Malta Journal of Health Sciences
https://www.um.edu.mt/healthsciences/mjhs/
DOI: 10.14614/CHILDOBES/8/17

Research paper

INVESTIGATING DETERMINANTS OF OBESITY IN 5- TO 6-YEAR-OLD MALTESE CHILDREN

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Abstract. Childhood obesity is increasing in most countries worldwide and Malta is no exception. However, local data regarding determinants of obesity is lacking. The aim of this preliminary study was to link some possible determinants of childhood obesity, namely, dietary intake and activity levels with anthropometric data in a sample of 5- to 6-year-old Maltese children and to investigate possible associations with parental body mass index (BMI). Stratified sampling which ensured good gender, geographical and socioeconomic representation and adequate representation from the three school-types (state, church, independent), provided a sample of 66 participants. Anthropometric measurements of children and parents were collected in 2015 and diet and lifestyle factors were assessed through food and activity diaries. The diaries were coded to retrieve energy and macronutrient intake and activity levels of the children. Multiple regression related BMI and waist circumference (WC) with dietary intake, activity levels and parental BMI. Children's BMI and WC were positively and significantly (r_s = 0.71, p < 0.001) correlated. Consumption of Non-Milk Extrinsic Sugars (NMES) were significantly higher for girls than boys (U = 366.0, p = 0.031). Multiple regression analysis yielded a significant positive relationship between NMES with both BMI (t (56) = 3.095, p = 0.003) and WC (t (56) = 3.365, p = 0.002). Paternal and child BMI were positively significantly correlated (r_s = 0.372, p = 0.005). NMES intake was one possible contributing factor to obesity and central adiposity with physical activity having a protective effect, whilst sedentary behaviour and fat intake did not appear to be risk factors at this age. Further studies are recommended on larger sample sizes to extensively investigate the effect of different determinants on obesity in this age group and work towards developing nutritional recommendations on a national basis.

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Received: 27.03.17; Revised: 22.05.17; Accepted: 06.06.17;
Published 26.06.17

Keywords: obesity; dietary intake; physical activity; body mass index (BMI).

1 Introduction

Childhood obesity is a worldwide public health crisis. In 2015 it was estimated that globally about 224 million school-aged children were overweight (World Obesity Federation, 2015). Malta is no exception with the most recent data, using World Health Organisation (WHO) criteria, showing that 41% of all Maltese school children are overweight or obese (Grech et al., 2016). Childhood obesity shortens life expectancy (World Obesity Federation, 2015) and leads to increased cardiovascular (Reilly et al., 2003; Daniels et al., 2005) and psychological (Dehghan, Akhtar-Danesh & Merchant, 2005) health risks in childhood. Obese children are more likely to be obese adults than non-obese children (Simmonds et al., 2016). Increased economic costs in childhood from use of healthcare services and loss of productivity of their legal guardians, is a consequence of childhood obesity (Lehnert et al., 2013).

Several factors have been attributed to the development of childhood obesity. International studies have identified dietary intake, lack of physical activity and sedentary behaviour as potential risk factors for childhood obesity, while age and gender of the child together with parental characteristics are influencing factors (Prentice-Dunn & Prentice-Dunn, 2012; Li et al., 2007; Cunningham, Kramer & Narayan, 2014; Ventura & Birch, 2008). Sleep duration which affects leptin and ghrelin levels, feeding practices (Dev et al., 2013), and environmental factors (Kirk, Penney & McHugh, 2009) are also linked to obesity development. An obesogenic environment that is characterised by limited infrastructure to encourage physical activity, access to energy dense food and cultural traditions supports a positive energy balance and contributes towards obesity (Cauchi, Rutter & Knai, 2015). Parental weight has been shown to be a risk factor for childhood obesity in several international studies, with increased parental weight causing an increased risk (Whitaker et al., 2010). However, the influence of parental BMI on child BMI has not been accurately determined, since some studies observed an association between maternal and child

BMI (Linabery et al., 2013), others between paternal and child BMI (Knight et al., 2007; Freeman et al., 2012; Fuiano et al., 2015), while some found similar associations with both parents (Botton et al., 2010). The recent major international I.Family study addressed the influence of families, friends and environment on health and behaviour. Results showed that few European children meet the recommendations for physical activity, healthy diets and sleep, with government intervention deemed necessary to tackle childhood obesity (Ahrens et al., 2017).

