated for its effectiveness (Bolger et al., in press). Project Spraoi is in line with the Irish Obesity Policy and Action Plan (Department of Health, RoI, 2016), which recognises that childhood obesity is a multidimensional issue. The policy highlights the role schools can play in obesity prevention by implementing a ‘whole of school’ approach, incorporating the promotion of healthy eating, physical activity and exercise (Department of Health, RoI, 2016).

1.2 Project Spraoi

Project Spraoi, (http://www.cit.ie/projectspraioi), is a primary school health promotion intervention that aims to promote PA, improve dietary intake and increase nutritional knowledge of Irish school children. The project was founded in 2013 by researchers at Cork Institute of Technology and is based on ‘Project Energize’ in New Zealand (www.projectenergize.org.nz/). Project Energize is a combined physical activity and healthy eating intervention. Project Energize has been running in the Waikato region of New Zealand for over ten years and is delivered to the 244 primary and intermediate schools in the Waikato District. The programme has been shown to be effective at improving CRF, body composition, BP and nutrition for children (Rush, 2014). It has also proven to be both sustainable and cost-effective (Rush et al., 2016). ‘Energizers’ are qualified personnel employed by Project Energize (qualified physical education teachers, sport and exercise science graduates, nutrition graduates), who work with school staff to deliver Project Energize. Energizers provide hands on support and assistance to schools and teachers. Project Spraoi has been delivered to over 3000 students in 10 primary schools in Cork city and county since October 2013 (see Figure 1). The data in this thesis was collected as part of Year 2 of the study, implemented from 2014-2016.
1.3 Project Spraoi Intervention

For this study, two schools were selected via convenience sampling and met the inclusion criteria shown in Figure 1, with the exception of size. All students from the intervention school (n=274) received the PA and nutrition intervention; children in the control school (n=567) did
not receive any of the intervention components. While all children from the intervention school took part in the nutrition and PA classes, evaluation of dietary intake, nutritional knowledge, BP, anthropometric and CRF measurements was only carried out on six year old and ten year old children. Data were collected over 4 days (two weekdays and two weekend days) at two time points (baseline, October 2014 and post-intervention, June 2016) by the researcher and other trained postgraduate students and staff of Cork Institute of Technology (Cork, Ireland). The same children were assessed at baseline and post-intervention, non-response rate for completed food diaries increased from 25% (n=25) at baseline to 32% (n=32) post-intervention. Informed assent 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.

The intervention took place over two academic years, from October 2014 – May 2016. The relevant intervention material used in ‘Project Energize’ was tailored for use in ‘Project Spraoi’, with minor adjustments applied (to make it culturally relevant to Ireland) in order to make it relevant to the Irish setting. From the outset, an agreement was signed by the school and the researcher who also acted as the ‘Energizer’ for the school (providing hands on support and assistance to schools and teachers), agreeing to the goals of Project Spraoi and to outline expectations, roles and responsibilities. The ‘Energizer’ and class teacher discussed plans for targeted nutrition and PA classes, which included providing specific material on healthier food choices, delivering simple healthy food demonstrations and modelling PA classes based on Kiwidex (Sport & Recreation New Zealand, 2005) and Project Energize (Rush et al., 2011). The researcher also provided information on unhealthy foods and ways to encourage a reduction in the amount of high energy/low nutrient food consumed. Parents were given the opportunity to attend information and demonstration sessions, delivered by the ‘Energizer’. These included healthy lunchbox ideas, tasting sessions and education sessions on high sugar
beverages and takeaways see Appendix 3. The researcher delivered PA classes including 20 minutes of huff and puff games, circuit classes, dance routines, gymnastics and whole school initiatives. Every class (n=10) in the school received one session per week, over two academic years from October 2014 – June 2016.

While a team of researchers carried out the physical testing, the researcher was solely responsible for the distribution, collection and analysis of the food diaries at the two time points for both the intervention and control school.

Subject Participation

For this study, two schools were selected via convenience sampling, as a sub-component of the larger study, ‘Project Spraoi’ (http://www.cit.ie/projectspraoi). 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 $6.09 \pm 0.33$ years and $9.9 \pm 0.37$ years for ‘Fourth Class’ students; these participants will subsequently be referred to as six and ten year olds.

1.4 Research Aims

The aims of the present research are to:

- Measure dietary intake, nutritional knowledge, CRF and markers of health among Irish primary school children in one school from Project Spraoi.

- Investigate the relationship between dietary intake, nutritional knowledge, CRF and markers of health of Irish primary school children in one school from Project Spraoi.
• Assess the effectiveness of the nutrition and PA intervention on dietary intake, nutritional knowledge, BP, CRF and markers of health of Irish school children in one school from Project Spraoi.

• Identify dietary patterns and their association with CRF, BP, nutritional knowledge and markers of health in six and ten year old Irish children, prior to and following intervention in one school.

1.5 Thesis Outline

This thesis is comprised of three papers. A literature review (Chapter 2) was undertaken and examines the importance of the preventive intervention setting; including family based programmes, primary care settings, community settings and primary schools. The review also identifies the most effective components of obesity prevention interventions designed for children, including healthy eating and physical activity (PA). Chapters 3 and 4 are research chapters and have been submitted for publication.

Chapter 3 describes the baseline dietary intake, nutritional knowledge, cardiorespiratory fitness and health markers of children from two primary schools in Cork. Chapter 4 explores the Project Spraoi Intervention; a two year longitudinal study on the effectiveness of a school-based nutrition and physical activity intervention on dietary intake, nutritional knowledge and markers of health of Irish school children. Chapter 5 identifies dietary patterns in Irish school children and their association with nutritional knowledge and markers of health before and after the Project Spraoi intervention.

Chapter 6 provides an overall discussion of the main findings, the strengths and limitations of the research, public health implications and direction for future research.
1.6 Author’s Contribution

I was the lead author of the research papers for Chapters 2, 3, 4 & 5. This involved conducting the literature search, data collection and analysis and the main author of each of the papers. I was one of a team of researchers for Project Spraoi and I was involved in the anthropometric and cardiorespiratory fitness data collection for six of the schools involved in the study at baseline (October 2014) and post-intervention (June 2016) (see Figure 2). I was solely responsible for the distribution, collection and analysis of the food diaries for participants in two of the schools at baseline and following the intervention. I also acted as the “Energizer” for one school, which involved the delivery of 20 minutes of nutrition and PA lessons to every class (n = 10) in one school, one day per week, from October 2014 – June 2016.
Meeting with Principals & Teachers. Needs Analysis conducted with Intervention School, October 2014.

Baseline testing Intervention School
Children (n = 54)
October 2014

Baseline testing Control School
Children (n = 47)
October 2014

Project Spraoi Intervention Commences October 2014

20 mins of Nutrition & PA delivered to 10 classes, one day per week from October 2014 – May 2016

Post-intervention testing Intervention School
Children (n = 54)
May 2016

Post-intervention testing Control School
Children (n = 47)
May 2016

Figure 2: Author contribution to the research and Project Spraoi intervention
Chapter 2.

Obesity prevention programmes in children: the most effective settings and components.

A literature review.

In Press:

Abstract

Overweight and obesity are now the most common childhood disorders in Europe. These disorders can cause social, psychological and physiological health problems in childhood and are linked to obesity and poor health outcomes later in life. The present review will examine the importance of the preventive intervention setting; including family based programmes, primary care settings, community settings and primary schools. The review also identifies the most effective components of obesity prevention interventions designed for children, including healthy eating and physical activity (PA). Evidence suggests that out of all the intervention settings, obesity prevention programmes are the most successful when delivered in the primary school setting. Furthermore, there is strong evidence to show that combined dietary and PA interventions are the most effective components to include in such strategies. There is, however, a lack of research on school-based obesity prevention strategies in Ireland. Definite conclusions as to the effectiveness of such programmes at preventing overweight and/or obesity are therefore not available. Without such interventions, overweight, obesity and unhealthy behaviours are at risk of continuing which could have both immediate and long term health implications.
2.1 Introduction

Overweight and obesity are now the most common childhood disorders in Europe (WHO, 2018). These disorders can cause social, psychological and physiological health problems in youth and are linked to obesity and poor health outcomes later in life (Waters et al., 2011). In 2010, the WHO estimated that 6.7% of children aged 0-5 years were overweight or obese, as increased from 4.2% in 1990 and based on current trends, is estimated to increase further to 9.1% by 2020 (WHO, 2010). Previous Irish statistics have shown that an alarming 19% of nine year olds were overweight and a further 7% obese (Layte & McCrory, 2011) and environmental and lifestyle factors, specifically poor diet, physical inactivity and sedentary behaviour, are recognised as the primary drivers of the condition (Perry et al., 2012). Furthermore, the WHO have recently predicted that Ireland will become the most overweight WHO nation by the year 2030 (Horan, 2015). In response to this, the Irish Obesity Policy and Action Plan (Department of Health, RoI, 2016) was developed to help people to reduce their levels of overweight and obesity and to improve overall health in the Irish population. This policy recognises the combined approach of individuals, families and communities needed to prevent obesity (Healthy Ireland, 2016). The Irish Obesity Policy and Action Plan (Department of Health, RoI, 2016) highlights the role of the school in reducing childhood obesity through the promotion of healthy eating and physical activity.
Childhood obesity has significant adverse effects on health; both short- and long-term (Reilly et al., 2003). Physical health consequences include sleep-disordered breathing and asthma, orthopaedic problems, fatty liver disease, type 2 diabetes and cardiovascular risk factors, including hypertension (Lobstein et al., 2004). Complications related to obesity are not only physical but also psychological and social, with such problems including depression, anxiety, stigmatisation, discrimination and body dissatisfaction (Lobstein et al., 2004) all reported. In addition to the many serious health impacts, obesity also has a significant negative economic impact, costing the Irish state an estimated 1.13 billion euro in 2009 (Perry, 2012).

In order to change the habitual activities of children across the nation, healthcare research needs to be translated into practice (Kessler, 2011). Families, primary-care, schools and communities represent important settings for obesity prevention efforts in children. Effectively preventing obesity in childhood may also prevent the onset of adult obesity and reduce chronic disease (Doak et al., 2006). The present review will examine the importance of the preventive intervention setting; including family based programmes, primary care settings, community settings and primary schools. It will also identify the most effective components of obesity prevention interventions designed for children.

In October 2014, a computer search was conducted through MEDLINE, Google Scholar, Cochrane Library, Elsevier and CIT’s online journal databases using the key terms “obesity,” “overweight,” and “children,” “prevention,” “intervention,” “Ireland,” “primary school,” “primary care,” “community” and “family”. Inclusion criteria included studies that assessed obesity prevention intervention for primary school children, five to twelve years of age, where data was collected between 1995 and 2014. Additional articles were identified by searching each article’s reference section and CIT’s database and included studies from America, the UK, Australia, Europe and Ireland. These searches yielded a total of twenty eight articles that were included in the present analysis.
2.2 Obesity Prevention Intervention Settings

2.2.1 Family based settings

Families have the ability to influence and shape child behaviours on a daily basis. Therefore, experts suggest that family involvement in the prevention of childhood obesity may provide greater behaviour changes and sustainable weight loss over time compared to interventions without parental involvement (Berge, 2009); as does overall support from family and friends (Epstein, 1996). Family based settings include the child and at least one family member, usually a parent, participating in the intervention with the child. Engaging parents in childhood obesity prevention programmes may make weight loss easier for children, with evidence suggesting parents help their children to choose healthy behaviours and are important role models for their children (Upton et al., 2014). Although the family unit is seen as one of the major influences in shaping children’s eating and PA patterns, evidence-based strategies for engaging parents in obesity prevention efforts are lacking (Fitzgibbon et al., 2013) and parental resistance may also be a barrier to the implementation of interventions (Kelleher et al., 2017). Such strategies may include family-based education programmes, which teach parents how to provide a positive food environment for their children (Haire-Joshu et al., 2008). However, there is conflicting evidence surrounding the success of family-based interventions and few studies have addressed the effectiveness of these approaches and their potential to influence a parent’s ability to improve children’s DI (LaRowe et al., 2007).

Evidence from Gruber and Haldeman (2009) suggests family-based intervention programmes are one of the most successful methods for obesity prevention. Contrastingly, Showell et al. (2013) argues that family-based obesity prevention studies fail to demonstrate a significant effect on weight outcomes and have limited effects on anthropometric and metabolic outcomes (Esfarjani et al., 2013). Little evidence exists for solely family-based interventions, therefore a total of five papers are selected for inclusion in this review (Epstein et al., 2001; French et al.,
2011; Lappe et al., 2004; Paineau et al., 2008; Thompson et al., 2008). All studies were randomised control trials (RCTs), and reported on either a diet intervention (n=3) or a combined diet and PA intervention (n=2). None of the five studies detected a statistically significant beneficial effect of intervention on BMI or other weight outcomes; including percentage body fat, waist circumference and skinfold thickness. However, positive effects were seen in some eating behaviours (increased fruit and vegetable consumption (French et al., 2011; Epstein et al., 2001; Thompson et al., 2008), increased nutrient intake (Lappe, 2004; Paineau et al., 2008) and a reduction in sweets consumed (French et al., 2011; Epstein et al., 2001). In the French et al. (2011) study, households were targeted over a 12 month period to try and increase fruit and vegetable consumption, decrease portion size and limit high calorie snacks and takeaways. Intervention components included researcher led group sessions (6 x 2-hour sessions on education and PA) and a television locking device. Results revealed significant declines in television viewing, snacks/sweets intake, and dollars per person spent eating out. The study by Lappe et al. (2004) was designed to determine whether calcium-rich diets cause excessive weight gain in 9 year old girls. In total, 59 girls were randomly assigned to either a calcium-rich diet, supplying at least 1,500 mg of calcium per day, or asked to continue consuming their usual diet. Reported findings showed that a calcium-rich diet significantly improved overall nutrient intake; with increases in intakes of protein, vitamins A and D and magnesium also evident. There were, however, no reported differences in body mass, fat mass or BMI (Lappe et al., 2004).

Epstein et al. (2001) targeted parents and children by instructing them to either increase their fruit and vegetable intake or decrease their intake of high-fat/high-sugar foods. The intervention was reported to significantly increase fruit and vegetable intake (high nutrient density foods) while also decreasing children’s consumption of high-fat/high-sugar (low nutrient density) foods. The intervention also prevented increases in the percentage of
overweight children (Epstein et al., 2001). Thompson et al. (2008) explored the viability of an eight week, internet-based obesity prevention programme as an effective channel for promoting healthy diet and PA behaviours in the home setting among 73 African American girls, aged 8-10 years. Although no significant effect was observed on BMI, statistically significant increases were observed in fruit, vegetable and juice consumption and PA (Thompson et al., 2008). In the study by Paineau (2008), participants were assigned to either a control (n=394) or to one of two intervention groups. Participants from the intervention groups were educated on either (i) reducing fat or increasing complex carbohydrate intake (n=280) or (ii) reducing both fat and sugar intake, whilst also increasing complex carbohydrate intake (n=275). Both groups received monthly family dietary phone counselling by a trained dietician and internet-based monitoring for eight consecutive months. Compared with the control group, the intervention groups reduced their total fat intake to < 35% of total energy intake and reduced their total sugar intake (by 25%) compared to their initial intake. The intervention groups also increased their intake of complex carbohydrate to > 50% of total energy intake and these changes in turn reduced their overall energy intake and improved macronutrient intake close to those recommended. However, the intervention had no effect on children’s BMI, fat mass or body weight (Paineau, 2008).

Findings therefore suggest that, despite the clear importance of family involvement, family-based interventions are not effective in preventing obesity but can be successful in altering eating patterns. Engaging and supporting parents is an essential part of the approach to promoting healthy weight and lifestyle behaviours in children but parents can be a difficult group to engage (Golley et al., 2011). Parental resistance can also act as a barrier to intervention implementation, with one study in Ireland revealing parents to not be accepting of the overweight/obese diagnosis of their children (Kelleher et al., 2017).
The time commitment required of parents to attend educational sessions is frequently cited as a barrier for this type of intervention, often resulting in lower recruitment and higher attrition rates (Warren et al., 2007; Golan, 2007). To overcome some of these barriers, a review by Li et al. (2013) suggests employing methods that are more convenient for parents, such as online learning and social media platforms however a lack of computer literacy may serve as an additional barrier (White et al., 2004).

2.2.2 Primary care based setting

Primary care based interventions refer to children attending medical professionals in a clinical setting. The primary care setting offers the opportunity to influence children and parents, encourage healthy lifestyle behaviours and improve weight status (through interventions) among children (O’Connor et al., 2013). Paediatric primary care is regarded as an important setting for obesity prevention efforts as medical professionals often follow children over their entire childhood and adolescence, allowing the potential for long-term efforts and follow-up (Stettler, 2004). The W82GO (http://w82go.ie/) programme is one such programme run by Temple Street hospital’s obesity service for overweight/obese children in Ireland. It aims to help children get their weight under control by helping them change their diet and increase their activity. However, the majority of published studies in primary care focus on obesity treatment, rather than prevention, and there is a distinct lack of research in the area aimed at primary school children (Sherwood et al., 2013). In fact, a review of primary care childhood obesity prevention and treatment interventions by Seburg et al. (2015) found out of 18 included studies, all studies were designed to treat, not prevent, obesity. Primary care settings as a preventive intervention, are a more common setting for younger children who haven’t yet started primary school (Quattrin et al., 2012; Stark et al., 2011; Taveras et al., 2011) as medical professionals often have regular contact with children at this age.
Due to the lack of research amongst primary school children in this setting, only two completed studies of primary care based interventions are included in this review. The PACE+ (Patient-centred Assessment and Counselling for Exercise + Nutrition) study in the United States of America included 878 participants, aged 11-15 years old (Patrick et al., 2006). Subjects assigned to the intervention group took part in a computer-assisted diet and PA assessment followed by counselling in a primary care setting, which was followed by 12 months of mail and telephone counselling. Compared with the control group, girls and boys in the nutrition and PA intervention increased servings of fruits and vegetables, decreased their consumption of saturated fat and increased their participation in PA, while also reducing sedentary behaviours. However, no between-group differences were seen in BMI (Patrick et al., 2006), which is consistent with findings from other family-based interventions (Thompson, 2008; French, 2011). The Maine Youth Overweight Collaborative (MYOC) programme study’s primary aim was to evaluate the impact of a brief primary-care-based intervention on BMI-z score for healthy, overweight and obese children (Gortmaker et al., 2015). The healthcare provider delivered the ‘5,2,1,0’ healthy habits message (five servings or more of fruit and vegetables; 2 hours or less of screen time; 1 hour or more of PA; and zero sugar-sweetened beverages [SSBs] daily) during one well-child visit. Children attended well-child visits, from birth to age 21, which included a complete physical exam and parents were provided with information on strategies to improve care, prevent health problems and help keep their child healthy (U.S. National Library of Medicine, 2016). Results showed no impact of the intervention on BMI z-score for participants, aged 5-18 years, in the healthy weight (50th–85th percentile, n=506) or overweight (85th–95th percentile, n=216) categories. A shortcoming of this intervention, was its duration; one, 4-6 minute visit is unlikely, on its own, to improve BMI (Gortmaker et al., 2015).
Two further studies (i) the Healthy Homes/Healthy Kids (HHHK) (Sherwood, 2013) and (ii) e-health tool (Avis et al., 2015), are still ongoing and are also aiming to prevent obesity by improving nutrient intake and increasing PA. The goal of the HHHK RC) is to evaluate the efficacy of a relatively low-cost primary care-based obesity prevention intervention aimed at 5 to 10 year old children who are at risk of obesity (Sherwood, 2013). This intervention combined brief counselling with a paediatric primary care provider and follow-up telephone coaching that supported parents in making changes at home to support healthful eating, activity patterns, and body weight. To date, no findings have been published for this study.

The Avis et al. (2015) study designed a technology-based application, using the SBIRT approach (Screening, Brief Intervention, and Referral to Treatment). The application was designed for use in a primary-care setting for children aged 5-17 years, to enhance parents support for children's healthy lifestyle behaviours and encourage the use of online resources and community services for childhood obesity prevention. The widespread use and availability of the internet highlights its potential value as a vehicle to deliver obesity prevention interventions (Whiteley et al., 2008). The SBIRT can also guide parents of children with unhealthy weights to access information and health services to improve their children’s weight status and associated health risks (Avis et al., 2015). Overall, findings from this project will examine the effectiveness of the SBIRT intervention across primary care-based settings. There are also no results currently published for this study.

Interventions to prevent obesity need to be accessible, affordable, and scalable in order to reach a large target audience yet clinic based interventions are often not feasible because of barriers associated with accessibility, transportation, limited time available and cost (Ebbeling and Antonelli, 2015). Similar to the family-based programmes, primary care based obesity prevention programmes do not show support for changes to BMI, however there is a need for more research (Seburg et al., 2015). While primary care setting interventions alone may not be
sufficient to prevent obesity, they represent an important place where messages to improve nutrition and PA can create awareness and motivate change that can be reinforced across community sectors in a powerful way (Mittman, 2012). More effective primary care interventions embedded in broader multisector approaches including families, schools and communities, with the potential to significantly improve BMI, need to be developed (Gortmaker et al., 2015).

2.2.3 Community Settings

Community-based interventions are usually included as part of a school-based intervention, with few interventions being implemented in the community alone. The Be Active Eat Well (BAEW) was a three year, community-based obesity prevention intervention in primary school children aged 4 – 12 years, that used a multi-strategy (promoting healthy eating and PA) and multi-setting (community and household) approach (Sanigorski et al., 2008). The findings show that the intervention was successful in modestly slowing unhealthy weight gain (by about 1kg) and waist gain (by about 3cm) in children, however, the changes were still not of sufficient magnitude to reduce the incidence of overweight or obesity (Sanigorski et al., 2008). Although mean BMI changes were modest, community-based interventions need to continue monitoring obesity promoting influences and behaviours, as small individual changes may result in large population effects (Johnson et al., 2012).