There are three critical periods for obesity development, these are pregnancy and early childhood, the adiposity rebound between five and seven years of age, and adolescence (Dietz, 1994). An earlier adiposity rebound, which is a decrease in BMI followed by a rise, increases the risk of obesity development (Williams, 2005; Tabacchi et al., 2007). Taller children, with a lower BMI and whose weight increased faster at three years of age tend to have an earlier adiposity rebound (Williams, 2005) and the latter has been related to a positive energy balance in early life (Rolland-Cachera & Péneau, 2013). Encouraging healthy behaviours early in life, monitoring young children and intervention for high-risk children and their families may help decrease the likelihood of early adiposity rebound (Hughes et al., 2014).

Local research on 5- to 6-year-old children has focused on prevalence of overweight and obesity (Grech & Farrugia Sant'Angelo, 2009), the probable influence of the obesogenic environment on local obesity rates (Cauchi et al., 2015) and potential environmental strategies that may influence anthropometric measurements (Cauchi et al., 2016). However, data regarding trends of dietary intake and activity levels and their effect on childhood obesity in this age-group is still lacking locally. The aim of this exploratory study was to link some determinants namely, dietary intake and activity levels with anthropometric data in a sample of 5- to 6-year-old Maltese children and possible associations with parental BMI.

2 Method

2.1 Study participants and ethical approval

Ethical approval was obtained from the Faculty Research Ethics Committee and the University Research Ethics Committee of the University of Malta (010/2015). Permission to carry out this research was obtained from the Directorate for Quality and Standards in Education (DQSE), the Malta Diocese, the college principals and the respective heads of school. Schooling in Malta is provided by three types of schools, free state schools, donation-dependent church schools and fee-paying independent schools. These will be referred to respectively as state, church and independent, and may act as indicators of socio-economic status (SES) since schooling in independent schools must be paid for by families who are able to afford the school fees. Stratified sampling was carried out to ensure good geographical, socio-economic and gender representation and provide appropriate representation from all three school-types in a proportion that was indicative of the population. Malta is divided into five districts: Northern, Northern Harbour, Western, South-Eastern and Southern Harbour districts. One socio-economic indicator used by the National Statistics Office, Malta (NSO), to classify the different districts, is the "at-risk-of-poverty" indicator, which is affected by employment and education level. A secondary education level has an "at-risk-of-poverty" rate of 17%, as opposed to 6% for people with a tertiary or higher level of education (NSO, 2012). Cluster sampling was used to select the 15 schools, which excluded Gozitan schools. However, these schools were chosen to reflect different combinations of the district were the school was located, the gender of the students and school-type. Convenience sampling was used by selecting all students who satisfied the inclusion criteria. Inclusion criteria included all 5- to 6-year-old boys and girls from the selected schools, who had at least one Maltese parent, whose parents had provided written consent and who assented to participate in the study. Exclusion criteria included children who had a physical and/or cognitive disability. Consent forms were distributed to all the 5- to 6-year-old (Year 1) children in the selected schools who satisfied the selection criteria and 165 consent forms were returned providing a response rate of 24.2%. Despite consenting, only 66 diaries were returned, giving a drop-out rate of 60%. Parents who had returned the diaries were contacted by telephone. Inability to contact parents over a three-month period resulted in 56 participating parents. Table 1 shows the details of the participants, together with "at-risk-of-poverty" indicators of the different districts in Malta which may indicate SES.

2.2 Research design

An informative meeting prior to initiation of the study provided parents with information about the study. Since not all parents were present, consent forms were distributed through the children at school. Anthropometric measurements of the children (height, weight and waist circumference (WC)) were taken in schools during the period March and June 2015 by the first author. The children's heights and weights were measured using Seca 217 portable stadiometer and Seca 877 digital scales, following the method recommended by the WHO Child Growth Assessment (WHO, 2008a); WC was measured using a stretch-resistant tape following the standardised WHO STEPS protocol (WHO, 2008b), with the children wearing light clothing and no shoes. Food and activity diaries together with completion instructions were distributed to participating children after physical measurements were taken. Parents were asked to complete and return a 7-day food and activity diary by post. Food diaries as the method of choice for dietary assessment, provided data on energy and macronutrient intake, allowed specific local foods to be included due to its open-ended structure and is in line with the dietary assessment method used for young children in other studies (Andersen et al., 2011; Collins, Watson & Burrows, 2010; Livingstone et al., 1992). This diary was not piloted or validated, however, this

Table 1. Details of participants by school-type, district, gender and "at-risk-of-poverty" indicator

School	District	"At-risk-of-poverty" indicator/% (description) (NSO, 2012)	School type	Number of students[a] (n)[b] [N][c]	Male	Female	Parents participating[d]
S1	Western	14.2 (low)	State	6 (9) [49]	2	4	5
S2	South Eastern	13.9 (low)	State	3 (6) [14]	1	2	3
S3	Southern Harbour	16.7 (high)	State	1 (5) [10]	0	1	1
S4	Northern	14.8 (medium)	State	5 (11) [57]	4	1	5
S5	Northern Harbour	15.1 (medium)	State	4 (13) [58]	2	2	3
I6	Northern Harbour	15.1 (medium)	Independent	19 (29) [87]	8	11	18
C7	Western	14.2 (low)	Church	7 (21) [79]	7	0	6
C8	Northern Harbour	15.1 (medium)	Church	7 (19) [74]	0	7	6
I9	Western	14.2 (low)	Independent	0 (5) [25]	0	0	0
S10	South Eastern	13.9 (low)	State	0 (4) [19]	0	0	0
S11	Southern Harbour	16.7 (high)	State	2 (7) [26]	0	2	2
S12	Northern	14.8 (medium)	State	4 (12) [105]	0	4	3
S13	Western	14.2 (low)	State	1 (2) [15]	0	1	1
S14	Northern Harbour	15.1 (medium)	State	1 (6) [17]	1	0	1
S15	Northern Harbour	15.1 (medium)	State	6 (16) [47]	3	3	2
Total				66 (165) [682]	28	38	56

Note. [a]Total number of students who consented to participate in the study and returned the diaries in each school.
[b]Total number of consent forms signed and returned in each school.
[c]Total number of consent forms distributed in each school.
[d]Number of parents who self-reported height and weight.
S=state; C=church; I=independent.

preliminary study served to pilot the diaries for possible research on larger sample sizes in the future.

When the diaries were returned, three days of the food and activity diaries were coded. Two weekdays (the first two weekdays filled in) and one weekend day (Sunday) were coded to be representative of a week, since 3-day food diaries (records) give comparable results to more time-consuming methods (Kolar et al., 2005). A coding protocol was prepared for the food and activity diaries to allow the coder to follow a standardised procedure for dealing with missing or incomplete information in the diaries (Puš, Podgrajšek & Simčič, 2012). Traditional Maltese recipes that were not included in the diaries were compiled making reference to a traditional Maltese cookery book (Caruana Galizia & Caruana Galizia, 1972). These recipes together with those included in the diaries and other recipes from the standard British food composition tables (Food Standards Agency, 2002), were added to the electronic database and used during the coding process. Nutritional labels of the specific food items or the internet were used to identify nutritional information not present in the database. Analysis of the food diaries was carried out using the WISP v3.0 Tinuviel Nutritional Analysis Software to retrieve energy and macronutrient intake of the children.

The activity diaries included information regarding type and duration of both physical activity and sedentary behaviour (screen time and academic sedentary behaviour) of the children after-school hours and during the weekend. Screen time included time spent watching television (TV) and using electronic devices, referring to the Australian guidelines for sedentary behaviour (Okely et al., 2012), while academic sedentary behaviour included time spent doing homework, reading and studying. The EU and the WHO do not have quantified recommendations regarding the maximum amount of sedentary or screen time, therefore, reference was made to the Australian guidelines on sedentary behaviour of not more than two hours a day of TV or use of other electronic media (electronic games, computer, internet) (The Sedentary Behaviour And Obesity Expert Working Group, 2010). Reference to the WHO physical activity recommendations (WHO, 2010) allowed inclusion or exclusion of activities recorded in the diaries. Activities were included if they could be classified as moderate or vigorous activity, muscle strengthening and bone strengthening activities.

All parents who had returned the diaries were eligible to participate in the study. Parents were asked to self-report their own height and weight over the telephone. Inability to contact some parents by telephone over a period of three months resulted in their exclusion. The BMI of the parents was calculated from their height and weight.