In contrast to the above evidence, a systematic review by Wang et al. (2015) concluded that interventions implemented in the community alone fail to produce significant effects. Yet, this review went on to further state that community-based interventions that included a school component were more successful in preventing obesity (Wang et al., 2015). Two community-based interventions that also included a school component (Chomitz et al., 2010; Economos et al., 2007) significantly decreased BMI z-score in children. Based primarily in the community,
the Healthy Living Cambridge Kids (HLCK) (Chomitz et al., 2010) (n=1858) and Shape UP Somerville (SUS) (Economos et al., 2007) (n=1178) also targeted the school, family and individuals and included city policies and community awareness campaigns to promote healthy eating and active living for 5-11 year olds. These studies both used collaborative community-based participatory research (CBPR) initiatives, with members of the community participating in all aspects of the research. The HLCK intervention resulted in a significant decrease in mean BMI $z$-scores ($p < 0.001$), and a significant decline in prevalence of obesity, from 20.2 to 18.0% ($p < 0.05$), and SUS also reported a significant decrease in BMI $z$-score ($p = 0.001$). These results highlight the importance of both community and school resources in influencing body mass changes in children. This emphasises the importance of the community as part of a multiple setting intervention, including schools, in reducing childhood overweight and obesity, more so than single-component interventions located in the community alone (Bleich et al., 2013). The review by Wang et al. (2015) supports recommendations made by the WHO (2012) that encourage community-based interventions to be included as part of multi-component interventions, applied across multiple settings and tailored to the local environment.

2.2.4 Primary School Setting

The school environment has the potential to make important differences in children’s health and presents a number of opportunities for intervention (Ward et al., 2007; Van Sluijs et al., 2008; Lavelle et al., 2012; Vasques et al., 2013). For this reason, primary schools have been a popular setting for the implementation of interventions as they offer continuous, intensive contact with children and the school infrastructure, policies, curriculum and teachers have the potential to positively influence the health of a child (Brown and Summerbell, 2008). Children spend approximately six hours per day at school and its setting allows large numbers of children to take part in an intervention at any given time (Garrow, 1991). The importance of targeting
ecological domains (including the built environment and community) beyond the individual has also previously been highlighted (Kahn et al., 2002; Perry et al., 2012; Sallis et al., 2012).

Schools have an important role in the prevention of childhood obesity however there are a number of considerations when designing school based interventions (Jones et al., 2014). Waters et al. (2011) suggests that for interventions to be successful, they have to be integrated into the school curriculum, include both healthy eating and PA, and provide support for teachers and parents. Some of the most successful school-based interventions, have included a parenting component, whereby parents are involved in the intervention via newsletters, workshops and homework (Llargues et al., 2011; Manios et al., 1999, Kafatos et al., 2007, Spiegel et al., 2006). These interventions have resulted in positive changes in diet, PA and BMI (Lindsay et al., 2006). An example of a successful school based, parent involvement intervention is the Child and Adolescent Trial for Cardiovascular Health (CATCH) (Coleman et al., 2005) programme. This was delivered to low income elementary school children, primarily Hispanic, and included a family component with activity packs that students took home to complete with their parents and participation in ‘family fun nights’ at the school. This parental component supplemented the classroom curriculum and the intervention reduced overweight, or the risk of overweight among both boys and girls (Coleman et al., 2005).

Similarly, the HEALTH-E-PALS, (Habib-Moored et al., 2014) intervention was a school-based programme to promote healthy eating and PA in children aged 9-11 years. It included 12 classroom sessions, a family programme and changes in food provided by school shops and lunch boxes. HEALTH-E-PALS increased students’ nutritional knowledge and decreased their purchase and consumption of high-energy snacks and beverages, however there were no changes in PA or BMI post intervention (Habib-Moored et al., 2014).

Research from a systematic review of 32 studies, with over 52,000 participants, reported that school-based interventions demonstrate more convincing evidence of their effectiveness in
reducing BMI than primary care and home-based settings (Sobel-Golberg et al., 2012). Research also shows that school-based interventions that are greater than 12 months in duration are more likely to be successful as they become embedded in the curriculum and in the behaviours of the school and parents (Gonzalez-Suarez et al., 2009). Guerra et al. (2016) also report that interventions longer than six months in duration and those that include parental involvement were identified as the most effective. However, the implementation of long-term interventions in most school districts may not be economically feasible (Shaya et al., 2008).

The WHO’s Health Promoting Schools (HPS) framework recognises the importance of the school environment in encouraging healthy behaviours and combatting obesity (Langford et al., 2015). The HPS framework promotes health in schools and addresses the whole school environment, including the curriculum, physical environment, policies and engaging with families and the wider community (WHO, 2016). The HPS framework has been shown to increase PA, fitness and fruit and vegetable intake in school students (Langford et al., 2014) and supportive partnerships between researchers, schools and families is crucial to the success of these programmes (Langford et al., 2015). Overall, there is sufficient evidence to support the idea that combined healthy eating and PA interventions implemented in schools prevent obesity (Wang et al., 2015).

Evidence suggests that of all the intervention settings, obesity prevention programmes are the most successful when delivered in the primary school setting. Individual components of school-based obesity interventions will be discussed in more detail below.

2.3 Components of school-based obesity prevention interventions

2.3.1 Healthy Eating

Balanced nutrition and the promotion of healthier eating habits are key to addressing the problem of overweight and obesity in children (Mooney, 2012). In addition, whilst chronic
disease tends to emerge in adulthood, disease precursors and behaviour patterns are established during childhood (Craigie et al., 2011). Both national (Health Service Executive (HSE), 2008) and international evidence (WHO, 2016) suggests that obese children are more likely to become obese adults, suggesting that surveillance and promotion of health behaviours should start early in life (Craigie et al., 2011).

It is well established that eating a diet rich in fruit and vegetables has numerous health benefits (Gillman, 1996) including helping to maintain healthy blood pressure, lowering blood cholesterol levels and lowering the risk of heart disease (Adebawo et al., 2006) due to these foods having high concentrations of fibre, vitamins, minerals and antioxidants (Slavin and Lloyd, 2012). There is also growing evidence that fruit and vegetable consumption in children may protect against a range of childhood illnesses (WHO, 2004). The role of fruit and vegetables in combatting overweight and obesity is related to their low energy density, high dietary fibre content, and associated high satiety effect (Tetens and Alinia, 2009). Fruit and vegetables are important sources of a wide range of vital micronutrients, yet, in Ireland, the National Children’s Food Survey (NCFS) highlighted low fruit and vegetable intakes among children aged 5 – 12 years, with only 10% of children meeting the WHO guideline (NCFS, 2011). Such eating habits are likely to contribute to the rising levels of childhood obesity (O’Neill et al., 2007).

Healthy packed lunches are one way of increasing children’s fruit and vegetable intake and ensuring recommended nutrient intakes are met. The need to improve the quality of food brought to school is particularly evident, given UK research indicating that primary school packed lunches often consist of foods that are high in fat, sugar and sodium (Rogers et al., 2007). Similar findings were reported in Ireland whereby a study in children aged 5-12 years (Walton et al., 2014) found higher than recommended intakes of fat, saturated fat, salt and added sugars in school lunch boxes. On a population level, the eating habits of Irish people
have changed, with homemade nutritious food frequently being replaced with convenient foods that are high in fat, calories and sugar (Mooney, 2012), thus reinforcing the need for a nutrition component to be included in obesity interventions for children. These interventions aimed at improving the diet of Irish children must also focus on changing parents’ behaviour so that parents provide healthy foods in their child’s lunchbox (Horne et al., 2009).

Table 1 outlines studies that aimed to improve healthy eating in primary school children. The majority of studies focused on increasing fruit and vegetable consumption. The Pro children intervention (Te Velde et al., 2008) reported an increase in both fruit and vegetables by 20%, while Anderson et al. (2015) reported an increase in fruit consumption by 50g but no increase in the amount of vegetables eaten. The Fresh Kids intervention in Australia (Laurence et al., 2007) increased the proportion of children bringing fruit (post-intervention 25-50%) and water (15-60% post-intervention) to school and also decreased the proportion of children bringing sweet drinks (ranging between 8-38%). However, Project Tomato (Evans et al., 2013), after implementing 12 healthy eating lessons, found no increase in fruit and vegetable consumption. Differences in the strategies used, duration and implementation of the intervention may have influenced the effectiveness of these programmes.

Three of the studies included reported a positive effect on weight outcome (James et al., 2007; Foster et al., 2008; Viggiano et al., 2015). The Christchurch Obesity Prevention Programme (CHOPPS) aimed to reduce the amount of carbonated beverages consumed (James et al., 2007). Significant differences in the proportion of overweight children in the control (7.5% increase) versus intervention groups was found after the 12 month intervention, however, two years after the completion of the study, this difference was no longer significant (James et al., 2007). Similarly, ‘Kaledo’, a board game, developed for health promotion delivery in school, improved nutrition knowledge and dietary behaviour over 6 months (once per week for 20
weeks). The intervention also resulted in a positive effect on the BMI z-score (.34) in the intervention group compared to the control group (.58) after eighteen months (Viggiano et al., 2015). Likewise, a school nutrition policy intervention (Foster et al., 2008) aimed to improve the school food environment and dietary intake of primary school children and resulted in a 50% reduction in the incidence of overweight, with significantly fewer children in the intervention (7.5%) versus control schools (14.9%) being overweight after 2 years. These three studies support the evidence for including a healthy eating component in school-based interventions aimed at preventing obesity.

A healthy eating component may improve nutrition and increase fruit and vegetable consumption however, the strength of evidence is low that school-based healthy eating interventions prevent obesity and overweight in children, as less than 50% (three of the eight studies included) reported a positive effect on body mass outcomes. Nevertheless, Gentile et al. (2009) suggests it is likely that longer-term studies are needed to record changes in BMI resulting from these modifications in eating patterns.
<table>
<thead>
<tr>
<th>Study reference, Country</th>
<th>Intervention Title (if available)</th>
<th>Study Design</th>
<th>Aims</th>
<th>Effect of intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson et al (2005) Scotland</td>
<td>RCT</td>
<td>One academic year</td>
<td>Two primary schools</td>
<td>N=129 participants, Age 6-7, 10-11 years</td>
</tr>
<tr>
<td></td>
<td>RCT</td>
<td>One academic year</td>
<td>Two primary schools</td>
<td>N=129 participants, Age 6-7, 10-11 years</td>
</tr>
<tr>
<td>Lawrence et al (2007) Australia</td>
<td>Interrupted time series design</td>
<td>Two year period</td>
<td>Four primary schools</td>
<td>N=691 participants, Age 6-12 years</td>
</tr>
<tr>
<td></td>
<td>RCT</td>
<td>One year intervention</td>
<td>Six primary schools</td>
<td>N=644 participants, Age 7-11 years</td>
</tr>
<tr>
<td>James et al (2007) UK</td>
<td>RCT</td>
<td>One year intervention</td>
<td>Six primary schools</td>
<td>N=644 participants, Age 7-11 years</td>
</tr>
<tr>
<td>Te Velde et al (2008) Norway, Spain &amp; the Netherlands</td>
<td>RCT</td>
<td>One year intervention</td>
<td>Sixty-two schools</td>
<td>N=1472 participants, Age 10-11 years</td>
</tr>
<tr>
<td>Foster et al (2008) USA</td>
<td>RCT</td>
<td>One year intervention</td>
<td>Sixty-two schools</td>
<td>N=1472 participants, Age 10-11 years</td>
</tr>
<tr>
<td>Evans et al (2013) UK</td>
<td>RCT</td>
<td>One year intervention</td>
<td>Sixty-two schools</td>
<td>N=1472 participants, Age 10-11 years</td>
</tr>
<tr>
<td>Viggiano et al (2015) Italy</td>
<td>RCT</td>
<td>One year intervention</td>
<td>Sixty-two schools</td>
<td>N=1472 participants, Age 10-11 years</td>
</tr>
</tbody>
</table>

*Denotes statistical significance at p < 0.05, ** denotes significance at p < 0.01. O/w = overweight.
2.3.2 Physical Activity

Regular participation in PA in childhood has many benefits including improvements in mental health, cognition and general academic performance. It also assists with weight control and social development, reduces anxiety and depression and adds to quality of life (Colley et al., 2012). Furthermore, active children are more likely to choose other healthy behaviours (Colley et al., 2012). Engaging in regular PA is widely accepted as an effective preventative measure for a variety of obesity-related chronic diseases including diabetes, metabolic syndrome and cardiovascular diseases (Muros et al., 2013). Vigorous PA, defined as requiring much effort, causing rapid breathing and significantly increasing heart rate (WHO, 2016), can reduce overall body fat while simultaneously increasing bone and muscle mass (Muros et al., 2013). While physical fitness (the ability to carry out tasks without undue fatigue and includes cardiorespiratory endurance, muscle strength, muscle endurance, flexibility and body composition) (Caspersen, 1985) is an important predictor of physical and psychological health in young people (Parfitt et al., 2009). Studies have also shown that children who display high levels of physical fitness are also more likely to perform better academically (Van Dusen et al., 2011).

Increasing the PA levels of children is of particular importance as children who are physically active are more likely to be active as adults and less likely to be unhealthy (Kelly, 2012). The vast majority of children (75%) in Ireland, however, do not meet the National PA Guidelines (Woods et al., 2012), with Ireland’s most recent PA Report Card for Children and Youth showing only 22% of 8-11 year olds meeting the PA guidelines of 60 minutes of moderate to vigorous physical activity (MVPA) every day (Harrington et al., 2016). Objective data on this behaviour in Ireland, however, remains poor.

Table 2 summarises studies that aimed to increase PA in primary school children. Three of these studies (Lazaar et al., 2007; Kriemler et al., 2010; Salmon et al., 2010) reported a positive
effect of the PA intervention on BMI in the intervention group compared to the control group. In the other studies, while no significant changes in BMI were found, significant improvements were reported for anaerobic and aerobic fitness (Thivel et al., 2011), CRF (Resalund et al., 2011; Reed et al., 2008) and daily PA (Donnelly et al., 2009). Improvements were also seen in systolic BP (Reed et al., 2008) and academic achievement (Donnelly, 2009). Consequently, by significantly increasing the amount of PA (see Table 2) amongst participants, these interventions have achieved multiple beneficial health effects (Lazaar et al., 2007; Kriemler et al., 2010; Salmon et al., 2010; Thivel et al., 2011, Resalund et al., 2011; Reed et al., 2008, Donnelly et al., 2009).
### Table 2: Summary of primary school interventions to promote physical activity

<table>
<thead>
<tr>
<th>Study reference, Country</th>
<th>Intervention Title</th>
<th>Study Design</th>
<th>Aims</th>
<th>Effect of intervention</th>
</tr>
</thead>
</table>
| Sallis et al. (1997) USA | SPARK              | • RCT       | To increase PA during PE classes and out of school. | • Increase in PA (33-40 mins per week)** during PE  
• Improvement in two components of health related fitness in girls (abdominal strength and endurance and cardiorespiratory endurance)*  
• No significant changes to BMI in any of the groups. |
| Lazaar et al. (2007) France | Action Schools! BC | • RCT       | To increase daily PA without disrupting the academic curriculum.  
• To improve CVD risk factors. | • In girls, significant positive effect on all anthropometric variables* except BMI.  
• In boys, only BMI z-score** and fat-free mass** were positively affected. |
| Donnelly et al. (2009) USA | Physical Activity Across the Curriculum (PAAC) | • RCT       | To increase PA by teaching existing academic lessons through PA.  
• To reduce increases in overweight and obesity. | • No change in BMI over 3 years.  
• Levels of exposure to PAAC lessons (≥75 minutes) were associated with smaller increases in BMI*.  
• 27% increase in MVPA.  
• Improvements in academic achievement*. |
| Kriemler et al. (2010) Switzerland | KISS (Kinder-Sportstudie) | • RCT       | To assess the effectiveness of KISS on physical and psychological health. | • At 12 months, improvements in body composition, aerobic fitness and PA*.  
• At 3 years only aerobic fitness benefits maintained.  
• Psychological quality of life did not change significantly. |
| Salmon et al. (2008) Australia | Switch-Play        | • RCT       | To prevent excess weight gain.  
• To improve FMS  
• To reduce time spent in screen behaviours.  
• To increase participation in PA. | • Behaviour modification/FMS group recorded significantly lower BMI*.  
• The FMS only group increased MVPA**.  
• BM group increased vigorous PA**.  
• No reduction in screen behaviours. |
| Resaland et al. (2011) Norway | Sogndal School Intervention study | • CCT       | To increase cardiorespiratory fitness (CRF) via PA intervention (60 minute per day) carried out at a moderate intensity. | • Improved children’s CRF, the mean VO₂ peak was 3.6 (2.5-4.6) mL/kg/min more than the control group**.  
• Greatest impact in children with initial low CRF levels. |
| Thavel et al. (2011) France |                   | • RCT       | To assess the effectiveness of a 6-month physical activity programme on body composition and physical fitness. | • No improvement in anthropometric measurements.  
• Anaerobic and aerobic fitness were significantly improved*. |

*Denotes statistical significance at p < 0.05, ** denotes significance at p < 0.01.
2.3.3 Healthy Eating and PA interventions

Although some studies, involving either a PA or a healthy eating component, showed positive effects on adiposity outcomes (Amini et al., 2015), combined nutrition and PA interventions seem to be more successful in preventing obesity in primary school children (Wang et al., 2015). Furthermore, a combined approach may also help to prevent the comorbidities associated with obesity (Bryan et al., 2011), encouraging children to establish long-lasting healthy habits. In addition, interventions that are implemented over a longer term (> 12 months) appear to be more effective in improving BMI compared to short term interventions (< 12 months) (Mei, 2016). School-based interventions that include a healthy eating and/or PA component may help prevent children becoming overweight (Wang et al., 2015) by improving knowledge and attitudes, behaviour and physical outcomes. Evidence has shown that knowledge, attitude, and habit may be relevant mediators of dietary intervention effects (Stralen et al., 2011) and according to ecological models of health behaviour, appropriate opportunities and settings that facilitate particular forms of activity, such as walking, help individuals achieve sufficient levels of PA for health benefits (Owen et al., 2000).

Table 3 describes studies aimed at improving nutrient intake and increasing PA among primary school children. Seven of these studies (Manios et al., 1998; Gortmaker et al., 1999; Sallis et al., 2003; Kain et al., 2004; Graf et al., 2005; Spiegl et al., 2006; Grydeleand et al., 2013) showed a significant improvement in mean BMI in the intervention compared with the control groups, however there were significant gender differences. Manios et al. (1998) carried out a diet and activity intervention in primary school children in Crete, which showed a significant improvement for BMI and skinfold thickness measurements at 3 and 6 years post intervention, compared to the control group. This significant result was maintained at 10 year follow-up (Kafatos, 2007). The study by Gortmaker et al. (1999) reduced the prevalence of obesity in girls but not boys, while Sallis et al. (2003) and Kain et al. (2004) both demonstrated significant
improvements in the BMI of boys in the intervention groups but not amongst the girls. The study (Step Two programme) from Germany (Graf et al., 2005) reported a lower increase in BMI and waist circumference in the intervention group, while the WAY programme (Spiegl et al., 2006) significantly reduced the risk of developing overweight and reduced overweight in the intervention group by 2%. A more recent study, (Grydeleand et al., 2013) also showed a significant improvement in BMI in girls.