2.3 Statistical analysis

Data was analysed statistically using the IBM SPSS (Statistical Package for the Social Sciences) version 23 software package. All measures were tested for normality using Kolmogorov-Smirnov test and Shapiro-Wilk tests. Energy intake, all macronutrients except non-milk extrinsic sugars (NMES) and physical activity followed normal distribution, while NMES, BMI, WC and screen time followed non-normal distribution; therefore, both parametric and non-parametric tests were used in the analysis of the data. The level of significance was set at 0.05. The Mann Whitney test compared mean measurements between gender groups, while the one–way Analysis of Variance (ANOVA) and Kruskal-Wallis tests compared mean measurements between school-type and district. The Spearman correlation test explored the relationship between child BMI and WC and between parental and child BMI. Multiple regression analysis was used to determine which dietary factors (energy intake, total fat intake, saturated fat intake, total sugar intake and NMES intake), activity levels and parental BMI are significant predictors of children's BMI and WC.

3 Results

3.1 Anthropometric measurements

Differences in mean BMI were not significant between gender, school-type and district, while differences in mean WC were not significant between gender and district (Table 2). However, there were significant differences in mean WC between school-types ($\chi^2(2) = 6.512$, $p = 0.039$) (Table 2). Post hoc tests used for pairwise comparisons between schools, showed that mean WC in church schools was significantly higher compared to state schools (U = 142.5, $p = 0.039$) and independent schools (U = 65.0, $p = 0.012$). Further comparison of WC between schools by gender, revealed the same pattern in girls but not in boys (Figure 1). The children's BMI and WC were positively and significantly correlated ($r_s = 0.71$, $p < 0.001$).

The majority of self-reported anthropometric measurements for both parents were provided by mothers participating in the study. This yielded a mean BMI of the fathers (M = 27.1, SD = 4.3 kg/m^2) which was higher than that of the mothers (M = 23.5, SD = 4.0 kg/m^2), putting the mean BMI of fathers in the overweight range and the mean BMI of mothers in the normal weight range.

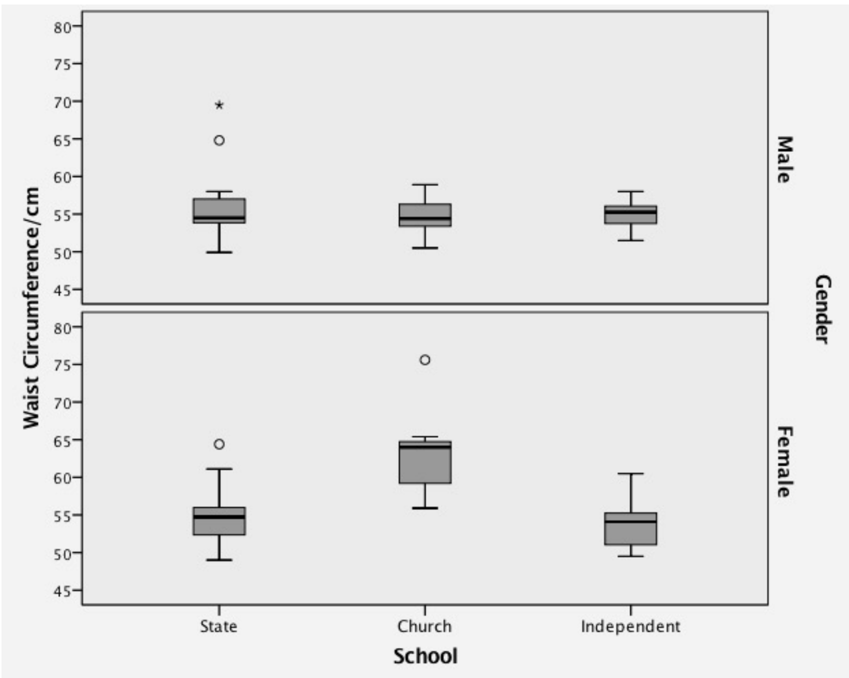

Figure 1. Mean waist circumference by gender between school types

Table 2. Sample mean WC and BMI with comparison by gender, school type and district