Five additional studies (Leupeker et al., 1996; Sahota et al., 2001; Cabellero et al., 2005; Rush et al., 2011; Fung et al., 2012) did not demonstrate a significant improvement in BMI, however other health related outcomes (PA, healthy eating and anthropometric measurements) were measured. Fung et al. (2012) demonstrated an increase in PA levels and Leupeker et al. (1996) saw both PA and MVPA levels increase. Furthermore, Rush et al. (2011) reported a reduced accumulation of body fat in younger children and a reduced rate of rise in systolic BP in older children. The CATCH intervention (Leupeker et al., 1996) decreased the total fat content of school lunches while a more recent intervention significantly decreased the daily total fat intake in the intervention group (Cabellero et al., 2005). Fung et al. (2012) also reported an increase in the consumption of fruits and vegetables as well as a decrease in energy intake, however Sahota’s et al. (2001) intervention only significant positive finding was a modest increase in the amount of vegetables consumed. Although, interventions that combine healthy eating and PA appear to have mixed success in improving BMI they have achieved other multiple beneficial health effects.
Table 3: Summary of primary school interventions to promote both healthy eating and physical activity

<table>
<thead>
<tr>
<th>Study Reference, Country</th>
<th>Intervention Title (if available)</th>
<th>Study Design</th>
<th>Aims</th>
<th>Effect of intervention</th>
</tr>
</thead>
</table>
| Leupeker et al. (1996) USA | Catch | • RCT  
• 3 years  
• 96 schools  
• N=5106 participants, Age 8-9 years  
• 5-12 weeks classroom lessons | • To prevent cardiovascular disease by improving BMI by enhancing school lunches and increasing MVPA during physical education (PE). | • No significant change in BMI.  
• Decreased total fat content of school lunches (39% to 32%)*.  
• Increased MVPA in PE (40% to 50%)**. |
| Manios et al. (1998, 1999) Greece | | • CCT  
• 3 years, 40 schools  
• N=1046 participants, Age 5-6 years  
• 13-17 hours of nutrition classes per year  
• 2 x 45 min PE sessions per week | • To improve children's diet, fitness, and physical activity.  
• To evaluate the effect of intervention on chronic disease risk factors. | • Significant improvement in BMI** at 3 years.  
• No significant improvements in nutrition or PA. |
| Gortmaker et al. (1999) USA | Planet Health | • RCT  
• 2 years  
• 10 schools  
• N=1560 participants, Age 11 years  
• Planet Health sessions taught in class through existing curriculum | • To increase FV consumption.  
• To decrease consumption of high-fat foods.  
• To increase MVPA.  
• To decrease television viewing. | • Reduced prevalence of obesity among girls (p=0.03).  
• FV consumption increased among girls (0.32 servings per day)**.  
• Reduced television hours among both girls (-0.58 hours)** and boys (-0.40 hours)**. |
| Sahota et al. (2001) UK | APPLES | • RCT  
• 10 months, 10 schools  
• N=636 participants, Age 9-11 years  
• Modify school meals and teacher training School Action plan | • To assess the effectiveness of Active programme promoting lifestyle in schools (APPLES) designed to improve both diet and physical activity. | • Modest increase in consumption of vegetables (0.5 portions per day)*.  
• No improvement in BMI, diet, physical activity or psychological state. |
| Sallis et al. (2003) USA | | • RCT  
• 2 years, Age 11-14 years  
• 24 schools (mean enrolment 1109 students)  
• Increase PA during PE classes  
• Provide low fat foods in school | • To evaluate the effect of intervention on PA and fat intake. | • Significant reduction in BMI among boys*.  
• No significant change in BMI for girls.  
• Significantly increased physical activity for boys**.  
• No reduction in fat intake. |
| Cabellero et al. (2003) USA | Pathways | • RCT  
• 3 years, 41 schools  
• N=1704 participants, Age 7.6 (0.6) years  
• Implemented through curriculum, family involvement and school lunches | • To reduce % body fat by improving dietary intake and increasing physical activity. | • No significant difference in weight, BMI or % body fat.  
• Body fat increased by 7% (approx.) in both groups.  
• Decreased fat intake (31.1% compared with 33.6%)*.  
• Improvement in food and health related knowledge and behaviours** |
| Kain et al. (2004) Chile | | • CCT  
• 6 months, 5 schools  
• N=3086 participants, Age 10.6 (mean) years  
• Nutrition education for children and parents  
• 90 mins additional PA per week | • To improve measures of adiposity and physical fitness through nutrition education and increasing PA. | • Positive effect on BMI was observed in boys for BMI Z**.  
• Physical fitness increased significantly in boys** (for each test) and girls** (for each test). |
<table>
<thead>
<tr>
<th>Study Authors and Year</th>
<th>Country</th>
<th>Program/Intervention Details</th>
<th>Objective(s)</th>
<th>Results</th>
</tr>
</thead>
</table>
| Graf et al. (2005) | Germany | Step Two | • CCT  
  • 9 months, 7 schools  
  • N=1678 participants, Age 8.2 (1.3) years  
  • Additional health and PA lesson | • To improve health education and increase PA using the STEP TWO programme and to investigate the relationship of increased BP with parameters of obesity. | • Lower BMI increase (p=0.069). |
| Spiegel et al. (2006) | USA | Wellness, Academics and You (WAY) | • RCT  
  • 6 months, 16 schools  
  • N=1013 participants, Age 9-11 years | • To increase fruit and vegetable consumption and PA and evaluate the effectiveness of the WAY programme on BMI. | • Change in BMI in the intervention group was an increase of 0.1606 while the control group's mean BMI increased by 0.5210**. 2% reduction in overweight. |
| Rush et al. (2011) | New Zealand | Project Energize | • RCT  
  • 2 years, 124 schools  
  • N=1352, Age 5 and 10 years  
  • Whole school nutrition & PA programme, 20 mins per day | • To reduce weight gain and chronic disease risk factors by increasing healthy eating and quality PA. | • Reduced accumulation of body fat in younger children*.  
• Reduced rate of rise in systolic BP in older children*. |
| Fung et al. (2012) | Canada | APPLE (Alberta Project Promoting active Living and healthy eating) Schools | • Quasi-experimental  
  • 3 years, 10 schools  
  • Age 10-11 years  
  • Allocation of a school health facilitator | • To increase physical activity and improve nutrition. | • Increase vegetables (by 0.39 servings per day)*.  
• Decreases in total energy intake (237 kcals per day)**.  
• Increase in reported MVPA*.  
• Changes in obesity prevalence only borderline significant. |
| Williamson et al. (2012) | USA | Louisiana HEALTH promotion | • RCT  
  • 4 schools, 20 months  
  • N=361 participants, Age 9-12 years  
  • Increasing healthy food options at school  
  • Weekly lessons on healthy eating and PA | • To test whether an environmental intervention is effective in preventing weight gain.  
• To test effectiveness of behaviour modification in preventing weight gain. | • No significant differences for body fat and BMI z-scores.  
• No differences found for changes in food intake, physical activity, or sedentary behaviour. |
| Grydeland et al. (2013) | Norway | HEIA (Health in Adolescents) | • RCT  
  • 20 months, 37 schools  
  • N=700 participants, Age 11 years  
  • 5 classroom nutrition & PA sessions  
  • 10 minute PA & fruit and vegetable breaks once per week | • To increase physical activity, decrease sedentary time and improve dietary behaviours and measure their effect on anthropometric outcomes. | • Beneficial effect on BMI* and BMIz** in adolescent girls, but not in boys. |

*Denotes statistical significance at p < 0.05, ** denotes significance at p < 0.01.
2.4 Conclusion

In summary, evidence for the role of the obesity prevention intervention setting is variable and conflicting. Yet, evidence suggests that out of all the intervention settings, obesity prevention programmes are the most successful when delivered in the primary school setting. Furthermore, there is strong evidence to show that combined dietary and PA interventions are the most effective components to include in such strategies. There is, however, a lack of research on school-based obesity prevention strategies in Ireland. There are currently no primary school based interventions being delivered and evaluated in Ireland that promote healthy PA and nutrition behaviours amongst primary school children. Definite conclusions as to the effectiveness of such programmes at preventing overweight and/or obesity are therefore not available. Without such interventions, overweight, obesity and unhealthy behaviours are at risk of continuing which could have both immediate and long term health implications.
References


Kelleher E, Harrington JM, Shiely F, et al. (2017) Barriers and facilitators to the implementation of a community-based, multidisciplinary, family-focused childhood weight management programme in Ireland: a qualitative study


Perry IJ. The cost of overweight and obesity on the island of Ireland. Safefood, 2012.


Chapter 3.

Project Spraoi: Baseline dietary intake, nutritional knowledge, cardiorespiratory fitness and health markers of Irish primary school children.

Published:
Abstract

Objective: Examine dietary intake, anthropometric measures, CRF and nutritional knowledge of school children.

Design: Cross-sectional study. Food Diary, nutritional knowledge questionnaire and 550m walk/run test were used to assess dietary intake, nutritional knowledge and CRF respectively. BP was also taken and BMI and 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. Nutritional knowledge 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, dietary intake, nutritional knowledge, 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.
3.1 Introduction

Regular collection of nutritional data of primary school children in Ireland is important as current dietary behaviours and practices observed in children may have harmful effects on their health (Rampersaud et al., 2005). Conditions such as overweight and obesity, type 2 diabetes mellitus, high BP and heart disease have all been attributed to poor dietary habits (Finucane, 2009; Sahoo et al., 2015). The 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 (WHO, 2017). 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 (WHO, 2003).

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, low fibre and calcium intake and higher than recommended salt, fat and sugar intake, among children aged five – twelve years (IUNA, 2011).

Cardiorespiratory fitness is a powerful marker of health in childhood (Ardoy et al., 2011; Ortega et al., 2008), with high levels of childhood CRF associated with lower total adiposity (Hurtig-Wennlof et al., 2007; Mesa et al., 2006) and reduced risk of developing cardiovascular disease (CVD) (Ortega et al., 2008; Mesa et al., 2006). Worldwide, levels of CRF in children are decreasing, with children currently about 15% less fit than their parents were at the same age (Tomkinson et al., 2013). 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 (Hussey et al., 2007). 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 (Fryar et al., 2012). A recent study by Gonclaves et al. (2014) highlighted the significant association between BMI and low CRF with CVD risk factors. As childhood obesity has an important influence on overall CVD risk (Raj, 2012) and is likely to track to later life (WHO, 2017), anthropometric measurements, BP and CRF provide valuable information at an early life stage. Anderson et al. (2003) found that low levels of CRF, raised BMI, low levels of PA and unhealthy dietary patterns, may influence the development of unhealthy risk profiles in children. WHtR is considered an accurate anthropometric measure in identifying children with cardiovascular risk factors (Ribeiro et al., 2010) and is a good predictor of adverse lipid profile among children (Ribeiro et al., 2010). In fact, waist circumference and WHtR have been shown to be better predictors of CVD risk factors in children than BMI (Savva et al., 2000).

Nutrition education is a key element to promoting lifelong healthy eating (Perez-Rodrigo & Aranceta, 2001). Improving nutritional knowledge among children may help them to make healthier food choices (Silveira et al., 2011; Toomer, 2016). There is some evidence of a strong correlation between nutritional knowledge and dietary quality (Conference Board of Canada, 2013), which supports the inclusion of nutritional knowledge in health education campaigns but research of this kind, in Ireland, remains limited.

Only a small number of Irish studies (Hussey et al., 2007; Walton et al., 2015) have objectively assessed the dietary intake, CRF or 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 dietary intake, nutritional knowledge and CRF status of Irish primary school children.
3.2 Methods

The researcher was involved in all stages of the data collection and data analysis. The researcher was part of a team responsible for the physical measurements of all participants from schools taking part in Project Spraoi. Baseline evaluation was carried out prior to the commencement of the intervention (October 2014). Data were collected after year one of the programme (June 2015) however due to poor response rates these results were not used in the final evaluation. Follow-up evaluation was carried out at the end of the intervention in May 2016. While a team of researchers carried out the physical testing, the researcher was solely responsible for the distribution, collection and analysis of the food diaries at the three time points for both the intervention and control school. The researcher also acted as the “Energizer” for the school and implemented the intervention by delivering healthy eating and PA sessions to every class (n=10) on one day per week, over two academic years, October 2014 – June 2016.

3.2.1 Subject Participation

Baseline data were 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 6.09 ± 0.33 years and 9.9 ± 0.37 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 (Coppinger et al., 2016) (http://www.isrctn.com/ISRCTN92611015). Inclusion criteria for schools included: mixed, middle/high socio economic status (SES), rural, medium sized (Department of Education and Science), 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 (Coppinger et al., 2016). 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.

3.2.2 Dietary analysis

Dietary intake 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 (Keane et al., 2014). The food diary has been shown to have high validity as a method of dietary assessment (Oretega, 2015) and is regarded as the most precise method for estimating food or nutrient intake (Cade et al., 2017) however the method also has limitations, including reporting bias and due to being self-reported, some misreporting and non-reporting is likely to have occurred (Poslusna et al., 2009). 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. While the researcher did not meet individually with parents, contact details of the researcher were made available to parents should they have any questions about the food diaries or data collection. To encourage accurate recording of portion sizes, images from the Young Person’s Food Atlas Primary (Foster et al., 2010) 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 (Lyons & Giltinan, 2013). The Irish Food Portion Sizes Database describes specific portion
weights for 545 food items for Irish children (5-8 years and 9-12 years). By enabling the researcher to assign a realistic portion weight the accuracy of the dietary assessment is improved (Lyons et al., 2013). Number of unhealthy snacks (sweets, crisps, chocolate, ice-cream, cake, biscuits, bars and pastries) were also estimated using the Irish Food Portion Sizes Database (Lyons & Giltinan, 2013).

The researcher entered all foods and beverages into the Dietplan 7 (Forestfield Software Ltd, Horsham, UK, 2015) software package and subsequently exported to SPSS (Version 22) for analysis. The Dietplan7 (Forestfield Software Ltd, Horsham, UK, 2015) database includes all the foods and nutrients from the 7th Edition of McCance and Widdowson’s The Composition of foods (Finglas et al., 2014) and the revised Composition of Foods Integrated Data Set (Finglas et al., 2015) and includes the new Irish Food Composition Data Base. Analysis examined fruit and vegetable intake, number of unhealthy snacks per day and macro- (protein, fat, saturated fat and carbohydrate) and micro- (sodium, calcium and iron) nutrient intake. Nutritional supplements were not included in the analysis as they were not available from any Dietplan 7 database. Where there were no food codes available for foods, the closest alternative was selected.

3.2.3 Identifying under-reporters

The mean energy intake for six year old males was 1308.26 kcals and females 1281.53 kcals and 1437.16 kcals and 1311.40 kcals for ten year old males and females, respectively. To identify under-reporters, each participant’s basal metabolic rate (BMR), based on their age, sex and weight according to Schofield et al. (1985) was multiplied by an assigned age and gender specific physical activity level (PAL), (Torun et al., 1996) 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.

3.2.4 Nutrition Knowledge Questionnaire

All participants completed a validated questionnaire, titled ‘Fit Kids ‘r’ Healthy Kids’ (Gower et al., 2010) 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 (Food Safety Authority, 2011) replaced the United States Department of Agriculture (USDA) food pyramid (2010) used in the original questionnaire (Gower et al., 2010). The questionnaire contained 15 multiple-choice questions that assessed knowledge on food groups, healthful foods and food functions.

3.2.5 Anthropometric and Blood Pressure Measurements

Height, body mass, BP, heart rate and waist circumference measurements were carried out, as detailed in Table 4. Height and body mass values were used to calculate BMI and BMI Z scores (Cole et al., 1995). International Obesity Task Force (IOTF) (Cole & Lobstein, 2012), 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 (Jackson et al., 2007). Waist circumference and height measurements were used to calculate WHtR. WHtR has been shown to be a better predictor for the presence of cardiovascular disease risk factors than BMI in children (Ribeiro et al., 2010; Savva et al., 2000) and the best predictor of obesity compared to BMI, waist circumference (WC) and waist-to-hip ratio (WHR) (Swainson et al., 2017). Since a WHtR higher than 0.50 is considered to be
an indicator of central obesity in children (Ashwell, 2009; Schwandt et al., 2010), children were classified into two categories (WHtR <0.50 and WHtR ≥0.50).

### Table 4: Details of Anthropometric and BP Measurements undertaken (adapted from Coppinger et al., 2016).

<table>
<thead>
<tr>
<th>Measure</th>
<th>Assessment tool</th>
<th>Method notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>Leicester portable height measure</td>
<td>Shoes were removed prior to measurement. Two measurements taken to the nearest 0.1cm. A third measurement was taken if the difference was &gt;0.5cm.</td>
</tr>
<tr>
<td>Body Mass</td>
<td>Tanita WB100MZ portable electronic scale</td>
<td>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 &gt;0.5kg.</td>
</tr>
<tr>
<td>Waist circumference (WC)</td>
<td>Non-stretch Seca 200 measuring tape</td>
<td>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 &gt;0.5cm.</td>
</tr>
<tr>
<td>Waist to height ratio (WHtR)</td>
<td>Non-stretch Seca 200 measuring tape and Leicester portable height measure</td>
<td>WHtR is calculated by dividing waist circumference by height.</td>
</tr>
<tr>
<td>Heart rate (HR)</td>
<td>Omron M2 Basic Auto Blood Pressure Monitor</td>
<td>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 &gt;10mmHg.</td>
</tr>
<tr>
<td>Blood Pressure (BP)</td>
<td>Omron M2 Basic Auto Blood Pressure Monitor</td>
<td></td>
</tr>
</tbody>
</table>

### 3.2.6 Cardiorespiratory Fitness

CRF was measured using a validated 550m walk/run test (Albon et al., 2008; Hamlin et al., 2014). 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 (<50th centile) and slow (>50th centile) categories based on the Waikato 2011 centile charts for time to complete 550m (Rush & Obolonkin, 2014).

### 3.2.6 Data Analysis

Data were 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 for anthropometric data were due to children being absent on the day of testing (n = 3), while missing values for dietary intake were due to incomplete food diaries (n=25). All statistical testing was performed using a 5% level of significance. Independent samples t-tests and Fisher’s Exact 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 (1988) for the correlations was used to indicate the strength of the correlation between the measurements; weak 0.1 ≤ r < 0.3, moderate 0.3 ≤ r < 0.5 and strong r ≥ 0.5.

3.3 Results

3.3.1 Dietary intake data

Baseline dietary and nutrient intake data categorised by age and gender, are presented in Table 5. There was a 75% (n=76) response rate for completed food diaries. Intakes of calcium and iron were below reference intakes for the 5-13 year age group (FSAI, 2011). 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 5: Dietary and nutrient intakes for 6 and 10 year old Irish primary school children

<table>
<thead>
<tr>
<th>Intake Recommendations</th>
<th>6 year olds</th>
<th>10 year olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Fibre (g)</td>
<td>11.09 ± 2.94</td>
<td>11.39 ± 4.09</td>
</tr>
<tr>
<td>Calcium (mg) RI = 800-1300mg[^4]</td>
<td>695.47 ± 209.63</td>
<td>721.07 ± 237.80</td>
</tr>
<tr>
<td>Iron (mg) RI = 8-11mg[^4]</td>
<td>6.84 ± 1.60</td>
<td>7.29 ± 1.99</td>
</tr>
<tr>
<td>Sodium (mg) (&lt;1600mg) (FSAI,2011)</td>
<td>1441.1 ± 269.58</td>
<td>1385.26 ± 439.87</td>
</tr>
<tr>
<td>Protein (% total energy) AMDR[^] =10-30%[^3]</td>
<td>15.29 ± 1.75</td>
<td>15.38 ± 2.76</td>
</tr>
<tr>
<td>Fat (% total energy) AMDR = 20-35%[^4]</td>
<td>34.31 ± 3.95</td>
<td>35.68 ± 4.92</td>
</tr>
<tr>
<td>Saturated Fat (% total energy) AMDR = &lt;10%[^4]</td>
<td>14.70 ± 3.49</td>
<td>17.17 ± 1.25</td>
</tr>
<tr>
<td>Carbohydrate (% total energy) DRV = 45-60% (EFSA,2010)</td>
<td>48.74 ± 4.35</td>
<td>47.19 ± 5.71</td>
</tr>
<tr>
<td>Sugar (% total energy)</td>
<td>21.26 ± 5.03</td>
<td>20.29 ± 6.21</td>
</tr>
<tr>
<td>Total Energy (kcal)</td>
<td>1308.26 ± 147.20</td>
<td>1281.53 ± 362.48</td>
</tr>
</tbody>
</table>

Data represents mean ± standard deviation. * Difference is significant at the 0.05 level, for males versus females in the same age group. ^ AMDR: Acceptable Macronutrient Distribution Range.

Table 6 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 (Healthy Ireland, 2016), with six and ten year olds consuming 1.23 and 1.52 servings per day, respectively.
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.

### 3.3.2 Nutritional Knowledge

The maximum possible score from the nutritional knowledge 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.

### 3.3.3 Anthropometric and Blood Pressure data

Anthropometric and BP data categorised by age and gender, are presented in Table 7. Descriptive 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 (Cole & Lobstein, 2012). 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

| Table 6: 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.
old children, 1 (4.3%) boy and 1 (3.4%) girl had a WHtR ≥ 0.50. Comparison of classification of weight status using BMI and WHtR showed that 4% of children were obese using BMI classifications (IOTF, Cole & Lobstein, 2012). This is in comparison to 7% when using the WHtR cut-off, which has been shown to be a better predictor of cardiovascular disease risk factors than BMI in children ((Ribeiro et al., 2010; Savva et al., 2000).

BP centiles, as detailed by Jackson et al. (2007) 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 (Jackson et al., 2007).

<table>
<thead>
<tr>
<th>Markers of Health</th>
<th>6 year olds</th>
<th>10 year olds</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Males</strong></td>
<td><strong>Females</strong></td>
<td><strong>Males</strong></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>117.33 ± 4.78</td>
<td>115.59 ± 5.66</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>22.60 ± 3.18</td>
<td>21.58 ± 2.49</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>16.36 ± 1.53</td>
<td>16.13 ± 1.31</td>
</tr>
<tr>
<td>BMI Z score</td>
<td>0.57 ± 0.96</td>
<td>0.29 ± 0.68</td>
</tr>
<tr>
<td>WHtR</td>
<td>0.45 ± 0.03</td>
<td>0.45 ± 0.03</td>
</tr>
<tr>
<td>Systolic BP (mmHg)</td>
<td>104.31 ± 8.89</td>
<td>103.44 ± 9.32</td>
</tr>
<tr>
<td>Diastolic BP (mmHg)</td>
<td>61.56 ± 8.99</td>
<td>61.52 ± 9.82</td>
</tr>
<tr>
<td>Heart rate (bpm)</td>
<td>85.63 ± 9.21</td>
<td>88.66 ± 12.35</td>
</tr>
</tbody>
</table>

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

### 3.3.4 Cardiorespiratory Fitness

Percentages of children assigned to the fast or slow category, by age and gender, are presented in Table 8. 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 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).

| Table 8: Fast & Slow run categories of Irish primary school children. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                 | **6 year olds** |                 | **10 year olds** |                 |                 |                 |
|                 | Males           | Females         | All             | Males           | Females         | All             |
| Fast Category   |                 |                 |                 |                 |                 |                 |
| (≤50<sup>th</sup> Centile) | 6 (26.1%)  | 5 (22.7%)  | 11 (24.4%)  | 9 (39.1%)  | 8 (32%)  | 15 (35.4%)  |
| Slow Category   |                 |                 |                 |                 |                 |                 |
| (>50<sup>th</sup> Centile) | 17 (73.9%) | 17 (77.3%) | 34 (75.6%) | 14 (60.9%) | 17 (68%) | 31 (64.6%) |
| Total           | 23 (100.0%)     | 22 (100.0%)     | 45 (100.0%)     | 23 (100.0%)     | 25 (100.0%)     | 46 (100.0%)     |

3.3.5 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 9 and 10. 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). Nutritional knowledge 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.
Table 9: Relationships between dietary intake, nutritional knowledge, anthropometric measurements, BP and CRF for 6 year olds.