Measurements	Whole sample	Gender			School type				District					
		M	F	*p*-value	S	C	I	*p*-value	N H	N	W	S E	S H	*p*-value
Mean WC/cm	55.9	55.6	56.2	0.876	55.6	59.0	54.2	0.039	57.0	53.8	54.5	56.8	54.7	0.273
(SD)	(4.8)	(3.9)	(5.4)		(4.3)	(6.5)	(2.8)		(5.8)	(2.0)	(2.2)	(4.5)	(2.2)	
Mean BMI	16.1	15.9	16.2	0.627	16.1	16.8	15.5	0.185	16.6	15.5	15.4	16.2	15.2	0.817
(SD)	(2.2)	(2.2)	(2.2)		(2.4)	(2.4)	(1.4)		(2.6)	(0.6)	(1.1)	(2.4)	(1.1)	

Note. WC – waist circumference; SD – standard deviation; BMI – body mass index; M – boys; F – girls; S – state; C – church; I – independent; NH – Northern Harbour; N – Northern; W – Western; SE – South Eastern; SH –Southern Harbour.

Table 3. Comparison of mean energy and macronutrient intakes by gender, school type and district

Mean (SD) energy & macronutrient intake	Gender		*p*-value	School type			*p*-value	District					
	M	F		S	C	I		NH	N	W	SE	SH	*p*-value
Energy/kcal	1148	1105	0.467	1115	1100	1155	0.776	1120	1153	1114	1315	923	0.392
(SD)	(271)	(216)		(241)	(221)	(260)		(238)	(101)	(218)	(515)	(331)	
Protein/%	17.1	17.0	0.864	17.4	17.7	15.9	0.047	16.4	17.3	17.8	18.1	18.8	0.186
(SD)	(2.4)	(2.4)		(2.4)	(2.2)	(2.3)		(2.2)	(2.9)	(2.3)	(3.8)	(0.8)	
Total fat/%	31.6	33.6	0.134	32.9	29.8	34.9	0.022	32.3	33.7	32.1	36.5	35.5	0.591
(SD)	(5.4)	(5.2)		(4.8)	(4.3)	(6.2)		(5.7)	(3.5)	(4.8)	(7.7)	(6.8)	
SFA/%	13.2	14.4	0.162	13.8	12.5	14.9	0.119	13.5	13.8	14.4	12.3	17.0	0.409
(SD)	(3.3)	(3.2)		(3.2)	(2.5)	(3.7)		(3.4)	(2.5)	(3.2)	(3.6)	(3.6)	
CHO/%	51.3	49.4	0.192	49.8	52.6	49.2	0.215	51.3	49.0	50.1	45.4	45.7	0.252
(SD)	(5.6)	(6.0)		(6.1)	(4.4)	(6.2)		(5.7)	(5.1)	(5.0)	(10.9)	(7.2)	
NMES/%	7.4	9.5	0.031	7.8	11.6	7.8	0.230	8.9	8.5	9.0	4.0	9.1	0.335
(SD)	(5.3)	(5.2)		(5.0)	(6.8)	(3.9)		(4.4)	(8.2)	(6.1)	(2.8)	(3.7)	

Note. kcal – kilocalories; % - as a percentage of food energy; SFA = Saturated fatty acids; CHO = carbohydrates; NMES = non-milk extrinsic sugars. M – boys; F – girls; S – state; C – church; I – independent; NH – Northern Harbour; N – Northern; W – Western; SE – South Eastern; SH –Southern Harbour.

3.2 Dietary intake

Comparison of mean energy and macronutrient intake by gender, school-type and geographical distribution did not show significant differences between districts however, intake of protein, saturated fats and NMES were highest in the Southern Harbour district. Significant differences were evident between gender and school-types, with intake of NMES being significantly higher (U = 366.0, p = 0.031) in girls than boys, and total fat intakes varied significantly (F (2,63) = 4.05, p = 0.022) between school-types (Table 3).

3.3 Physical activity and sedentary behaviour

Physical activity duration (M = 1.3, SD = 0.8 hours), screen time (M = 1.2, SD = 1.0 hours) and total sedentary behaviour (M = 1.9, SD = 1.2 hours) were recorded in the activity diaries. Mean physical activity duration, mean screen time and mean total sedentary behaviour varied marginally between gender, school type and districts; however, boys living in the Northern district and attending independent schools demonstrated the highest mean physical activity and screen time (Table 4). Mean total sedentary behaviour was higher in boys (M = 2.0, SD = 1.3 hours) than in girls (M = 1.8, SD = 1.1 hours).