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<th>BMI</th>
<th>SBP</th>
<th>DBP</th>
<th>Pulse</th>
<th>WHtR</th>
<th>Run Score</th>
<th>Nut. Score</th>
<th>Fibre</th>
<th>Sat Fat</th>
<th>Trans fat</th>
<th>Na</th>
<th>Ca</th>
<th>Iron</th>
<th>Fruit</th>
<th>Veg</th>
<th>Unhealthy Snack</th>
<th>% E Fat</th>
<th>% E CHO</th>
<th>% E Pro</th>
<th>% E Sugar</th>
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| % E Protein  | 1   | .166** | 1   | 79

* Correlation is significant at the 0.05 level, ** Correlation is significant at the 0.01 level. #: Spearman’s Rank Order Correlation. v: 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 10: Relationships between dietary intake, nutritional knowledge, anthropometric measurements, BP and CRF for 10 year olds.

<table>
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<th>Measurements</th>
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<th>DBP</th>
<th>Pulse</th>
<th>WHtR</th>
<th>Run Score</th>
<th>Nut. Score</th>
<th>Fibre</th>
<th>Sat Fat</th>
<th>Trans fat</th>
<th>Na</th>
<th>Ca</th>
<th>Iron</th>
<th>Fruit</th>
<th>Veg</th>
<th>Fruit &amp; Veg</th>
<th>Unhealthy Snack</th>
<th>% E Fat</th>
<th>% E CHO</th>
<th>% E Pro</th>
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* Correlation is significant at the 0.05 level, ** Correlation is significant at the 0.01 level. * Spearman’s Rank Order Correlation. v Pearson’s product-moment correlation.


80
3.4 Discussion

The study examined dietary intake, anthropometric measures, CRF and nutritional knowledge 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 underweight based on the IOTF (Cole & Lobstein, 2012) classifications. These values are significantly lower than those found by Keane et al. (2014), who found that over one quarter of Cork primary school children were overweight (20.9%) or obese (6.2%), and the NCFS (IUNA, 2005) 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. (2014) and the NCFS (IUNA, 2005), included schools from low SES backgrounds, which may explain their higher percentages of overweight and obesity (Wang & Lim, 2012). This is supported by research reported in the Growing Up in Ireland study (Williams et al., 2009) 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 (CSO, 2006).

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 (WHO, 2003). These results are similar to those previously reported (Walton et al., 2015; IUNA, 2005). 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 non-communicable diseases (NCDs) (WHO, 2017). Micronutrient intakes, including calcium and iron were lower than recommended (Food Safety Authority of Ireland, 2011). 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 (Holick, 2004). 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 (National Institute of Health US, 2007). Fibre intake (10 year olds) was lower than recommended in dietary guidelines (FSAI, 2011). Inadequate fibre intake can increase the risk of constipation (Glackin et al., 2008). Furthermore, research has shown that diets high in fibre have lower energy density and may therefore help in moderating obesity (Anderson et al., 2009). High fibre diets may also lower the risk of metabolic syndrome, Type 2 Diabetes and BP in children (Edwards et al., 2015). Saturated fat intake and number of unhealthy snacks per day were also higher than recommended by the European Food Safety Authority (2010). The WHO (2015) 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 (WHO, 2015). 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.

Unhealthy eating habits are likely to contribute to the rising levels of child obesity (SACN, 2015) and can also lead to increased risk of Type 2 diabetes and CVD (WHO, 2015). Additionally, research indicates a positive relationship between intake of free sugars and dental caries in children (O’Neill et al., 2007). 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 (Moynihan, 2016). It is possible that reporting bias may have contributed to the inverse association between sugar intake and WHtR (Bingham et al., 2007) in that foods high in sugar are often underreported by people with overweight/obesity (Bellisle & Rolland-Cachera, 2001) Our results also demonstrate an inverse correlation between sugar intake and nutritional knowledge, suggesting that improving nutritional knowledge may help to reduce sugar intake.
High BP in children is a cause for concern as it is a risk factor for CVD (Te Morenga et al., 2012). BP values from this study are similar to those found for nine and ten year olds in the CCLaS (2014). However, our results showed 15.7% of ten year olds had high BP, compared to 8% of children who took part in the Cork Children’s Lifestyle Study (2014). Children with elevated BP are likely to become adults with high BP and therefore early intervention is key (Riley & Bluhm, 2012).

Our results highlight that greater nutritional knowledge is associated with some healthy dietary intake (higher protein intake (six year olds) and lower sugar intake (ten year olds). However, it has previously been suggested that primary school children's dietary intake may be more reflective of parental choices rather than their own choices (Naeeni et al., 2014). Research conducted in Ireland by Walsh & Nelson (2010) revealed that parents were a major influence in their children’s diets. Thus, improving children’s nutritional knowledge 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 (Rush et al., 2014). Such a finding is positive, since Rush et al. (2015) 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.

3.5 Conclusion

In this study, children consumed 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 intake and CRF values and sub-optimal health, and the finding that a greater nutritional knowledge 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.
References


Dietary Supplement Fact Sheet: Iron, 2007, Office of Dietary Supplements (ODS), National Institutes of Health US.


Chapter 4.

Project Spraoi: A two year longitudinal study on the effectiveness of a school-based nutrition and physical activity intervention on dietary intake, nutritional knowledge and markers of health of Irish school children.

Submitted for publication:

Abstract

Objective: To assess the effectiveness of a nutrition and PA intervention on dietary intake, nutritional knowledge, BP, anthropometric measures and CRF of school children.

Design: Longitudinal study. Dietary intake, nutritional knowledge, BMI, WHtR, BP and CRF were all measured/calculated prior to (October 2014) and at the end of (June, 2016) intervention delivery.

Setting: Two primary schools (one intervention and one control school), Cork, Ireland.

Subjects: six year olds (n = 49; age 6.09 ± 0.33 years) and ten year olds (n = 52; age 9.9 ± 0.37 years).

Results: There was a large statistically significant difference between the change in fibre intake in six year old males (p = 0.024, ES = 0.315) and percentage energy from protein in ten year old females (p = 0.021, ES = 0.276) in the intervention and control groups. There was a large statistically significant difference between the change in WHtR (p = 0.0005, ES = 0.386) and a moderate statistically significant difference between the change in nutritional knowledge (p = 0.027, ES = 0.107) for ten year olds in the intervention and control groups. There was also a large and a moderate statistically significant difference between the change in systolic (p = 0.005, ES = 0.165) and diastolic BP (p = 0.023, ES = 0.116) respectively for ten year olds in the intervention and control groups.

Conclusion: Although only undertaken in one school, Project Spraoi is Ireland’s first ever school based intervention that has been evaluated and shown promise at improving dietary intake, nutritional knowledge, WHtR and BP in older Irish primary school children.
4.1 Introduction

Poor diet, high BP and low levels of physical fitness in childhood have been associated with multiple health problems including overweight and obesity, cardiovascular diseases, cancer and type 2 diabetes mellitus (WHO, 2009; Weiss et al., 2014). Furthermore, overweight and obesity are now the most common childhood disorders in Europe (WHO, 2018), causing social, psychological and physiological health problems in childhood and poor health outcomes as an adult (Waters et al., 2011). Environmental and lifestyle factors are recognised as the primary drivers of obesity; with poor diet and sedentary behaviours playing a role (Perry et al., 2012). Both national (Bel-Serrat et al., 2012) and international statistics (WHO, 2016) show that obese children are more likely to become obese adults, indicating that surveillance and the promotion of healthy behaviours early in life is warranted (Craigie et al., 2011).

The school environment has the potential to make important differences in children’s health and presents a number of opportunities for intervention (Vasques et al., 2013; Lavelle et al., 2012; Van Sluijs et al., 2008; Ward et al 2007). In fact, school-based interventions show consistent improvements in children’s knowledge and attitudes, behaviour and, when tested, physical and clinical outcomes (WHO, 2009). Primary schools are particularly favourable, as children of primary school age can be highly influenced by health promotion initiatives, which can then promote positive behavioural changes that can continue into adulthood (WHO, 2017). Children also spend considerable amounts of time at school and this setting enables large numbers of children to be targeted at one time (Garrow, 1991).

Research from a systematic review of 32 studies, with over 52, 000 participants (Sobol-Goldberg et al., 2013) reported that recent school-based interventions demonstrate more convincing evidence for improvements in BMI by enhancing DI and increasing PA than earlier initiatives. Another systematic review (Waters et al., 2011) also found strong evidence to support the beneficial effects of school-based programmes targeted to children aged 6 - 12.
years. Such programmes include increased PA, improvements in nutritional quality of school food and providing environments and cultural practices to support healthy eating and activity throughout each day (Waters et al., 2011). Parental support is also important, which includes encouraging children to be more active, eat more nutritious foods and spend less time in screen based activities in the home (Horne et al., 2009). Although some studies involving either a PA or a healthy eating component have shown positive effects on adiposity outcomes, combined nutrition and PA interventions seem to be more successful in improving multiple health behaviours (not just adiposity reduction) in primary school children (Amini et al., 2015; Wang et al., 2015). A combined approach may also help to prevent the comorbidities associated with obesity (Bryan et al., 2011); encouraging children to establish long-lasting healthy lifestyle habits. In addition, long term interventions (> 12 months) appear to be more effective in achieving healthier BMI (Sobol-Goldberg et al., 2013; Mei et al., 2016) and improving diet and PA (Wan et al., 2015), compared to short term interventions (< 12 months).

To date, there are no health promotion programmes targeting both nutrition and PA in Irish primary schools that have been evaluated and proven effective. Definite conclusions as to the effectiveness of such programmes at improving health behaviours and preventing overweight and/or obesity are therefore not available. Without such interventions, unhealthy behaviours are at risk of continuing which could have both immediate and long term health implications. To address this, Project Spraoi (http://www.cit.ie/projectspraoi), a primary school health promotion intervention that aims to promote PA, improve dietary intake and increase nutritional knowledge of Irish school children, was created. Project Spraoi is based on ‘Project Energize’ (www.projectenergize.org.nz/); a combined PA and nutrition intervention that is effective at improving CRF, body composition and BP for children (Rush et al., 2014). The project, which has been running in New Zealand for 10 years, has proven to be both sustainable and cost effective (Rush et al., 2016). The intervention is based on the Social Ecological Model
of Health Behaviour (Sallis et al., 2008) which aims to create an environment that promotes a healthy diet and physical activity and to teach children the knowledge and skills needed to participate in these healthy behaviours (Coppinger et al., 2016). With only minor changes to the Project Energize resources to make them suitable to an Irish setting, Project Spraoi aims to achieve similar health improvements in Cork school children.

4.2 Methods

4.2.1 Subject Participation

Two schools were selected via convenience sampling for the purpose of a larger study, ‘Project Spraoi’, described in detail elsewhere (Coppinger et al., 2016). Inclusion criteria for schools included: mixed, middle/high socio economic status (SES), rural, medium sized (Educate Together, 2007), 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 (Coppinger et al., 2016). The intervention and control schools were matched on the inclusion criteria listed above. A total of 101 children (n=49 six year olds, n=52 ten year olds; 45.5% boys, 54.5% girls) participated. The mean age for six year olds was 6.09 ± 0.33 years and 9.9 ± 0.37 years for ten year olds.

All students from the intervention school (n=274) received the PA and nutrition intervention; children in the control school (n=567) did not receive any of the intervention components. While all children from the intervention school took part in the nutrition and PA classes, evaluation of dietary intake, nutritional knowledge, BP, anthropometric and CRF measurements was only carried out on six year old and ten year old children. Data were collected over 4 days (two weekdays and two weekend days) at two time points (baseline, October 2014 and post-intervention, June 2016) by trained postgraduate researchers and staff of Cork Institute of Technology (Cork, Ireland). The same children were assessed at baseline
and post-intervention, non-response rate for completed food diaries increased from 25% (n=25) at baseline to 32% (n=32) post-intervention. Informed assent 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.

4.2.2 ‘Project Spraoi’ Intervention

The Project Spraoi intervention took place over two academic years, from October 2014 – May 2016. The relevant intervention material used in ‘Project Energize’ was tailored for use in ‘Project Spraoi’, with minor adjustments applied (to make it culturally relevant to Ireland) in order to make it relevant to the Irish setting. From the outset, an agreement was signed by the school and the ‘Energizer’ (who provide hands on support and assistance to schools and teachers), agreeing to the goals of Project Spraoi and to outline expectations, roles and responsibilities. The ‘Energizer’ and class teacher discussed plans for targeted nutrition and PA classes, which included providing specific material on healthier food choices, delivering simple healthy food demonstrations and modelling PA classes based on Kiwidex (Sport & Recreation New Zealand, 2005) and Project Energize (Rush et al., 2011). Information was also provided on unhealthy foods and ways to encourage a reduction in the amount of high energy/low nutrient food consumed. Parents were given the opportunity to attend information and demonstration sessions, delivered by the ‘Energizer’. These included healthy lunchbox ideas, tasting sessions and education sessions on high sugar beverages and takeaways see Appendix 3. However, only a small number of parents (n=12) attended. The PA classes included the delivery of 20 minutes of huff and puff games, circuit classes, dance routines, gymnastics and whole school initiatives. The key objectives of the Project Spraoi nutrition and PA interventions are described in Table 11.
Table 11: Key Aims of the Project Spraoi nutrition and physical activity intervention

<table>
<thead>
<tr>
<th>Nutrition</th>
<th>PA</th>
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<td>• Water is the best drink.</td>
<td>• Encourage additional 20 minutes PA per day.</td>
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<td>• Consume milk and high calcium foods daily.</td>
<td>• Increase lunchtime PA with organised games.</td>
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<tr>
<td>• Increase fruit and vegetable consumption.</td>
<td>• Encourage home play (active homework) and reduce time spent engaging in sedentary activities.</td>
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<td>• Improve nutritional quality of food brought from home and reduce energy dense foods.</td>
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<tr>
<td>• Increase availability of healthy choices at school.</td>
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<td>• Decrease availability of energy dense foods in school.</td>
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<tr>
<td>• Increase awareness of the importance of breakfast and a breakfast routine.</td>
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<td>• Consistent nutrition messages in all aspects of school and community interaction.</td>
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4.2.3 Dietary analysis

A four day estimated food diary (two weekday and two weekend days), adapted from the Cork Children’s Lifestyle study (CCLaS) (Keane et al., 2014) was used to examine dietary intake. Written instructions were provided to participants and the researcher also provided guidance each day in the classroom setting on completing the food diary. Each day of the food diary was broken into six meal sections; breakfast, morning snack, lunch, afternoon snack, dinner and evening snack. Ten year old children completed the food diaries themselves and were advised to seek help from parents and teachers when filling in their food diary, while parents of six year old children were asked to complete the food diary with them. To improve dietary data completion, the researcher sat down with all ten year olds at the end of food diary collection to fill in any missing information. To encourage accurate recording of portion sizes, images from the Young Person’s Food Atlas (primary) (Foster et al., 2010) were included with the diary. The Irish Food Portion Sizes Database (Lyons & Gilitinan, 2013) was used to assign an age appropriate median portion size when no estimation was given. Number of unhealthy snacks (sweets, crisps, chocolate, ice-cream, cakes, biscuits, bars and pastries) were estimated using the Irish Food Portion Sizes Database (Lyons & Gilitinan, 2013).
All foods and beverages were entered into the Dietplan 7 (Forestfield Software Ltd, Horsham, UK, 2015) software package. SPSS (Version 22) was used to analyse and examine 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.

4.2.5 Identifying under-reporters

To estimate total daily energy requirements, each participant’s basal metabolic rate (BMR, based on their age, sex and weight according to the equation devised by Schofield et al. (1985) was multiplied by an allocated physical activity level (PAL) (Torun et al., 1996). 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 energy requirements and it was found that 54.5% (n=55) of children were classified as under-reporters at baseline and 54.4% (n=55) following the intervention. To consider the likelihood of misreporting, all macronutrients in the present study were expressed as a proportion of energy consumed (Coppinger et al., 2016).

4.2.6 Nutrition Knowledge Questionnaire

The validated ‘Fit Kids ‘r’ Healthy Kids’ (Gower et al., 2010) questionnaire was used to assess participants’ knowledge of healthy eating. To ensure its age appropriateness and relevance in an Irish setting, it was first piloted in a primary school in Cork (n=23 students). Minor changes were made to the pictures and the Irish Food Pyramid (FSAI, 2011) replaced the United States Department of Agriculture (USDA) (2010) food pyramid used in the original questionnaire (Gower et al., 2010). A total of 15 multiple-choice questions measured knowledge of food groups, healthful foods, and food functions.
4.2.7 Anthropometric and Blood Pressure Measurements

Height (cm), body mass (kg) and waist circumference (cm) measurements were taken prior to (October, 2014), and at the end of (June, 2016) intervention delivery. Height and body mass were measured to calculate BMI and BMI Z scores (Cole et al., 1995; Cole & Lobstein, 2012). International Obesity Task Force (IOTF) (Cole & Lobstein, 2012) age and gender -adjusted cut off points were applied to the data in order to assign BMI classifications (thin, normal, overweight, obese) and to make international comparisons. BMI Z scores were also calculated to evaluate adiposity adjusted for age and sex (Cole et al., 2012). Waist-to-height-ratio (WHtR) was also calculated by dividing waist circumference by height and the universal cut-off value for children of 0.5 indicated risk of obesity and cardiometabolic syndrome (Ashwell, 2009). Waist circumference (cm) was measured in duplicate using a non-stretch Seca 200 measuring tape, height (cm) was measured using Leicester portable height scales and weight was measured using Tanita WB100MZ portable electronic scales. BP (mmHg) was measured 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 to ensure an accurate reading. A third measurement was taken if the difference was >10mmHg and an average was calculated. Children were classified into BP categories (normal and high-normal/high) according to gender and age-specific BP cut-points (Jackson et al., 2007).

4.2.8 Cardiorespiratory Fitness

CRF was measured using a validated 550m walk/run test (Albon et al., 2008; Hamlin et al., 2014). The run usually took place on the same day as anthropometric testing (weather dependent) but was always after the anthropometric and BP measurements. An oval loop using a 110 metre rope was set up on a level grassed area outside. The run/walk test was first explained before all children participated in a warm up lap. Participants, in groups of up to
five, were asked to complete 5 laps as quickly as possible. Time taken to complete the 550m
for each participant were recorded, in minutes and seconds, using calibrated XLR8
stopwatches. Run scores were classified into fast (≤50th centile) or slow (>50th centile)
categories, based on the Waikato 2011 centile charts for time to complete 550m (Rush &
Obolonkin et al., 2014).

4.2.9 Data Analysis

Data were analysed using IBM SPSS (Version 22.0 for Windows). Mean and standard
deviation were used to summarise the data for all continuous variables. Children absent from
school on the day of testing were recorded as missing values. Children were divided into four
sub-groups according to age and gender; six year old boys (n = 22), six year old girls (n = 27),
ten year old boys (n = 24) and ten year old girls (n = 28). Shapiro Wilk test and Levene’s test
were used as criteria for satisfying the assumptions of measurements being normally distributed
and homogeneity of variance, respectively. A repeated measures analysis of variance
(ANOVA) was undertaken to investigate statistically significant differences in dietary intake,
nutritional knowledge, height, weight, BMI, WHtR, BP and CRF between the intervention and
control group. All statistical testing was performed using a 5% level of significance. The effect
size (ES), $\eta^2$, was calculated to determine the strength of any statistically significant findings
(Small: $0.01 \leq \eta^2 < 0.06$; Medium: $0.06 \leq \eta^2 < 0.14$; Large: $\eta^2 \geq 0.14$).

4.3 Results

Repeated measures ANOVA was implemented to compare results of anthropometric
measurements, BP, run time, nutritional knowledge (shown in Tables 12 and 13) and dietary
intake (shown in Tables 14 and 15) at baseline and post-intervention. Statistically significant
interaction effects for the intervention were found at 0.05 or 0.01 level of significance. There
was statistically insignificant differences between gender for anthropometric measurements,
BP, run time and nutritional knowledge. Hence, results are reported for the total sample in Tables 12 and 13. There was no significant difference in the energy intake for 6 year olds and ten year olds from baseline to post-intervention.

### Table 12: Intervention Effect for 6 year olds: Anthropometric, BP measurements, Run Time & Nutritional Knowledge.

<table>
<thead>
<tr>
<th>Marker of Health (unit)</th>
<th>Intervention</th>
<th>Control</th>
<th>Intervention Effect</th>
<th>p-value</th>
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<tbody>
<tr>
<td>BMI (kg/m²)</td>
<td>Baseline</td>
<td>Follow-up</td>
<td>Baseline</td>
<td>Follow-up</td>
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<tr>
<td></td>
<td>16.22 (1.30)</td>
<td>16.67 (2.02)</td>
<td>16.44 (1.42)</td>
<td>16.60 (1.57)</td>
</tr>
<tr>
<td>Systolic Blood Pressure (mmHg)</td>
<td>103.43 (9.12)</td>
<td>105.22 (6.97)</td>
<td>104.57 (8.32)</td>
<td>101.26 (5.62)</td>
</tr>
<tr>
<td>Diastolic Blood Pressure (mmHg)</td>
<td>59.57 (8.16)</td>
<td>59.72 (6.85)</td>
<td>64.46 (11.09)</td>
<td>57.71 (6.85)</td>
</tr>
<tr>
<td>WHtR (cm)</td>
<td>0.46 (0.03)</td>
<td>0.41 (0.03)</td>
<td>0.45 (0.03)</td>
<td>0.41 (0.03)</td>
</tr>
<tr>
<td>Run Time (secs)</td>
<td>207.73 (25.23)</td>
<td>178.68 (21.07)</td>
<td>203.62 (20.41)</td>
<td>183.61 (30.21)</td>
</tr>
<tr>
<td>Nutritional Knowledge</td>
<td>9.45 (2.18)</td>
<td>11.89 (2.50)</td>
<td>8.94 (2.11)</td>
<td>11.35 (1.27)</td>
</tr>
</tbody>
</table>

Repeated Measures ANOVA; Mean (SD).