Exploring the link of anthropometric measurements with dietary intake and activity levels did not show significant relationships between BMI or WC with NMES and physical activity (Table 5). However, inclusion of parental BMI as a predictor, yielded a significant positive relationship between NMES and child BMI (t (56) = 3.095, p = 0.003) and NMES and child WC (t (56) = 3.365, p = 0.002).

Spearman correlation tests demonstrated a significant positive association between child BMI and paternal BMI (r_s = 0.372, p = 0.005) (Figure 2), but not with maternal BMI (r_s = 0.043, p = 0.752).

In summary, mean WC in church schools was significantly higher than that in state and independent schools and the same pattern was seen in girls but not in boys when comparing WC between schools by gender. Analysis of dietary intake revealed that NMES intake was significantly higher in girls than in boys while total fat intake varied significantly between school types. Physical activity, screen time and total sedentary behaviour did not vary significantly between gender, school type or district. However, mean

Table 4. Sample mean physical activity and screen time with comparison by gender, school type and district

Mean activity /hours	Whole sample	Gender			School type				District					
		M	F	*p*-value	S	C	I	*p*-value	N H	N	W	S E	S H	*p*-value
Mean PA/hrs	1.3	1.5	1.2	0.155	1.3	1.2	1.5	0.563	1.3	1.8	1.3	1.0	1.1	0.304
(SD)	(0.8)	(0.8)	(0.8)		(0.8)	(0.7)	(0.9)		(0.8)	(0.9)	(0.7)	(0.4)	(0.4)	
Mean ST/hrs	1.2	1.3	1.0	0.310	1.2	1.0	1.2	0.656	1.2	1.3	1.1	0.7	0.7	0.683
(SD)	(1.0)	(1.2)	(0.8)		(1.2)	(0.9)	(0.8)		(1.2)	(0.8)	(0.8)	(0.5)	(0.3)	

Note. PA/hrs – physical activity in hours; SD – standard deviation; ST/hrs – screen time in hours; M – boys; F – girls; S – state; C – church; I – independent; NH – Northern Harbour; N – Northern; W – Western; SE – South Eastern; SH –Southern Harbour.

Table 5. Effect of predictors on BMI and WC

	BMI				WC			
	B	SE B	*β*	*p*-value	B	SE B	*β*	*p*-value
Constant	20.55	2.70		0.000	70.66	5.63		0.000
Mean physical activity/hours	-0.01	0.01	-0.16	0.245	-0.02	0.01	-0.20	0.111
Mean screen time/hours	-0.47	0.29	-0.22	0.106	-1.41	0.59	-0.30	0.021
Energy/kcal[a]/day	-0.00	0.00	-0.21	0.130	-0.00	0.00	-0.10	0.442
Total fat/%[b]	0.03	0.08	0.08	0.702	-0.15	0.17	-0.17	0.401
SFA/%[b]	-0.21	0.12	-0.32	0.073	-0.28	0.24	-0.20	0.241
Total sugars/%[b]	-0.00	0.06	-0.00	0.983	-0.11	0.12	-0.15	0.352
NMES/%[b]	0.07	0.06	0.18	0.237	0.25	0.13	0.27	0.055

Note. R^2 = 0.24 (BMI); R^2 = 0.32 (waist circumference)

[a]kilocalories, [b]as a percentage of food energy; SFA = saturated fatty acids; NMES = non-milk extrinsic sugars; BMI = body mass index; WC = waist circumference. B = unstandardised regression coefficient; β = standardised regression coefficient; R^2 = effect size