### Table 13: Intervention Effect for 10 year olds: Anthropometric, BP measurements, Run Time & Nutritional Knowledge.

<table>
<thead>
<tr>
<th>Marker of Health (unit)</th>
<th>Intervention</th>
<th>Control</th>
<th>Intervention Effect</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI (kg/m²)</td>
<td>Baseline</td>
<td>Follow-up</td>
<td>Baseline</td>
<td>Follow-up</td>
</tr>
<tr>
<td></td>
<td>17.19 (2.08)</td>
<td>17.33 (2.19)</td>
<td>17.93 (2.63)</td>
<td>18.65 (2.55)</td>
</tr>
<tr>
<td>Systolic Blood Pressure (mmHg)</td>
<td>113.88 (6.42)</td>
<td>110.05 (8.18)</td>
<td>98.35 (11.79)</td>
<td>104.35 (7.33)</td>
</tr>
<tr>
<td>Diastolic Blood Pressure (mmHg)</td>
<td>70.70 (5.47)</td>
<td>64.35 (5.73)</td>
<td>59.54 (10.43)</td>
<td>59.35 (6.58)</td>
</tr>
<tr>
<td>WHtR (cm)</td>
<td>0.4 (0.03)</td>
<td>0.38 (0.02)</td>
<td>0.42 (0.04)</td>
<td>0.41 (0.04)</td>
</tr>
<tr>
<td>Run Time (secs)</td>
<td>161.79 (19.42)</td>
<td>148.05 (21.76)</td>
<td>183.90 (24.07)</td>
<td>164.71 (20.51)</td>
</tr>
<tr>
<td>Nutritional Knowledge</td>
<td>12.45 (1.23)</td>
<td>13.55 (0.88)</td>
<td>12.96 (1.11)</td>
<td>13.15 (1.12)</td>
</tr>
</tbody>
</table>

Repeated Measures ANOVA; Mean (SD). ˚ Denotes small effect size, ˝ medium effect size and ˚˚ a large effect size.

#### 4.3.1 Intervention Effects: Six year olds

There was only one significant finding for the six year olds; a large statistically significant difference of 5.97g between the change in fibre intake in six year old males in the intervention
and control groups (p = 0.024, ES = 0.315) (Table 14). Figure 3 (a) displays the fibre intake at baseline and post-intervention for six year olds in the control school and the intervention school. Fibre intake increased by 3.43g within the intervention group and decreased by 2.54g in the control group, see Figure 3 (a). Fibre intake increased by 3.43g within the intervention group and decreased by 2.54g in the control group, see Figure 3 (a).

**Table 14:** Intervention Effect for 6 year olds: Macro and Micro Nutrient Intake, Fruit & Vegetable intake & Number of Unhealthy Snacks.

<table>
<thead>
<tr>
<th>Dietary Intake</th>
<th>Intervention</th>
<th>Control</th>
<th>Intervention Effect</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Follow-up</td>
<td>Baseline</td>
<td>Follow-up</td>
</tr>
<tr>
<td>Fibre Intake Males (g)</td>
<td>10.47 (2.90)</td>
<td>13.9 (5.94)</td>
<td>11.30 (3.29)</td>
<td>8.76 (1.79)</td>
</tr>
<tr>
<td>Fibre Intake Females (g)</td>
<td>12.15 (5.03)</td>
<td>12.27 (3.71)</td>
<td>9.76 (3.17)</td>
<td>11.03 (2.71)</td>
</tr>
<tr>
<td>Sodium Intake Males (mg)</td>
<td>1427.63 (157.60)</td>
<td>1552.81 (427.11)</td>
<td>1420.20 (285.54)</td>
<td>1282.20 (377.41)</td>
</tr>
<tr>
<td>Sodium Intake Females (mg)</td>
<td>1484.00 (500.46)</td>
<td>1311.00 (512.12)</td>
<td>1071.66 (278.42)</td>
<td>1355.33 (390.85)</td>
</tr>
<tr>
<td>Calcium Intake Males (mg)</td>
<td>694.45 (147.49)</td>
<td>782.09 (243.89)</td>
<td>570.80 (130.36)</td>
<td>568.60 (130.98)</td>
</tr>
<tr>
<td>Calcium Intake Females (mg)</td>
<td>785.71 (305.58)</td>
<td>723.85 (202.43)</td>
<td>905.66 (234.29)</td>
<td>1060.33 (246.87)</td>
</tr>
<tr>
<td>Iron Intake Males (mg)</td>
<td>6.47 (1.51)</td>
<td>8.42 (2.89)</td>
<td>6.54 (0.74)</td>
<td>7.20 (2.66)</td>
</tr>
<tr>
<td>Iron Intake Females (mg)</td>
<td>7.24 (1.97)</td>
<td>7.43 (1.78)</td>
<td>7.25 (2.63)</td>
<td>9.25 (2.82)</td>
</tr>
<tr>
<td>Fat Intake Males (% total energy)</td>
<td>33.63 (3.67)</td>
<td>32.60 (3.67)</td>
<td>34.50 (5.39)</td>
<td>33.98 (5.06)</td>
</tr>
<tr>
<td>Fat Intake Females (% total energy)</td>
<td>34.87 (6.73)</td>
<td>30.21 (2.94)</td>
<td>37.46 (3.78)</td>
<td>35.63 (8.56)</td>
</tr>
<tr>
<td>Saturated Fat Intake Males (% total energy)</td>
<td>15.79 (2.89)</td>
<td>14.18 (2.80)</td>
<td>14.58 (4.27)</td>
<td>14.66 (1.95)</td>
</tr>
<tr>
<td>Saturated Fat Intake Females (% total energy)</td>
<td>17.41 (2.92)</td>
<td>13.97 (1.46)</td>
<td>15.51 (4.38)</td>
<td>14.93 (3.32)</td>
</tr>
<tr>
<td>Sugar Intake Males (% total energy)</td>
<td>23.10 (4.74)</td>
<td>17.30 (5.66)</td>
<td>18.16 (5.29)</td>
<td>16.56 (5.04)</td>
</tr>
<tr>
<td>Sugar Intake Females (% total energy)</td>
<td>20.88 (8.92)</td>
<td>20.10 (5.34)</td>
<td>18.40 (3.67)</td>
<td>12.10 (8.90)</td>
</tr>
<tr>
<td>Protein Intake Males (% total energy)</td>
<td>15.24 (1.66)</td>
<td>15.52 (2.47)</td>
<td>14.82 (1.44)</td>
<td>15.80 (1.53)</td>
</tr>
<tr>
<td>Protein Intake Females (% total energy)</td>
<td>12.15 (5.03)</td>
<td>12.27 (3.71)</td>
<td>9.76 (3.17)</td>
<td>11.03 (2.71)</td>
</tr>
<tr>
<td>Total Servings of Fruit &amp; Vegetables</td>
<td>2.69 (1.82)</td>
<td>2.50 (2.00)</td>
<td>1.64 (0.44)</td>
<td>1.95 (0.82)</td>
</tr>
<tr>
<td>Number of Unhealthy Snacks</td>
<td>1.16 (0.66)</td>
<td>1.20 (0.72)</td>
<td>1.09 (0.41)</td>
<td>1.12 (0.65)</td>
</tr>
</tbody>
</table>

Repeated Measures ANOVA; Mean (SD). * Denotes small effect size, ** medium effect size and *** a large effect size.

4.3.2 Intervention Effects: Ten year olds

For ten year olds, there was a large statistically significant difference of 9.83 mmHg between the change in systolic BP in the intervention and control groups (p = 0.005, ES = 0.165). The
systolic BP decreased by 3.83 mmHg within the intervention group and increased by 6 mmHg in the control group, see Figure 3 (b). Figure 3 (b) displays the systolic BP at baseline and post-intervention for ten year olds in the control school and the intervention school. There was a moderate significant difference of 6.16 mmHg between the change in diastolic BP in the intervention and control groups (p = 0.023, ES = 0.116). Figure 3 (c) displays the diastolic BP at baseline and post-intervention for ten year olds in the control school and the intervention school. The diastolic BP decreased by 6.35 mmHg for ten year olds in the intervention group and decreased by 0.19 mmHg in the control group (Figure 3 (c)).

Figure 3 (d) displays the WHtR at baseline and post-intervention for ten year olds in the control school and the intervention school. There was a large statistically significant difference of 0.01 between the change in WHtR in the intervention and control groups (p = 0.0005, ES = 0.386). WHtR decreased by 0.02 in the intervention group compared to the control group, which decreased by 0.01, see Figure 3 (d). Figure 2 (e) displays the nutritional knowledge at baseline and post-intervention for ten year olds in the control school and the intervention school. There was a moderate statistically significant difference of 0.91 (6.07%) between the change in nutritional knowledge in the intervention and control groups (p = 0.027, ES = 0.107). Nutritional knowledge of the intervention group improved by 1.1 points, while the control group only increased their nutritional knowledge by 0.19, see Figure 3 (e).

There was only one significant change in dietary intake for ten year olds. Figure 3 (f) displays the percentage energy from protein at baseline and post-intervention for ten year olds in the control school and the intervention school. There was a large statistically significant difference of 2.53% between the change in percentage energy from protein in ten year old females in the intervention and control groups (p = 0.021, ES = 0.276). The percentage energy from protein increased by 2.07% within the intervention group and decreased by 0.46% in the control group, see Figure 3 (f).
Figure 3 (a): Fibre Intake Six year olds

Figure 3 (b): SBP Ten year olds
**Figure 3 (c):** DBP Ten year olds

**Figure 3 (d):** WHtR Ten year olds
Figure 3 (e): NK Ten year olds

Figure 3 (f): % Protein intake Ten year old Females
Repeated Measures ANOVA; Mean (SD). * Denotes small effect size, ** medium effect size and *** a large effect size.

### Table 15: Intervention Effect for 10 year olds: Macro and Micro Nutrient Intake, Fruit & Vegetable intake & Number of Unhealthy Snacks.

<table>
<thead>
<tr>
<th>Dietary Intake</th>
<th>Intervention</th>
<th>Control</th>
<th>Intervention Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Follow-up</td>
<td>Baseline</td>
</tr>
<tr>
<td>Fibre Intake Males (g)</td>
<td>11.30 (3.24)</td>
<td>14.50 (3.94)</td>
<td>10.93 (3.61)</td>
</tr>
<tr>
<td>Fibre Intake Females (g)</td>
<td>10.10 (2.34)</td>
<td>12.46 (4.38)</td>
<td>11.88 (2.56)</td>
</tr>
<tr>
<td>Sodium Intake Males (mg)</td>
<td>1891.80 (553.29)</td>
<td>1693.40 (219.18)</td>
<td>1468.77 (295.03)</td>
</tr>
<tr>
<td>Sodium Intake Females (mg)</td>
<td>1483.63 (353.62)</td>
<td>1705.72 (423.70)</td>
<td>1282.11 (245.89)</td>
</tr>
<tr>
<td>Calcium Intake Males (mg)</td>
<td>840.80 (327.50)</td>
<td>900.00 (289.18)</td>
<td>603.88 (168.45)</td>
</tr>
<tr>
<td>Calcium Intake Females (mg)</td>
<td>559.18 (209.44)</td>
<td>739.45 (200.26)</td>
<td>591.55 (125.03)</td>
</tr>
<tr>
<td>Iron Intake Males (mg)</td>
<td>7.94 (1.99)</td>
<td>9.02 (2.51)</td>
<td>6.68 (2.01)</td>
</tr>
<tr>
<td>Iron Intake Females (mg)</td>
<td>6.31 (1.02)</td>
<td>7.70 (2.44)</td>
<td>7.05 (2.02)</td>
</tr>
<tr>
<td>Fat Intake Males (% total energy)</td>
<td>38.84 (1.26)</td>
<td>34.16 (2.28)</td>
<td>35.96 (5.55)</td>
</tr>
<tr>
<td>Fat Intake Females (% total energy)</td>
<td>36.95 (4.05)</td>
<td>37.02 (3.60)</td>
<td>34.41 (3.95)</td>
</tr>
<tr>
<td>Saturated Fat Intake Males (% total energy)</td>
<td>18.34 (0.89)</td>
<td>15.46 (1.64)</td>
<td>15.51 (4.38)</td>
</tr>
<tr>
<td>Saturated Fat Intake Females (% total energy)</td>
<td>15.19 (2.46)</td>
<td>15.97 (2.63)</td>
<td>14.72 (2.36)</td>
</tr>
<tr>
<td>Sugar Intake Males (% total energy)</td>
<td>17.06 (2.96)</td>
<td>18.48 (1.66)</td>
<td>17.86 (3.56)</td>
</tr>
<tr>
<td>Sugar Intake Females (% total energy)</td>
<td>19.72 (7.20)</td>
<td>19.09 (3.99)</td>
<td>20.06 (3.07)</td>
</tr>
<tr>
<td>Protein Intake Males (% total energy)</td>
<td>15.24 (2.66)</td>
<td>16.00 (2.09)</td>
<td>15.57 (3.27)</td>
</tr>
<tr>
<td>Protein Intake Females (% total energy)</td>
<td>13.38 (1.93)</td>
<td>15.45 (1.69)</td>
<td>16.35 (1.71)</td>
</tr>
<tr>
<td>Total Servings of Fruit &amp; Vegetables</td>
<td>1.73 (1.09)</td>
<td>2.38 (1.78)</td>
<td>1.73 (0.69)</td>
</tr>
<tr>
<td>Number of Unhealthy Snacks</td>
<td>1.50 (0.87)</td>
<td>1.35 (0.71)</td>
<td>1.66 (0.81)</td>
</tr>
</tbody>
</table>

4.4 Discussion

Project Spraoi is the only PA and nutrition intervention to date that has been implemented and evaluated amongst primary school children in Ireland. The intervention has been proven to significantly reduce systolic and diastolic BP in ten year old children. Our findings are consistent with research that school based nutrition and PA intervention programmes can reduce BP (Rush et al., 2011; Hollar et al., 2010) and thereby improve children’s health in the long term. Previous studies have demonstrated that a combination of increased PA and improved dietary intake has a positive effect on BP in children when intervention duration was greater than twelve months.
(Hollar et al., 2010) and the reduction in BP was more marked in those studies in which combined diet and PA interventions were used (Cai et al., 2014). Early intervention is critical as high BP is also correlated with WHtR (Chen et al., 2012) and BP in childhood predicts hypertension and metabolic syndrome later in life (Sun et al., 2007). It has previously been shown in adults that every mm Hg decrease in BP decreases the risk of cardiovascular disease (Boggia et al., 2007). Our results demonstrate the value of implementing a health promotion programme such as Project Spraoi in primary schools to significantly reduce systolic and diastolic BP.

Although there was no change in BMI, WHtR has been shown to be a better predictor for the presence of cardiovascular disease risk factors than BMI in children (Ribeiro et al., 2010; Savva et al., 2000) and higher levels of fat accumulation around the abdominal area is associated with less favourable cardio metabolic profiles in youth (Khoury et al., 2013). Therefore, the significant improvement in WHtR for ten year old males and females in the intervention group is an important finding and supports the effectiveness of Project Spraoi in preventing overweight and obesity and decreasing cardiometabolic risk in children.

The significant increase in the nutritional knowledge of ten year olds is similar to previously published data in the United States of America (Gower et al., 2010) and supports the notion that increased nutritional knowledge has the potential to enhance children’s dietary intake (Rosario et al., 2013). Research by Worsley (2002) asserts that nutritional knowledge may play a small but pivotal role in the adoption of healthier food habits. Yet, there was only one significant dietary change amongst the ten year olds in the Project Spraoi intervention group (increase in % energy from protein). These results are disappointing and may be attributed to the fact that, despite their nutritional knowledge, primary school children have little control over what they eat. Research conducted with children in Northern Ireland indicated that parents were major influencers in their children’s diets (Walsh & Nelson, 2010). Parents are responsible for what children at this age eat and therefore despite the efforts of the intervention, dietary intake is dependent on food provided
by parents (Savage, 2007). Parents play a critical role in developing an environment that fosters healthy eating and providing nutritious food (Lindsay et al., 2006). Birch et al. (2007) report that in order to improve primary school children’s healthy food preferences, there must be increased exposure, availability and accessibility to healthy foods from parents. Although Project Spraoi involved parents in some aspects of the programme (healthy lunchbox demonstrations, sugary drinks and takeaway information sessions, recipes), this involvement was limited and therefore increasing the amount of parental participation in any future delivery of the intervention may help to further improve dietary intake.

Although there was no significant increase in fruit and vegetable intake, there was a significant increase in fibre intake of six year old males who participated in the intervention. Children with diets high in fibre see many health benefits; including normal gastrointestinal function, prevention and treatment of childhood obesity, lower BP and lower risk for CVD in adulthood (Andersen et al., 2004; Threapleton et al., 2013). However, the increase in fibre may be energy related. The increase in protein intake in ten year old females is consistent with findings of the Nutrition Pathfinders program for 4th grade students (aged approximately 10 years) who found that girls in the intervention group significantly increased their protein intake compared to girls in the control group; an effect not seen in boys (Larsen et al., 2015). Although other positive dietary behaviours were not found among six year olds at follow up, it should be noted that as the family food environment still has an important influence on a six year olds dietary intake (Campbell et al., 2006). It may be that a longer implementation of the intervention may be needed before changes are seen in the younger age children involved in this intervention.

Strengths & Limitations
A key strength of this research is the public health implications of the findings, Project Spraoi supports primary schools to implement nutrition and physical activity policies which promote healthy eating and encourage children to be active which is line with the Obesity Policy and
Action Plan (Department of Health, RoI, 2016) which focuses on a ‘whole school’ approach to tackling obesity. As dietary habits can track into adulthood, promoting healthy eating patterns in childhood may be a useful preventative strategy. The four day estimated food diary provides detailed data on dietary intake and is a key strength of the research. Furthermore, this study is the first of its kind in primary schools in Ireland, although the intervention was only in one school, the positive findings emerging highlight the importance of creating a healthy school environment.

The food diary has been shown to have high validity as a method of dietary assessment (Oretega, 2015), the method also has limitations, including error, reporting bias and food diaries are also time consuming for participants to complete. Our research relied on parents filling out the food diaries on behalf of the six year olds, which may have decreased the response rate (Shim et al., 2014). In order to try and counteract this and increase response rate, all children with completed food diaries were entered into a draw to win a pair of sports shoes. The food diaries were self-reported, therefore some misreporting and non-reporting is likely to have occurred (Poslusna et al., 2009). Debriefing with the researcher at the end of diary completion may have also introduced reporting bias of dietary intake (Bingham et al., 1995). A total of 54.5% of children were classified as under-reporters by comparing each child’s total energy intake to their estimated energy requirements using PAL cut off values (Torun et al., 1996). To minimise the impact of misreporting all macronutrients in the present study were expressed as a proportion of energy consumed (Coppinger et al., 2016) The under-reporting of dietary intake is a considerable challenge in dietary assessment studies (Livingstone et al., 2004). The percentage of subjects who under-reported their energy intakes is high, but broad ranges from 10 - 50% have been reported elsewhere (Livingstone & Black, 2003). Data must therefore be evaluated with caution (Livingstone et al., 2004). The low sample size also made it more difficult to assess the impact of the intervention.
Another limitation of this study was the minimal involvement of parents and this may have effected results as parents are responsible for providing their child with healthy food choices. Increased parental involvement in future research with Project Spraoi is crucial in changing the dietary habits of children, research has shown significantly stronger effects in studies with a high level of parental involvement (Charlebois et al., 2012). Regular communication with parents, special events, newsletters, information about lunch boxes and repeated opportunities for parents to be included are some of the ways to increase parental involvement (Charlebois et al., 2012).

Potential confounding factors may include SES, seasonality and physical activity levels, however we tried to limit the impact of these factors by matching the schools on SES and rural/urban. Seasonality may be an issue as baseline testing was carried out in October 2014 (Autumn), while follow-up testing was undertaken in May/June (Summer). While it was beyond the scope of this study, investigating the effect of seasonality on dietary intake, physical activity and cardio-respiratory fitness is recommended in future research. However, both the control and intervention data were collected at the same time so if seasonality is a factor, it is expected that it would affect both groups similarly.

4.5 Conclusion

Although only in one intervention school, the evaluation of the effectiveness of Project Spraoi has shown enhancements to WHtR, BP, nutritional knowledge and healthier intakes of protein and fibre of participating children. This combined nutrition and PA intervention supports research that schools play a key role in implementing health promotion strategies to improve the overall health of children. Furthermore, it is in line with Ireland’s Obesity Policy and Action Plan (Department of Health, RoI, 2016) of supporting primary schools to implement health promotion initiatives which promote healthily eating and encourage children to be active. Improvements shown in this study signify Project Spraoi’s potential for long-term benefits and indicate that the expansion of the intervention to other schools is both justified and warranted.
References


The Educational Impact of the Size of Primary Schools: A Literature Review carried out by Dublin City University School of Education Studies, Commissioned by Educate Together. www.educatetogether.ie/wordpress/wp-content/..../Research-lit-review-school-size.pdf


Chapter 5.

Identifying dietary patterns in Irish school children and their association with nutritional knowledge and markers of health before and after intervention.

Submitted for publication:

Abstract

**Objective:** Identify dietary patterns and examine differences in anthropometric measures, BP, CRF and nutritional knowledge of six and ten year old children at baseline and following a nutrition and PA intervention with respect to dietary pattern and treatment group.

**Design:** Longitudinal study. Food Diary, nutritional knowledge questionnaire and 550m walk/run test measured dietary intake, nutritional knowledge and CRF, respectively. BP, weight, height and waist circumference were also measured and BMI and WHtR were derived. All measurements were performed at baseline and following intervention.

**Setting:** Two primary schools (one intervention and one control school), Cork, Ireland.

**Subjects:** Six (n=34, age 5.9 ± 0.6 years) and ten (n=46, age 9.8 ± 0.5 years) year olds.

**Results:** Two dietary patterns were identified, using k-means cluster analysis, for both six (unhealthy and nutrient dense) and ten year olds (processed and Western diet) at baseline. Dietary patterns derived post-intervention were 1) plant based and 2) processed foods for six year olds and 1) nutrient dense and 2) unhealthy for ten year olds. There was no significant difference in difference patterns for six and ten year olds at baseline and post-intervention (p > 0.05). There were also statistically insignificant differences in nutritional knowledge, BMI, WHtR, CRF and BP for six and ten year olds with respect to dietary pattern, at baseline and post-intervention. Following the intervention, a MANOVA showed there were statistically insignificant differences in nutritional knowledge, BMI, WHtR, CRF and BP based on dietary pattern and intervention/control group (p > 0.05).

**Conclusion:** Three out of four dietary patterns identified for six and ten year olds were unfavourable. Furthermore, dietary patterns of Irish schoolchildren were not associated with nutritional knowledge or markers of health before or after the Project Spraoi intervention.
5.1 Introduction

Examining dietary patterns, rather than individual foods, provides a more accurate account of dietary intake (Hu, 2002; Ritchie et al., 2007). The study of dietary patterns facilitates the study of the whole diet, examining the interactive effect of individual nutrients; interactions often not detected in isolated analyses of nutrients (Hu, 2002). The increasing prevalence of overweight, low levels of fitness and elevated blood pressure (BP) in Irish children is a growing health concern (Childhood Obesity Research Bulletin, 2017) and there is strong evidence to suggest that “unhealthy” dietary patterns are associated with CVD risk factors (Rocha et al., 2017; Funtikova et al., 2015). Since dietary habits established in childhood are known to track into later life (Mikkila et al., 2005), the early establishment of healthy dietary patterns is important for reducing future cardiometabolic risk (Ambrosini et al., 2005).

Several international studies have examined dietary patterns in children (North et al., 2000; Rasanen et al., 2002; Mikkila et al., 2005; Northstone et al., 2008; Craig et al., 2010; Gubbels et al., 2012), describing children’s diets as ‘healthy/health conscious’ (Mikkila et al., 2005; Northstone et al., 2005; Craig et al., 2010), ‘unhealthy’ (Aranceta et al., 2003; Shin et al., 2007; Northstone et al., 2008; Craig et al., 2010), as well as ‘traditional’ (Shin et al., 2003; Mikkila et al., 2005; Northstone et al 2008; Kontigianni et al., 2011; Gubbels et al., 2012). While a small number of studies have identified dietary patterns in Irish children (O’Brien et al., 2013; Walton et al., 2014), none have examined their relationship with health markers, particularly over time. O’Brien et al. (2013) derived two clusters, ‘more healthful’ (higher intake of fruit and vegetables, rice, pasta, starches and grains, wholemeal bread and products, breakfast cereals, low-fat milk, fish, and fresh poultry) and ‘less healthful’ (higher intake of white bread and products, butters and spreads, chips and processed potato products, processed red meats, sugars and confectioneries and high calorie beverages). Walton et al. (2014) explored dietary patterns in relation to change in dietary energy density (DED) with age and found that children
moved from a less energy dense diet in pre-school to a more energy dense diet (consuming less fruit and vegetables, and more fat, confectionery, snacks and sugar-sweetened beverages) as they got older.

Identifying dietary patterns and their association with markers of health may provide a better prediction of diet-disease relationships (Slattery et al., 2010). Shang et al. (2012) found that children with ‘healthy’ dietary patterns (high in fruits, vegetables and white meat) had a lower prevalence of obesity and Smith et al. (2014) established that a ‘health aware’ dietary patterns (high in fibre, fruit and vegetables) was linked with decreased fat mass gain in girls aged 9 to 11 years. However, evidence is not yet conclusive, as Saeedi et al. (2017) found no significant associations between dietary patterns and markers of cardiovascular health; including CRF, hand grip strength, fat mass index and arterial stiffness in their study of New Zealand children aged 9 to 11 years.

There is evidence that school-based obesity prevention interventions have some success in improving dietary intake by increasing fruit and vegetable consumption (Anderson et al., 2005; Fung et al., 2012; Lauren et al., 2007; Te Velde 2008) and reducing fat intake (Leupeker et al., 1996; Cabellero et al., 2005). An example of one such intervention in Ireland, Project Spraoi (Coppinger et al., 2016), has shown success at increasing fibre and protein intake in children, whilst also improving nutritional knowledge, WHtR and BP. Yet, to date, no Irish study has examined differences in nutritional knowledge and markers of health with respect to dietary patterns or investigated the effect of a school-based obesity prevention intervention on overall dietary patterns in children.

The present study aims to identify dietary patterns in Cork primary school children, six and ten years old from one intervention school and to examine the association with nutritional knowledge, CRF, BP, BMI and WHtR over a two year period, adding novel data to the
literature. The ability of the Project Spraoi (http://www.isrctn.com/ISRCTN92611015) intervention to change dietary patterns over time will also be examined.

5.2 Methods

5.2.1 Study Design & Subject Participation

Project Spraoi (http://www.cit.ie/projectspraoi) is a primary school-based PA and nutrition intervention that has been described in detail elsewhere (Coppinger et al., 2016; Merrotsy et al., 2018). Briefly, targeted nutrition and PA classes that included healthy lunchbox ideas, healthy food tasting sessions and education sessions on sugary beverages, takeaways, healthy breakfasts and food groups, as well as ‘huff and puff’ games and other PA-centred activities were delivered by an ‘Energizer’. Two schools from Cork were selected via convenience sampling to participate in the study. Inclusion criteria for schools included: mixed gender, middle/high socio economic status (SES), urban/rural, medium sized, 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. Data were collected in October 2014 and June 2016 and a total of 80 children (six year olds, n=34; ten year olds, n=46) participated. The mean age was 5.9 ± 0.6 for six year olds and 9.8 ± 0.5 years for ten year olds. Informed consent and parental consent were required from all children and their parents/guardians before participation. Ethical approval was obtained from Cork Institute of Technology Research Ethics Review Board in September 2013.

5.2.2 Dietary analysis

Dietary intake was examined using a four-day estimated food diary (two weekday and two weekend days); a validated measure in children (Yang et al., 2010). The diary was adapted from the Cork Children’s Lifestyle Study (CCLaS) three day food diary (Keane et al., 2014). Written instructions to complete the food diary, including food photographs from the Young Person’s Food Atlas Primary (Foster et al., 2010) to aid portion size estimation, were provided
at the beginning of the food diary. The researcher also provided verbal instruction to participants in the classroom on each day of diary completion. Each day of the food diary was broken into six meal sections; breakfast, morning snack, lunch, afternoon snack, dinner and evening snack. Parents of the six-year-old children were asked to complete the food diary for their child (with the child also present), while ten year old children were advised to seek help with the completion of their diaries from parents/guardian and teachers. The Irish Food Portion Sizes Database (Lyons & Giltinan, 2013) was used to assign an age appropriate median portion size, where no estimation was given and also to estimate the number of unhealthy snacks (sweets, crisps, chocolate, ice-cream, cake, biscuits, bars and pastries) consumed.

All foods and beverages were entered into the Dietplan 7 (Forestfield Software Ltd, Horsham, UK, 2015) software package. Output measures included 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.

5.2.3 Nutrition Knowledge Questionnaire

Participant’s knowledge of healthy eating was assessed using the validated questionnaire ‘Fit Kids ‘r’ Healthy Kids’ (Gower et al., 2012). It was first piloted by the researcher in a primary school in Cork (n=23) to ensure its relevance in an Irish setting and the Irish Food Pyramid (Food Safety Authority Ireland (FSAI), 2012) replaced the United States Department of Agriculture (USDA) food pyramid used in the original questionnaire. Fifteen multiple-choice questions assessed knowledge on food groups, healthful foods and food functions.
5.2.4 Anthropometric and Blood Pressure Measurements

Height, body mass, BP, heart rate and waist circumference were measured by trained researchers using standard procedures (Graham et al., 2008). Height and body mass values were used to derive BMI and BMI Z scores (Cole et al., 1995; Cole & Lobstein, 2012). Waist circumference and height measurements were used to calculate WHtR and children were classified into two categories (WHtR <0.50 and WHtR ≥0.50); where a WHtR greater than or equal to 0.50 was considered to be an indicator of central obesity (Ashwell, 2009).

5.2.5 Cardiorespiratory Fitness

A validated 550m walk/run test (Albon et al., 2008; Hamlin et al., 2014) was used to measure CRF. The run was performed outside on grass, where a 110 metre rope was arranged in an oval shape. Children were instructed to run/walk as fast as they could for the five laps of the test. Completion time was recorded using a stopwatch to the nearest minute and second. Run scores were then classified into fast (≤50th centile) and slow (>50th centile) categories based on the Waikato 2011 centile charts for time to complete 550m (Rush & Obolonkin, 2014).

5.2.6 Dietary Patterns

Dietary patterns can be derived using two common approaches; a priori and a posteriori. A priori methods assess diet based on prior knowledge and scientific evidence (Ocke, 2013), while a posteriori methods use statistical approaches to provide information about existing dietary patterns within the population (Ocke, 2013). Cluster analysis is one of the most commonly used methods for deriving dietary patterns, which combines individuals into non-overlapping groups based on similarity of dietary intakes (Moeller et al., 2007; Newby, 2004). Cluster analysis also provides a simple way of examining changes in dietary patterns over time (Northstone, 2013) and allows for the identification of dietary patterns without any pre-defined criteria (Perez-Rodrigo et al., 2016). Cluster analysis, in comparison with the a priori approach, has previously been used to identify relationships between dietary patterns and central obesity.
(Wadolowska et al., 2017) and was thus the method of choice for this research. Dietary patterns were determined using k-means cluster analysis (Newby and Tucker, 2004). Fibre, sodium, calcium, iron, portions of fruit, portions of vegetables, portions of fruit and vegetables, number of unhealthy snacks, fat percentage, carbohydrate percentage, protein percentage, sugars percentage, starch percentage, and saturated fat percentage were selected as cluster variables. Energy was adjusted prior to analysis, all macronutrients were expressed as a percentage of total energy consumed (Coppinger et al., 2016).

5.2.7 Statistical Analysis

Data were analysed using IBM SPSS (Version 22.0 for Windows). Children absent from school on the day of testing were recorded as missing values (n = 15). A k-means cluster analysis (KCA) derived two dietary patterns for each age group. Variables were standardised prior to the KCA being performed and analyses were run for two - four clusters. The best cluster solution was then chosen based on the size of the clusters. Analysis of Variance (ANOVA) was then used to explore the differences in nutritional knowledge, BP, BMI, WHtR and CRF with respect to dietary patterns. Changes in dietary patterns over the two-year period were analysed with Chi-square analyses.

A multivariate ANOVA was conducted to explore differences in results of BMI, WHtR, BP, CRF and nutritional knowledge from baseline to post-intervention with respect to dietary patterns and treatment groups (intervention or control). Shapiro Wilk test and Levene’s test were used as criteria for satisfying the assumptions of measurements being normally distributed and homogeneity of variance, respectively. All statistical testing was performed using a 5% level of significance.
5.3 Results

5.3.1 Baseline Dietary Patterns and Differences

K-means clustering derived clusters based on the selected cluster variables; the two cluster solution was found to give the best fit. At baseline, these clusters for six year olds were labelled as: 1) unhealthy (n = 22) and 2) nutrient dense (n = 12), see Figure 4 (a). Figure 4 (b) shows DPs at baseline for ten year olds, which were labelled as: 1) processed (n = 26) and 2) Western diet (n = 20).

For six year olds, the ‘unhealthy’ cluster had higher intakes of fat and saturated fat, while the ‘nutrient dense’ cluster had higher intakes of fruit, vegetables and fibre. For ten year olds, the ‘processed’ cluster had higher intakes of carbohydrates and starch, while the ‘Western diet’ had higher intakes of fat, saturated fat and sodium.

A multivariate ANOVA showed there were statistically insignificant differences for nutritional knowledge, BMI, WHtR, CRF and BP combined with respect to dietary patterns for six year olds (p = 0.924) and ten year olds (p = 0.997). Table 16 presents the results from the two-way ANOVA for the individual variables (nutritional knowledge, BMI, WHtR, CRF and BP) for 6 and 10 year olds respectively, which were also statistically insignificant (p > 0.05). There were no differences in BMI, BP, WHtR, CRF or nutritional knowledge based on dietary patterns.

<p>| Table 16: Baseline Differences in Markers of Health and Nutritional Knowledge of Irish Primary School Children with respect to Dietary Patterns |
|----------------------------------|---------------|---------------|---------------|</p>
<table>
<thead>
<tr>
<th>Marker of Health (unit)</th>
<th>Six Year Olds</th>
<th>Ten Year Olds</th>
</tr>
</thead>
<tbody>
<tr>
<td>p-value</td>
<td>Effect Size</td>
<td>p-value</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>0.411</td>
<td>0.023</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>0.780</td>
<td>0.003</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>0.401</td>
<td>0.024</td>
</tr>
<tr>
<td>Waist to Height Ratio (cm)</td>
<td>0.349</td>
<td>0.030</td>
</tr>
<tr>
<td>Run time (secs)</td>
<td>0.553</td>
<td>0.012</td>
</tr>
<tr>
<td>Nutritional Knowledge</td>
<td>0.561</td>
<td>0.012</td>
</tr>
</tbody>
</table>

Statistical analysis was carried out by a one-way between-groups ANOVA. Difference is significant at the 0.05 level.
5.3.2 Post-Intervention Dietary Patterns and Differences

At post-intervention, clusters were labelled for six year olds as: 1) plant based and 2) processed foods (see Figure 5 (a)) and for ten year olds as: 1) nutrient dense and 2) unhealthy (see Figure 5 (b)). For six year olds, the ‘plant based’ cluster had higher intakes of fruit and vegetables, while the ‘processed’ cluster had higher intakes of carbohydrates and starch. For ten year olds, the ‘nutrient dense’ cluster had higher intakes of fibre, fruit and vegetables, while the ‘unhealthy’ cluster had higher intakes of fat, saturated fat protein and sodium.

A multivariate ANOVA showed there were statistically insignificant differences for mean nutritional knowledge, BMI, WHtR, CRF and BP combined based on dietary patterns and intervention/control group for six year olds (p = 0.162) and ten year olds (p = 0.746). Table 17 presents the results from the two-way ANOVA for the individual variables (nutritional knowledge, BMI, WHtR, CRF and BP) for 6 and 10 year olds respectively.
Figure 4 (a): Baseline DP for Six year olds

Figure 4 (b): Baseline DP for Ten year olds
Figure 5 (a): Post-Intervention DP for Six year olds

Figure 5 (b): Post-Intervention DP for Ten year olds
Table 17: Intervention Effect on DP for six and ten year olds in relation to NK and Markers of Health.

<table>
<thead>
<tr>
<th>Marker of Health (unit)</th>
<th>Six Year Olds</th>
<th>Ten Year Olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>p-value</td>
<td>Effect Size</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>0.500</td>
<td>0.023</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>0.181</td>
<td>0.088</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>0.966</td>
<td>&lt;.0005</td>
</tr>
<tr>
<td>Waist to Height Ratio (cm)</td>
<td>0.688</td>
<td>0.008</td>
</tr>
<tr>
<td>Run time (secs)</td>
<td>0.342</td>
<td>0.045</td>
</tr>
<tr>
<td>Nutritional Knowledge</td>
<td>0.412</td>
<td>0.034</td>
</tr>
</tbody>
</table>

Statistical analysis was carried out by repeated Measures ANOVA. Difference is significant at the 0.05 level.

5.3.3 Changes in Dietary Patterns following intervention

A chi-square analysis revealed there was no significant difference in dietary patterns for six (p = 0.661) and ten year olds (p = 0.738) at baseline and post-intervention.

5.4 Discussion

Identification of the overall combination of foods consumed is essential to understanding the relationships between diet and disease (Harrington et al., 2008). The aim of this study was to identify dietary patterns and investigate their relationship with nutritional knowledge, CRF, BP, BMI and WHtR and to examine the effect of the intervention on dietary patterns.

The present study identified two dietary patterns at baseline for six year old (unhealthy and nutrient dense) and ten year old (processed and Western) Irish children. Dietary patterns derived post-intervention were 1) plant based and 2) processed foods for six year olds and 1) nutrient dense and 2) unhealthy for ten year olds. Although non-significant, the positive change in dietary patterns for ten year olds shows a healthier trend emerging, which may have proved significant if a larger sample size and/or longer intervention delivery time had been incorporated.
Previous research examining the overall diets of children identified ‘unhealthy’ dietary patterns to consist of high intakes of processed foods, low intakes of fibre and high intakes of sodium, fat, and refined carbohydrates (Karatzì et al., 2014; Park et al., 2013; Romero-Polvo et al., 2012; Shang et al., 2012). Contrastingly, ‘healthy’ dietary patterns in the literature are characterised by high intakes of fruit and vegetables, milk/yoghurt, eggs and legumes (Mikkila et al., 2007; Romero-Polvo et al., 2012; Shang et al., 2012). O’Brien et al (2013) identified two patterns in Irish children aged 7-13 years and termed these as 'more healthful' or 'less healthful'. These clusters are similar to the two clusters identified for six year olds in the current study.

Some evidence suggests that “unhealthy” dietary patterns are associated with CVD risk factors (Rocha et al., 2017; Funtikova et al., 2015) but contrary to these findings, the present study found no significant relationship between dietary pattern and nutritional knowledge, BMI, BP, WHtR or CRF. However, evidence for any association between dietary pattern and markers of health is mixed (Craig et al., 2010; Smith et al., 2014; Rocha et al., 2016; Saeedi et al., 2017; Akbarzadeh et al., 2017). In a study of children from the UK, a ‘Health Aware’ dietary pattern was linked to decreased fat mass gain in girls between the ages of nine and eleven years (Smith et al., 2014). Craig et al. (2010) also found that ‘healthier’ dietary patterns were associated with less screen time in Scottish five to eleven year olds. This is supported by a more recent review by Akbarzadeh et al. (2017) who found diets with a higher healthy eating index to be inversely associated with metabolic syndrome in youth, whereas western type diets (diets that score lower on the healthy eating index) were positively associated with the condition. A systematic review by Rocha et al. (2016) also found a positive association between ‘unhealthy’ dietary patterns and cardiometabolic alterations in children and adolescents. Similar to the current study’s findings, however, Craig et al. (2010) found little association between dietary patterns and overweight and obesity and the NCFS (2011) found no evidence that overweight or obese children have
unhealthy dietary patterns. Saeedi et al. (2017) also found no significant associations between dietary patterns and markers of cardiovascular health in nine year old New Zealand children. The conflicting evidence may be due to differences in sample size, methods used to analyse dietary patterns, duration of the study and the age of participants, which may all effect the ability to detect an association between dietary patterns and health markers. Furthermore, associations between dietary patterns in childhood and health markers may not become clear until later in life (Bull & Northstone, 2016).

Strengths & Limitations

A significant strength of this study is the longitudinal design and the use of a four day food diary to investigate dietary intake. Furthermore, examining dietary patterns, as opposed to individual nutrients, is a useful method for examining diet and the association with health markers. This was the first study in Ireland known to investigate the longitudinal association between dietary patterns and obesity-related outcomes in children and to utilize dietary patterns analysis to assess a health promotion intervention in children.

Limitations of this study include subjective decision making in determination of the number of clusters and how the clusters are labelled may also be considered as a limitation. The dietary patterns identified in this study, however, were similar to previous research (O’Brien et al, 2013). Furthermore, the food dairies were self-reported, therefore some misreporting and non-reporting is likely to have occurred (Poslusna et al., 2009). Debriefing with the researcher at the end of diary completion may have also introduced reporting bias of dietary intake (Bingham et al., 1995). The small sample size and limited generalizability are also significant limitations of the research.
Public Health Implications

Project Spraoi is based on Project Energize, which has been implemented in New Zealand since 2004, and proven to be successful and cost-effective (Rush, 2016). Initial findings from this research indicate that Project Spraoi also has the potential to improve the health of children in Ireland, which supports recent policy (provide ref for the obesity plan instead here). Preventing children from becoming overweight and obese is the best approach (The National Taskforce on Obesity, 2005) and this is the focus of Project Spraoi, which aims to make healthy eating and increased PA a daily habit. Although some of the findings were not significant, there were positive trends emerging for the ten year olds and these findings are important given that small cumulative differences may ultimately contribute to significant improvements in dietary intake and markers of health in a public health context.

5.5 Conclusion

This is the first study in Ireland to examine the relationship between dietary patterns and markers of health in children and to assess the impact of a health promotion intervention on these, over time. Despite finding no evidence to support the relationship between dietary patterns and health markers, previous research has shown that food habits established during childhood may track into adulthood and are therefore important to monitor for health outcomes later in life. While no evidence of intervention impact was found on dietary patterns, a positive trend was emerging amongst ten year olds in the current study. Additional studies with larger sample sizes that deliver interventions over a longer period of time are warranted to further clarify the role of dietary patterns with markers of health and inform future interventions.
References


Chapter 6.

General Discussion and Recommendations.
6.1 Introduction

The primary aim of this thesis was to evaluate the impact of a nutrition and PA intervention on dietary intake, nutritional knowledge, BP, BMI, WHtR and CRF in one primary school in Cork, Ireland. The intervention was implemented from October 2014 to May 2016. This chapter aims to bring together findings from the three research studies reported within the thesis and provide overall conclusions. Contribution to the research field and implications of the findings are described. Finally, conclusions of the thesis are presented.

6.2 Main Findings

6.2.1 Study One

Study One (Chapter 3) examined dietary intake, BP, anthropometric measures, CRF and nutritional knowledge of six and ten year old children at baseline. Results showed that children were consuming (< 2 servings/day) below the WHO recommendation (400g or 5 servings/day) for fruit and vegetables (WHO, 2003) and low fruit and vegetable intake was associated with higher WHtR. Previous evidence (WHO, 2003) suggests that low consumption of fruit and vegetables is linked to ill health and increased risk of non-communicable diseases (NCDs). Calcium and iron intakes for six and ten year olds, and fibre intake for ten year olds, were also lower than recommended (FSAI, 2011), which may negatively influence bone development (Holick, 2014), lead to iron deficiency anaemia (National Institutes of Health US, 2007) and increase the risk of constipation (Glackin, 2008). This study highlighted the high intake of sugars (>20% of total energy) and saturated fat (>10% of total energy); both of which have been identified as potential contributors to the rising levels of childhood obesity (SACN, 2015) and may also lead to increased risk of Type 2 diabetes and early signs of CVD in children (WHO, 2015).

High BP, another CVD risk factor (Riley, 2012), was also present in 12.2% of six year old and 15.7% of ten year old children. Higher run scores (slower time to run completion),
indicating poorer CRF, were positively correlated with BMI and WHtR, thus, highlighting the importance of including CRF in future health promotion intervention efforts aimed at school children.

6.2.2 Study Two

Study two (Chapter 4) examined the impact of the Project Spraoi intervention on dietary intake, nutritional knowledge, BP, BMI, WHtR and CRF in one Project Spraoi School. The combined nutrition and PA intervention significantly reduced systolic and diastolic BP in ten year old children; a finding which is consistent with previous childhood intervention research (Rush et al., 2011; Hollar et al., 2010). This is a substantial finding, as research shows that elevated BP in childhood is linked to metabolic syndrome later in life (Sun et al., 2007). Furthermore, the significant improvement in WHtR in ten year olds strengthens the evidence for Project Spraoi at reducing overweight and obesity and decreasing cardiometabolic risk in children.

While nutritional knowledge significantly improved for ten year olds in the intervention group, this did not result in the expected improvements in dietary intake; with only a significant increase in protein intake in ten year old females recorded. Parents’ influence children’s dietary intake by the foods they make accessible (Walsh & Nelson, 2010) and this may explain dietary intake not improving despite an improvement in nutritional knowledge. Children’s nutritional knowledge is important and nutrition education should continue to form part of a multi-component intervention to improve dietary behaviour (Worsley, 2002), however parental involvement also needs to be included. With regard to younger children, there was only one significant improvement to dietary intake amongst intervention participants; a significant increase in fibre intake among six year old males. As the family food environment still has an important influence on a six year olds dietary intake (Riley & Bluhm, 2012), it may be that a longer implementation of the intervention, with
additional parental involvement, may be needed before changes are seen in the younger age children involved in this intervention.

6.2.3 Study Three
Study 3 (Chapter 5) is the first study in Ireland to identify dietary patterns and examine differences in anthropometric measures, BP, CRF and nutritional knowledge of six and ten year old children at baseline and following a nutrition and PA intervention with respect to dietary patterns and treatment group. Two dietary patterns at baseline were identified for six year olds (unhealthy and nutrient dense) and ten year olds (processed and Western diet) in the sample. Dietary patterns derived post-intervention were 1) plant based and 2) processed foods for six year olds and 1) nutrient dense and 2) unhealthy for ten year olds. This study found no significant relationship between dietary pattern, nutritional knowledge, BMI, BP, WHtR and CRF at baseline, which is consistent with findings by Craig et al. (2010) and Saeedi et al. (2017). However, research in this area is conflicting, as some recent research has found positive associations between ‘unhealthy’ dietary patterns and cardiometabolic risk (Smith et al., 2014; Rocha et al., 2016; Akbarzadeh et al. (2017)). Following the intervention, there were statistically insignificant differences in nutritional knowledge, BMI, WHtR, CRF and BP based on dietary pattern and intervention/control group.

The current thesis highlighted that Irish school children consume diets high in fat and low in fruit and vegetables, while also displaying low levels of CRF. It also demonstrated that Project Spraoi, Ireland’s first ever school-based nutrition and PA intervention, is effective in improving dietary intake, nutritional knowledge, WHtR and BP in older Irish primary school children. This supports research that schools play a key role in implementing health promotion strategies to improve the overall health of children. However, increased parental involvement in future interventions is crucial in changing the dietary habits of children. These improvements signify Project Spraoi’s potential for long-term benefits and indicate
that the expansion of the intervention to other schools, integrating a high level of parental involvement, is both justified and warranted.

6.3 Future Directions for Research

In terms of Project Spraoi, studies on the feasibility of the continued implementation of the programme throughout Cork and Ireland are needed. In future delivery, implementation fidelity should be assessed to ensure the intervention is carried out as intended and to understand what will contribute to the success of the programme in the transition from research into practice (Schmidt, 2017). Project Spraoi has proven to be scalable, as its effectiveness has been demonstrated at a population level; further horizontal scaling (replication) (WHO, 2010) will allow for the expansion of the intervention to other primary schools in Cork and throughout Ireland.

Further research focusing on ways to increase parental involvement in primary school based health promotion interventions is necessary. Additional large scale studies are also needed to clarify the association between dietary patterns and markers of health, with a view to informing future interventions, as the low sample size in the current study made it difficult to detect associations.

6.4 Strengths and Limitations

In line with supporting the Irish Obesity and Action Plan (Department of Health, RoI, 2016) to reduce overweight and obesity in Irish children, this thesis has addressed the effectiveness of a PA and nutrition intervention, using a whole of school approach. A key strength of this study was the implementation and evaluation of an intervention in a ‘real life’ setting, which clinical testing of interventions often impedes (Landberg, 2018). Furthermore, direct measurement of children’s food intake, PA and anthropometric measurements alongside the analysis of dietary patterns are also strengths of the study, as
they provide objective assessment of intervention effectiveness and dietary patterns and take into account the whole diet, providing an overall picture of total dietary intake.

The under-reporting of dietary intake is a considerable challenge in dietary assessment studies and the percentage of subjects who under-reported their energy intakes was high (54.5%). Reporting error is a common limitation associated with the direct measurement of dietary intake in children (Livingstone et al., 2004) and therefore data should be evaluated with caution. To consider the likelihood of misreporting, all macronutrients in the study were expressed as a proportion of energy consumed (Coppinger et al., 2016) and attempts were made during data collection to minimise under-reporting by following up incomplete information directly with participants. Low sample size (n=80) also made it more difficult to assess dietary intake, dietary patterns and their association with health markers. The limited age of the children (six and ten years old), may mean the results are not generalisable to children of all ages and as the intervention was only implemented in one intervention school, the implication of the results is limited.

**Public health and policy implications**

It is widely recognised that childhood obesity is a multidimensional issue however the WHO (2015) have highlighted that schools are one of the most important sectors for addressing obesity. Yet Ireland has very few preventative strategies or interventions which prevent overweight and obesity in children; these interventions are important as part of the whole school approach recommended by the Irish Obesity Policy and Action Plan (Department of Health, RoI, 2016). The effectiveness of this study may help guide initiatives that promote healthy dietary habits and PA in schools at a national level. However, for school interventions to be successful, the role of parents needs to be considered, as parents influence children’s eating and physical activity habits.
This research has started to address how the school environment may promote nutrition and PA in schools; Project Spraoi is the first intervention in Ireland to target both. Important insights have been obtained into how a nutrition and physical activity intervention can improve dietary intake, nutritional knowledge, WHtR and BP in primary school children in Ireland which supports recent policy (Department of Health, RoI, 2016), small cumulative differences may ultimately contribute to significant improvements in dietary intake and markers of health in a public health context.

6.5 Conclusions

The overarching findings from this research show that Project Spraoi was effective in improving nutritional knowledge, WHtR, BP and some aspects of dietary intake (fibre, protein) in older Irish primary school children in one intervention school in Cork, Ireland. Although no relationship between dietary patterns and health markers or intervention impact on dietary pattern was found, a positive trend was emerging amongst ten year olds in the study. The continued implementation and evaluation of Project Spraoi throughout Ireland is needed to ascertain whether the programme can instil healthier eating habits and promote PA amongst all primary school aged children.
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URL:http://apps.who.int/iris/bitstream/10665/80149/1/9789241504782_eng.pdf?ua=1.


World Health Organization (2017) Population-based approaches to CHILDHOOD OBESITY.

Appendix 1.

Publications
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, cardiopulmonary fitness (CPF) 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 CPF respectively. Blood pressure (BP) was also taken and body mass index (BMI) and waist to height ratio (WHR) 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, 48.9% 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. WHR 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 WHR 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, CPF, 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, CPF, 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 other important 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 (CPF) is a powerful marker of health in childhood [7,8], with high levels of childhood CPF associated with lower total adiposity[9,10] and reduced risk of developing cardiovascular disease (CVD) [9,10]. Worldwide, levels of CPF 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 CPF in children and found that both BMI and waist circumference were inversely related to CPF [12]. However, detailed data on the CPF 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 Goncalves et al. [14] (2014) highlighted the significant association between body mass index (BMI) and low CPF 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...
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 [15].

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 9.6 ± 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 Spraoil’, (http://www.cit.ie/projectspraoil) a primary school-based PA and nutrition intervention project, described in detail elsewhere [24] (http://www.isrch.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 Spraoil’ 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 WHR. Since, a WHR higher than 0.50 is considered to be an indicator of central obesity in children [37,38], children were classified into two categories (WHR < 0.50 and WHR > 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 (<50th centile) and slow (>50th 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.

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

<table>
<thead>
<tr>
<th>Measure</th>
<th>Assessment tool</th>
<th>Method notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>Leicester portable height scales</td>
<td>Shoes were removed prior to measurement. Two measurements taken to the nearest 0.1cm. A third measurement was taken if the difference was &gt;0.5cm.</td>
</tr>
<tr>
<td>Body Mass</td>
<td>Tanita WB100ME portable electronic scale</td>
<td>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 &gt;0.5kg.</td>
</tr>
<tr>
<td>Waist circumference (WC)</td>
<td>Non-stretch Seca 200 measuring tape</td>
<td>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 &gt;0.5cm.</td>
</tr>
<tr>
<td>Waist to height ratio (WHR)</td>
<td>Non-stretch Seca 200 measuring tape and Leicester portable height scales</td>
<td>WHR is calculated by dividing waist circumference by height</td>
</tr>
<tr>
<td>Heart rate (HR)</td>
<td>Omron M2 Basic Auto Blood Pressure Monitor</td>
<td>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 &gt;10mmHg.</td>
</tr>
<tr>
<td>Blood Pressure (BP)</td>
<td>Omron M2 Basic Auto Blood Pressure Monitor</td>
<td></td>
</tr>
</tbody>
</table>
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 old 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 ($2.26 \pm 1.26$ and $2.55 \pm 1.72$ servings/day for males and females, respectively) compared to ten year olds ($1.73 \pm 1.02$ and $1.86 \pm 0.95$ 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   | 6 year olds    | 10 year olds   |
|                                       | Males          | Females        | Males          | Females        |
| **Fibre (g)**                          |                |                |                |                |
| RI = Age = 5g                           | 11.09 ± 2.94   | 11.39 ± 4.09   | 11.16 ± 2.91   | 10.73 ± 2.44   |
| **Calcium (mg)**                        |                |                |                |                |
| RI = 800-1300mg                         | 696.47 ± 209.63| 721.07 ± 237.80| 706.89 ± 238.85*| 568.24 ± 170.30*|
| **Iron (mg)**                           |                |                |                |                |
| RI = 8-11mg                             | 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 ± 326.49*|
| **Protein (%)**                         |                |                |                |                |
| AMDR = 10-30%                           | 15.29 ± 1.75   | 15.38 ± 2.76   | 15.06 ± 2.74   | 14.93 ± 2.39   |
| **Fat (%)**                             |                |                |                |                |
| AMDR = 20-35%                           | 34.31 ± 3.95   | 35.68 ± 4.92   | 36.22 ± 4.37   | 34.88 ± 4.24   |
| **Saturated Fat (%)**                   |                |                |                |                |
| AMDR <10%                               | 14.70 ± 3.49   | 17.17 ± 1.25   | 15.85 ± 3.44   | 14.30 ± 2.41   |
| **Carbohydrate (%) DRV = 45-60% (EFSI,2010)** | 48.74 ± 4.35 | 47.19 ± 5.71 | 47.21 ± 4.70 | 48.52 ± 4.23 |
| **Sugar (%)**                           |                |                |                |                |
|                                          | 21.36 ± 5.03   | 20.29 ± 6.21   | 18.68 ± 4.29   | 20.32 ± 5.19   |
| **Total Energy (kcalis)**               |                |                |                |                |
|                                          | 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

<table>
<thead>
<tr>
<th></th>
<th>6 year olds</th>
<th>10 year olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Fruit Intake (servings/day)</td>
<td>1.31 ± 0.78</td>
<td>1.42 ± 1.01</td>
</tr>
<tr>
<td>Vegetable Intake (servings/day)</td>
<td>0.90 ± 0.64</td>
<td>1.13 ± 0.79</td>
</tr>
<tr>
<td>Total fruit veg (servings/day)</td>
<td>2.26 ± 1.26*</td>
<td>2.59 ± 1.72*</td>
</tr>
<tr>
<td>Number of unhealthy snacks (servings/day)</td>
<td>1.21 ± 0.67</td>
<td>1.26 ± 0.79</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th></th>
<th>6 year olds</th>
<th>10 year olds</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>117.33 ± 4.78</td>
<td>115.59 ± 5.66</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>22.60 ± 3.18</td>
<td>21.58 ± 2.49</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>16.36 ± 1.53</td>
<td>16.13 ± 1.31</td>
</tr>
<tr>
<td>BMI Z score</td>
<td>0.57 ± 0.96</td>
<td>0.29 ± 0.68</td>
</tr>
<tr>
<td>WHR</td>
<td>0.45 ± 0.03</td>
<td>0.45 ± 0.03</td>
</tr>
<tr>
<td>Systolic BP (mmHg)</td>
<td>104.31 ± 8.89</td>
<td>103.44 ± 9.32</td>
</tr>
<tr>
<td>Diastolic BP (mmHg)</td>
<td>61.66 ± 8.99</td>
<td>61.52 ± 9.82</td>
</tr>
<tr>
<td>Heart rate (bpm)</td>
<td>85.63 ± 9.21</td>
<td>88.66 ± 12.35</td>
</tr>
</tbody>
</table>

Data represents mean ± standard deviation. BP: Blood Pressure; BMI: Body Mass Index; WHR: 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 WHR < 0.50 while 7 (7.0%) children had a WHR > 0.50. When categorised by age and gender, a total of 3 (13.0%) six year old boys and 2 (6.5%) six year old girls had a WHR > 0.50. Among ten year old children, 1 (4.3%) boy and 1 (3.4%) girl had a WHR > 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 6: Relationships between Dietary Intake, Nutritional Knowledge, Anthropometric Measurements, BP and CRF for 6 Year Olds

<table>
<thead>
<tr>
<th>Measurements</th>
<th>BMI</th>
<th>SBP</th>
<th>DBP</th>
<th>Pulse</th>
<th>WHR</th>
<th>Run Score</th>
<th>Nut Score</th>
<th>Fibre</th>
<th>Sat Fat</th>
<th>Trans Fat</th>
<th>Na</th>
<th>Ca</th>
<th>Iod</th>
<th>Fruit</th>
<th>Veg</th>
<th>Fruit &amp; Veg</th>
<th>Unhealthy Snacks</th>
<th>% Fat</th>
<th>% CHO</th>
<th>% Pro</th>
<th>% Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>1</td>
<td>.222*</td>
<td>-.066</td>
<td>-.088</td>
<td>.665**</td>
<td>-.012*</td>
<td>-.071*</td>
<td>.050*</td>
<td>.051*</td>
<td>.244*</td>
<td>-.192*</td>
<td>.089*</td>
<td>.467***</td>
<td>- .335*</td>
<td>.127*</td>
<td>-.056*</td>
<td>.097*</td>
<td>-.066*</td>
<td>-.057*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| SBP          | 1   | .468*** | .074 | -.010* | -.193* | .069* | .121* | .151* | .039* | .120* | .001* | .038* | -.035* | -.175* | .042* | .039* | .032* | .109* | .
| DBP          | 1   | .042  | .210* | .077* | .201* | .328* | .322* | .207* | .134* | .124* | -.140* | .059* | -.316* | -.054* | .013* | .014* | .042* | .190* | .
| Pulse        | 1   | -.054* | -.003* | -.021* | -.022* | -.057* | -.033* | -.070* | .032* | .084* | .032* | -.011* | -.016* | -.029* | .131* | -.039* | -.164* | .041* | .
| WHR          | 1   | .113* | -.289* | -.159* | -.008* | -.049* | -.110* | -.071* | -.274* | -.078* | .377*** | -.168* | .116* | .150* | .269* | .271* | .138* | .
| Run Score    | 1   | .009* | -.116* | -.135* | -.299* | -.454*** | -.181* | -.037* | .034* | -.164* | -.059* | -.301* | -.248* | .234* | -.064* | -.138* | .
| Nut Knowledge| 1   | -.065* | -.102* | -.112* | -.056* | .070* | .015* | .188* | .319* | .310* | -.061* | -.160* | -.047* | .430* | .139* | .
| Fibre        | 1   | .344*** | .227* | .503*** | .311* | .572*** | .651* | .548* | .475* | .536* | -.203* | .229* | -.250* | .119* | .
| Saturated Fat| 1   | .718*** | .652*** | .520*** | .523*** | .112* | .094* | .048* | .364*** | .504*** | .500*** | .572*** | .536* | .203* | .229* | .250* | .119* | .
| Trans Fat    | 1   | .581*** | .699*** | .418*** | .074* | .151* | .162* | .357*** | .450*** | .369*** | -.004* | -.035* | .119* | .319* | .150* | .269* | .271* | .138* | .
| Sodium       | 1   | .589*** | .399* | .029* | .224* | .096* | .253* | .264* | .251* | .013* | .249* | .
| Calcium      | 1   | .508*** | .243* | .150* | .225* | .122* | .194* | .239* | .172* | .054* | .
| Iron         | 1   | .345** | .399* | .462*** | .150* | .058* | .057* | .058* | .012* | .249* | .
| Fruit        | 1   | .560*** | .893*** | .310* | .352* | .288* | .045* | .511*** | .
| Vegetables   | 1   | .342*** | .255* | .117* | .143* | .402*** | .
| Fruit & Vegetables | 1   | .342*** | .255* | .117* | .143* | .402*** | .
| Unhealthy Snacks | 1   | .039* | .003* | .005* | .234* | .
| % Fat        | 1   | -.108* | .111* | -.082* | .548** | .
| % CHO        | 1   | -.503*** | .548** | .
| % Protein    | 1   | -.108* | .

*Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level. *: Spearman's Rank Order Correlation. †: Pearson's product-moment correlation. BP: Blood Pressure; BMI: Body Mass Index; WHR: 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 16 Year Olds

<table>
<thead>
<tr>
<th>Measurements</th>
<th>BMI</th>
<th>SBP</th>
<th>DBP</th>
<th>Pulse</th>
<th>WHR</th>
<th>Run Score</th>
<th>Nat. Score</th>
<th>Fibre</th>
<th>Sat Fat</th>
<th>Trans Fat</th>
<th>Na</th>
<th>Ca</th>
<th>Inmn</th>
<th>Fruit</th>
<th>Veg</th>
<th>Fr. It &amp; Veg</th>
<th>Unhealthy Snacks</th>
<th>% Fat</th>
<th>% CHO</th>
<th>% Pro</th>
<th>% Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>1</td>
<td>.983**</td>
<td>.197**</td>
<td>-.157**</td>
<td>.554***</td>
<td>.482***</td>
<td>.983**</td>
<td>-.023**</td>
<td>-.030**</td>
<td>-.030**</td>
<td>.056**</td>
<td>.078**</td>
<td>.032**</td>
<td>.059**</td>
<td>.305**</td>
<td>.224**</td>
<td>.060**</td>
<td>.233**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBP</td>
<td>1</td>
<td>.667***</td>
<td>-.079**</td>
<td>-.159**</td>
<td>-.206**</td>
<td>-.130**</td>
<td>-.020**</td>
<td>-.028**</td>
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*Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level.* : Spearman’s Rank Order Correlation. x: Pearson’s product-moment correlation. BP: Blood Pressure; BMI: Body Mass Index; WHR: 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 WHR 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 ($r = 0.462$, $p = 0.01$). WHR 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 WHR and run score ($r = 0.350$, $p = 0.05$). WHR 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 WHR. 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 childhood 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.

ACKNOWLEDGEMENTS

I would sincerely like to thank the schools and participants for their involvement in and contribution to this study.

CONFLICT OF INTEREST

None.

REFERENCES


[57] SACN. Carbohydrates and Health 2015. www.sacn.gov.uk


https://doi.org/10.6000/1928-5427.2018.07.02.3

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Appendix 2.

School and Parent Correspondence
Project Spraoi Memorandum of Understanding

Between

__________________________________________________________

and

Cork Institute of Technology, provider of Project Spraoi

Aim: To confirm our commitments to the goals of Project Spraoi and outline expectations, roles and responsibilities.

Background

Project Spraoi is aligned to the goals of the Exercise & Health Research Cluster in Cork Institute of Technology (CIT) and in so doing aims to improve children’s overall health; through the promotion of physical activity, health eating and a reduction in sedentary time. A key element is thorough evaluation.

Objectives

**Healthy Eating**
- To encourage and promote water as the best drink
- To encourage the consumption of milk and other high calcium foods every day
- To encourage an increase in fruit and vegetable consumption
- To advocate for and encourage a reduction in the amount of high energy/low nutrient food
- To encourage and advocate for an increase in availability of healthy choices at school and decrease in availability of high energy/low nutrient foods
- To increase the awareness of the importance of breakfast and encourage a breakfast habit
- To work towards consistent nutrition messages in all aspects of school

**Physical Activity**
- To encourage a minimum of 20 minutes quality daily physical ‘huff and puff’ activity
- To encourage and advocate for at least five minutes of ‘home play’ every day
- To encourage a reduction in sedentary time especially screen time if over two hours a day
- To raise awareness of incidental activity opportunities at home and school
- To raise awareness of the importance of children learning fundamental movement skills and movement literacy

**Whole School Approach**

Project Spraoi involves a ‘whole school approach’ that works towards developing an ethos and environment that supports learning and promotes health and wellbeing for all. The programme consults and encourages participation of all within the wider school community.
This includes:

- Principal, teaching staff and Board of Management commitment
- Involvement of whole school community in policy development
- Celebrating achievement
- Working in partnership with parents/guardians/family and the local community
- Giving pupils greater responsibility in the school
- Addressing staff health and well being
- Improving the school environment
- Working in partnership with external agencies
- Planning and delivery of a programme that meets the needs of all pupils

Upper Glannmire National School are committed to a one year trial of Project Spraoi from September 2014 to September 2015.

The amount of resources offered to schools will be relative to identified needs and capacity and commitment of the school. On-going process and outcome evaluation of the programme will be carried out as required by Cork Institute of Technology.

**Project Spraoi agrees to the following responsibilities:**

1. Each Project Spraoi school will have an Energizer assigned to their school as a key contact. Typically the Energizer will spend no more than two days per week in the school in Year 1 of Project Spraoi and one day per fortnight in any subsequent years.

2. The Energizer will be able to share best practice and innovative ideas from all schools involved in the project.

3. Energizers are available to support schools and school communities with any initiatives that will lead to long term sustainability of increased physical activity and improved healthy eating.

4. It is expected that Project Spraoi will become an integral part of the school.

5. There will be a focus on assisting each school to take ownership of their own plans and initiatives.

6. Energizers will act in a number of roles, they may be:
   - Catalysts
   - Facilitators
   - Coordinators
   - Ideas people
   - Strategists
   - Negotiators
   - Project supporters

7. Energizers will provide an annual written and oral report outlining achievements to the Principal.

8. Energizers understand that a schools’ action plan is a flexible document and can be modified or expanded as required. Schools are able to determine the scope of their Spraoi plan and make decisions about priorities each term. Each school owns their plan.
9. Energizers are members of the Exercise and Health Research Cluster at CIT and are postgraduate researchers. In the event of an Energizer leaving CIT a replacement Energizer will, where feasible, be appointed to the school.

The school agrees to the following responsibilities:

1. The Principal and the Board of Management support and endorse the school’s involvement in Project Spraoi by signing this agreement.

2. To appoint a lead teacher who will work closely with their Energizer.

3. Schools are also encouraged to set up a ‘working group’ with representation from teachers, support staff, parents and children.

4. Taking part in a needs analysis that involves teachers and students.

5. All teachers, board members and parents have the opportunity to attend a Project Spraoi information session.

6. To develop in conjunction with their Energizer, an action plan, and a term by term implementation plan. The content of such a plan will be determined by the physical activity and nutrition needs of the school, their children, teachers and the wider school community. The implementation plan will be supported by Spraoi.

7. Over time to take ownership of the goals of Project Spraoi and work towards sustainable policies and procedures where physical activity and healthy eating are a part of the school culture.

8. To work towards using a ‘whole school approach’ with a focus on the sustainability of Project Spraoi goals and outcomes.

9. To provide adequate time and resources for their teachers to implement the Project Spraoi action plan effectively. This would include, as required:
   - Meetings in school
   - Time at staff meetings
   - Workshops for all teachers
   - Time for planning programmes and developing physical activity and nutrition opportunities

10. To support the key messages and goals of Project Spraoi as specified on page one.

11. To support the standardised components of Project Spraoi, such as tip sheets, nutrition nuggets (newsletter snippets) and home play tasks.

12. To support regular professional development of teachers. Professional development will be delivered at no cost to the school by the Energizer or other trained presenters recruited by Project Spraoi. Professional development could be delivered to large or small groups and could take place after school, before school, lunch time or during teacher release times. The Energizer is also able to work with individual teachers on modelling sessions to support and enhance teacher’s skills and confidence.
13. To support the initial collection of baseline data in September/October 2014 and follow up data in May/June 2015

**Evaluation**

Participation in the school based components of Project Spraoi would be seen as normal school activities. The information collected will not be identifiable to individual children and can be gathered within the context of the school day.

**Evaluation may involve:**

- All children in senior infants and fourth class being asked to participate in a 550m run.
- All children in senior infants and fourth class being asked to have their height, weight, waist and upper arm circumference, blood pressure, and a measure of body fat (through specialised scales) taken.
- Data collection by means of a food diary.
- Some children in senior infants and fourth class being asked to wear an activity monitor for seven days in order to monitor levels of physical activity.
- Questions to principal/lead teacher on different topics including: knowledge and attitudes of teachers, school's nutrition and activity resources, transport to and within school, curriculum, canteen/shop and the availability of after-school activities.
- Teacher interview & physical activity profile to assist in school programming.
- Household Survey to be sent home and completed by parent/guardian.
- Questionnaires to school stakeholders (students, principal, teachers, school support staff, parents/guardians, members of the Board of Management) to aid in the process evaluation.

**Thank you for your participation!**

Please sign below if you agree to the terms outlined above

Signed (Principal)........................................................................................................Date........................................

Signed (Energizer).........................................................................................................Date........................................

Signed (CIT supervisor)....................................................................................................Date........................................
Information Sheet for Parents/Guardians

**Study title:** Project Spraoi – A strategy to improve physical activity and nutrition in primary school children.

**Background:** Project Spraoi uses the best practice model from Project Energize (New Zealand), which has been adapted to an Irish setting. The project involves the delivery of a school-based physical activity and nutrition programme to encourage and promote physical activity, healthy eating habits and a reduction in sedentary (sitting) time in Irish primary school children.

**Who is organising the study?** The Exercise and Health Research Cluster at Cork Institute of Technology, in conjunction with Upper Glanmire National School.

**What will happen to my child if they take part?**

**Physical Measurements and Fitness Test**
If you allow your child to participate they will have their height, weight, waist circumference, blood pressure, physical fitness and body composition measured. Your child will be asked to wear an activity monitor for seven days. The monitor is small and light (about the size of a matchbox) and is worn on an adjustable elastic belt around the waist. These measurements will be taken on two occasions (October 2014 and May 2015).

**Food Diary and Questionnaire**
Fourth class children will be asked to complete a food diary, which will involve recording all food and drinks consumed over a maximum five day period. A parent/guardian of participating Senior Infant children will be asked to complete a food diary on their behalf.

**What is required of me?** We would like you to fill in a short questionnaire about your child’s eating and physical activity habits, which will help us to obtain a picture of your child’s current lifestyle behaviours. If you are happy to give your consent for your child to participate in this project, please sign the attached form and return it to your child’s school by: **MONDAY 13th OCTOBER.**
Consent Form for Parents/Guardians and Children

Study title: Project Spraoi
Name of Researcher: Alison Merrotsy

If you agree, please tick the box:
I agree to allow my child to take part in the physical measurements and fitness testing
I agree to allow my child to complete a food diary

Print Name of Child: ________________________________

I agree to take part in the above study

Child Signature: ________________________________

Or

Colour the box

YES

NO

Parent/Guardian Signature:

Sign: ________________________________

Date: ________________________________

Parent/Guardian - If you would like to receive texts to remind your child to wear their activity monitor, please provide a mobile number here: ________________________________

If you require further information please contact:

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Cork Institute of Technology.
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E: amerrotsy@yahoo.com

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MSc Supervisors,
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Appendix 3.

Project Spraoi Material
FOOD DIARY AND INSTRUCTIONS

School Name: 
Child’s Class: 
Start Date: ___________ Finish Date: ___________ 

Code: __________

HOW TO FILL IN YOUR FOOD DIARY

We would like to know everything that you eat and drink over the next 5 days.

- Eat and drink as you USUALLY do.

- Bring your food diary with you EVERYWHERE you go. Fill in the food diary at SCHOOL and at HOME.

- There are 2 PAGES FOR EACH DAY.

- Use a NEW LINE for every food and drink that you eat.

- Write down EVERYTHING you eat and drink, HOW MUCH of it you had (you can use the pictures to help you with this) and the TIME you ate or drank it at.

- List foods such as sandwiches as SEPARATE food items. For example, a ham sandwich is written as: 2 slices of white bread, butter and 1 slice of ham.

- Don’t forget all those LITTLE EXTRAS that you eat with your meals. Some examples are salt, sugar, butter, ketchup and gravy.

- Don’t forget to include all SNACKS AND DRINKS that you have in between meals. Some examples are biscuits, crisps, fruit and drinks such as tea, water, fizzy drinks and diluted drinks.
• For any **FAST FOOD** or takeaways, write down the **NAME** of the restaurant such as McDonald’s or Burger King. You can write this in the “where” box.

• For all cooked foods, tell us **HOW** it was **COOKED**. Some ways of cooking foods are frying, boiling, roasting or barbequing.

• Include all **SUPPLEMENTS** you take such as Vitamin C or Cod Liver Oil etc.

**USING THE PICTURES - WHICH ONE DID YOU HAVE?**

When you are filling out your food diary:

• Use the pictures on pages 3 to 7 to help you decide **how much** of each food you had.

• Use the number written next each picture to fill in the ‘**how much did you eat or drink**’ section of your food diary.

• You can also use the pictures for similar foods to those in the pictures. You can use the ‘**bread and jam**’ pictures for butter or chocolate spread too.

• We have a book with lot of other pictures of foods and drinks. We will show you some more of these pictures in the classroom if you need some extra help.

**HERE ARE SOME TIPS TO ESTIMATE PORTION SIZE:**

<table>
<thead>
<tr>
<th>Amount of food</th>
<th>Portion size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meat</strong> = the size of a deck of card or the palm of your hand</td>
<td>3 oz</td>
</tr>
<tr>
<td><strong>Cheese</strong> = the of your thumb or a small matchbox</td>
<td>1 oz</td>
</tr>
<tr>
<td><strong>Rice, cereal or pasta</strong> = size of your fist</td>
<td>1 cup</td>
</tr>
<tr>
<td><strong>Rice, cereal or pasta</strong> = small handful or a light bulb</td>
<td>½ cup</td>
</tr>
<tr>
<td>A piece of <strong>fruit</strong> = tennis ball</td>
<td>Medium sized</td>
</tr>
<tr>
<td><strong>Butter, nutella or mayonnaise</strong> = thumb tip</td>
<td>1 teaspoon</td>
</tr>
<tr>
<td>What type of FOOD or DRINK did you have?</td>
<td>How much did you EAT or DRINK?</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td><strong>BREAKFAST</strong></td>
<td>Time: [ ] : [ ] am</td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>MORNING SNACK</strong></td>
<td>Time: [ ] : [ ] am</td>
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<td></td>
</tr>
<tr>
<td><strong>LUNCH</strong></td>
<td>Time: [ ] : [ ] pm</td>
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<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Nutrition Questionnaire
Q1. Pick the food from the milk group.
Q2. Pick the food from the meat group.
Q3. Pick the food from the fruit group.

A [Bread]
B [Banana]
C [Chicken]
Q4. Pick the food from the grain group.

A  Apple
B  Bread
C  Broccoli
Q5. Pick the food from the vegetable group.

A

B

C
Q6. Pick the most nutritious food for breakfast.

A  B  C
Q7. Pick the most nutritious drink.
Q8. Pick the most nutritious snack.
Q.9  Pick the most nutritious snack.
Q10. Pick the most nutritious snack.

A  

B

C
The Food Pyramid

A
B
C
D
E
Q11. Pick the food group that builds strong bones.
Q12. Pick the food group that heals cuts.
Q13. Pick the food group that builds muscle.
Q14. Pick the food group that helps eyes see better.

A
B
C
D
E
Q15. Pick the food group that provides the most energy.
You have completed the questionnaire, thank you.
Session 1: Sugary Drinks

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Equipment Needed ............................................................................

Key Messages

- Kids don’t need sweet drinks
- Make water and low fat milk your first choice drink
- Water is always on tap, it’s freely available and has no added sugar
- Low fat milk is great for building strong bones and teeth
Section 1: Sugar content of popular drinks

Activity 1: Warm up and introduction

Warm-up

Get children in a circle. Students take turns to each name a drink that they know of, drink, or like. Aim to have no repeats, so students need to think creatively.

From here, lead into a discussion about how there are so many drinks available to us and that some are really good for us and others aren’t so good.

Activity 2: Discuss ‘good’ and ‘bad’ drinks

1. Place 10 drinks on table:
   Water, low fat milk, flavoured water, glass of Raro, a can of V, can of coke (355ml), bottle of coke (600ml), e2 (Blackcurrant 800ml), Mother, Powerade

2. Ask the group what ingredients/nutrients are in the drinks that makes them either good for us or not so good, and why

Should raise the following points:

Negatives:

- Sugar – provides you with empty calories and no nutritional value. That is sugary drinks don’t give you any goodness (calcium for bones, protein for muscles etc) that you would otherwise get from healthy food. Sugar is also bad for your teeth.
- Caffeine – found in coke, energy drinks, coffee and tea. This is a stimulant which means it speeds up the heart and therefore can be very dangerous for children. It is also very addictive and excessive caffeine can leach/pull calcium out of the bones. Energy drinks are not recommended for people under the age of 18.
- Children might talk about the fact that drinks like e2 give them ‘energy’. Explain to them that all food and drinks (apart from water) give us energy. The problem with sugary drinks is that they give us lots of energy but no goodness. Eg. A banana gives us energy + fibre and vitamins
• Sugary drinks can give you a ‘sugar rush’ (make you hyper) but this is followed by a big ‘crash’ leaving you to feel worse than before.

Positives

• Calcium – Helps to keep bones and teeth strong. Very important in children as they are still growing and need to maximise their bone density when young.
• Water – helps to keep us hydrated as we lose water throughout the day through sweating, breathing, and going to the toilet. If we don’t drink water we can become dehydrated which can make us tired, grumpy, lack in concentration and might give you headaches.
  ▪ Your body is made up of 70% water, it is important to keep this level up as your body and brain does not work properly. Don’t let yourself get thirsty as this is the first sign of dehydration
  ▪ The best way to see if you are dehydrated is to look at your urine. You are dehydrated if your urine is dark (yellow or orange) in colour. When you are well hydrated it is a clear colour.

Activity 3: Put drinks in order

Part 1

Get children to line the 10 drinks up from most to least sugar.

• Remember that it is the amount of sugar you would consume if you drank the WHOLE drink.

Part 2

Match drinks with equivalent bags of sugar

<table>
<thead>
<tr>
<th>Drinks (In correct order)</th>
<th>Sugar Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>0 tsp</td>
</tr>
<tr>
<td>Low fat milk</td>
<td>2 tsp</td>
</tr>
<tr>
<td>Glass of Raro (200ml orange mango flavour)</td>
<td>4 tsp</td>
</tr>
<tr>
<td>Flavoured Water (700ml tangerine flavour)</td>
<td>5 tsp</td>
</tr>
<tr>
<td>V Energy Drink (250ml can)</td>
<td>7 tsp</td>
</tr>
<tr>
<td>Can of Coke (330 ml)</td>
<td>10 tsp</td>
</tr>
<tr>
<td>Mother energy drink (500ml)</td>
<td>13 tsp</td>
</tr>
<tr>
<td>Powerade (750ml)</td>
<td>14 tsp</td>
</tr>
<tr>
<td>Bottle of Coke (600ml)</td>
<td>16 tsp</td>
</tr>
<tr>
<td>E2 (blackcurrent 800ml)</td>
<td>20 tsp</td>
</tr>
</tbody>
</table>
Ask Q: Is there anything surprising about the order of drinks?

Discussion points:

- **Flavoured water** – These are not naturally flavoured, instead they add sugar to make it sweeter. There are lots of other ways that we can flavour water naturally. E.g. slices of fruit or mint leaves. Note: Sparkling flavoured water has even more sugar – 7 teaspoons.

- **Fruit Drink vs Fruit Juice** – Fruit juice and fruit drinks are not the same. A fruit juice contains natural fruit and has the vitamins/minerals from the fruit. Because of this it can count as one of the fruit serves each day.

  There is still about 6 teaspoons of sugar (from the fruit) in a 250ml serve so limit to a sometimes drink. A fruit drink is just sugar, water and flavour. There is nothing nutritious about these drinks.

  Look for the word fruit “juice” or “drink” on the label to help you choose the healthier option.

- **E2** – this is a fruit drink not a fruit juice. Therefore it is sugar and water with less than 5% natural fruit juice.

- **Raro** – very concentrated sugar content (250ml with 4tsp). Children often drink more than one glass in a day. It is a fruit drink not a fruit juice

- **Energy drinks** – large amount of sugar in a small vessel and it contains caffeine. They are not recommended for children. All energy drinks are similar in sugar/caffeine content

- **Sports drinks** – these were originally designed for elite athletes. When children are participating in sport the best drink is water. Sports drinks aid recovery and help the body to get through a long (over 90 minutes) and hard training session or race.

  Advertising teaches children to like sweet drinks. Which famous people drink Powerade? Elite sports people are the face of these and yes it helps them as they are doing so much training.

- **Hot drinks** – Tea and coffee contain caffeine, they should be for adults only. Milo has a lot of sugar in it (1 teaspoon of milo has ½ teaspoon of sugar), a low fat milky milo is a good way to get calcium but limit the milo to 1 teaspoon.

**Section 2: Drinks for everyday**

Add the following drinks to the group:

- Ribena – 250ml (6 ½ tsp sugar),
- Chocolate flavoured milk – 250ml (7 tsp sugar),
- Coke Zero (0 tsp sugar but it has caffeine),
- Just Juice – 250 ml (6 tsp sugar)
Activity 1: Sort drinks into groups

Get children to put the drinks into the correct group based on the criteria below.

**Everyday/first choice (green)**
- Plain, basic, best for everyday
- Little or no sugar
- Healthiest choice

**Sometimes/small (orange)**
- Some nutritional value e.g. calcium or vitamins
- Most have added sugar
- No more than 2 times a week

**Occasional/hardly ever (red)**
- Heaps of sugar and some have caffeine
- No nutritional value (no goodness)
- High energy/low nutrient
- Keep for special occasions

<table>
<thead>
<tr>
<th>Everyday</th>
<th>Sometimes</th>
<th>Occasional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Just juice</td>
<td>Coke x2</td>
</tr>
<tr>
<td>Low fat milk</td>
<td>Chocolate milk</td>
<td>Coke Zero</td>
</tr>
<tr>
<td></td>
<td>Flavoured water</td>
<td>PowerAde</td>
</tr>
<tr>
<td></td>
<td></td>
<td>E2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ribena</td>
</tr>
<tr>
<td></td>
<td></td>
<td>V can</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Raro</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mother</td>
</tr>
</tbody>
</table>

**Discussion points:**

- **Best choice drinks are water and low fat milk.** These should always be offered first as they provide the body with so much goodness.
- **Diet or ‘zero’ drinks are not recommended because they contain caffeine.** The artificial sweetener is controversial – some research says its ok, others do not. But the bottom line is that water and low fat milk are still the best.

- **Flavoured milk is better than fizzy** because it contains calcium for strong bones, but it’s still high in sugar – 6 ½ tsp per carton. If buying, stick to the small boxes – not the 600ml or 2 litre bottles!

- **Flavoured water has 5 tsp sugar in a bottle** and is an expensive way to drink water. Try flavouring your own water with lemon, orange, berries, mint.

## Section 3: Summary

*Summary of session and recap messages:*

1. Kids don’t need sweet drinks
2. Make water and low fat milk the first choice
3. Water is always on tap / freely available / has no added sugar
Appendix: Additional Session Information

1) Fat and calcium contents vary depending on the type of milk. Best choices for anyone over two years is low fat milk, milk with added calcium is also beneficial. Good choices = Cali-xtra milk (yellow top), mega- milk (orange top) or trim milk (green).

<table>
<thead>
<tr>
<th>Milk type</th>
<th>Fat content (g/100ml)</th>
<th>Calcium content (mg /100ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue (blue top)</td>
<td>3.3</td>
<td>116</td>
</tr>
<tr>
<td>Trim (dark green)</td>
<td>0.1</td>
<td>133</td>
</tr>
<tr>
<td>Lite (light blue)</td>
<td>1.5</td>
<td>125</td>
</tr>
<tr>
<td>Mega milk (orange)</td>
<td>2.0</td>
<td>160</td>
</tr>
<tr>
<td>Super trim (light green)</td>
<td>0.1</td>
<td>140</td>
</tr>
<tr>
<td>Xtra (yellow)</td>
<td>0.2</td>
<td>200</td>
</tr>
<tr>
<td>Powdered Milk (trim)</td>
<td>0.1</td>
<td>120</td>
</tr>
<tr>
<td>Powdered Milk (blue)</td>
<td>3.6</td>
<td>120</td>
</tr>
</tbody>
</table>

2) Sweet drinks give ‘empty calories’ without goodness. This includes cordial.
• Generally any sweet drink marketed for children contains a lot of sugar (unless it is diet)
• On average, 1 glass contains about 6 teaspoons of sugar
• Sugar damages teeth and can affect body weight
• Giving children sweet drinks develops their taste for more sweet drinks.
In summer and winter you need to drink water to keep your body hydrated and working well. Every day we lose water from our body; drinking water replaces it.

**ADD SOME FLAVOUR**

**ALWAYS CARRY A WATER BOTTLE WITH YOU**

**KEEP A JUG OF WATER IN THE FRIDGE**

**TIP!** Sweet drinks contain lots of sugar - they are special occasion drinks.
Parent Information and Tasting Session
“Nice Cream” Tasting Session
(frozen banana and berries)

Green Hulk Smoothie

- 1 cup of milk
- 1 Banana (frozen)
- 1 cup of frozen mango
- 1 cup of baby spinach
- Blitz & Enjoy