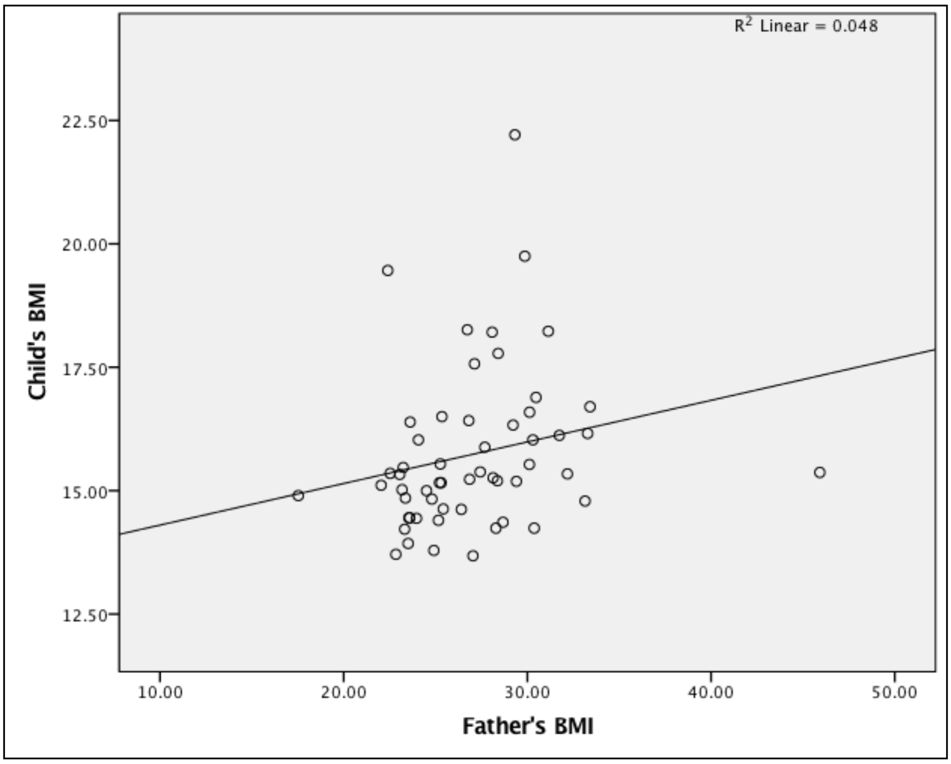

Figure 2. Relationship between paternal and child BMI

physical activity and screen time were higher in boys living in the Northern district and in independent schools, and mean total sedentary behaviour was higher in boys than in girls. A significant positive relationship was present between NMES intake and child BMI and NMES intake and child WC. There was a significant positive association between child BMI and paternal BMI.

4 Discussion

This preliminary study has explored the possible links between dietary intake, activity and sedentary behaviour levels and parental BMI with obesity in a sample of 5- to 6-year-old Maltese children. Local research using objectively measured physical activity, screen time and obesity status has been carried out in 10- to 11-year-old children (Decelis, Jago & Fox, 2014). In line with findings from Decelis et al. (2014), boys were more active and engaged in more screen time than girls. In comparison to Australia and the United States of America (USA), 10- to 11-year-old Maltese children were more active, but less active than children in England, and spent less time in front of a screen than children in almost all countries. Boys in this study had a higher total sedentary time and a lower BMI than girls; this is in contrast to the findings of Decelis et al. (2014) which also showed that prevalence of overweight and obesity in 10- to 11-year-old Maltese children especially in boys was amongst the highest in the world. Outcomes of a review by Wilks et al. (2011) could possibly indicate that physical inactivity may not be the largest contributing factor to obesity in all children.

All girls and children attending church schools had a larger mean BMI and mean WC than boys and children attending other school-types. This may imply that an inverse relationship is exhibited between obesity and SES, similarly to that observed in other developed countries (Knai et al., 2012). Since SES can be indicated by income and education level, one may argue that a low SES may affect the likelihood of a healthy diet and access to sports facilities as compared to a higher SES (Craig & Mindell, 2006). Larger waist circumference in girls than in boys in this study is in line with that of another study in the United Kingdom of similar aged children (Griffiths, Dezateux & Cole, 2011). This may be related to high intakes of NMES and low amounts of physical activity in girls, and may indicate the need of further research in gender-specific studies. Results of this study indicated a significant positive association between BMI and WC. BMI-for-age is used to establish weight status in children and waist circumference is a specific indicator of central fatness (Brambilla et al., 2006). This positive association may possibly indicate that both BMI and WC may provide an easy, effective and non-invasive way for identifying body weight (Chinedu et al., 2013).

Dietary assessment in this study showed a higher intake of protein and carbohydrates in boys when compared to girls, with girls exhibiting a larger intake of total fats, saturated fats and a significantly higher intake of NMES. This is in line with findings from other studies (Caine-Bish & Scheule, 2009; Maier et al., 2013; Santiago et al., 2013; Wansink, Cheney & Chan, 2003; Lanfer et al., 2012; Deheeger, Rolland-Cachera & Fontvieille, 1997) showing the diverse macronutrient intake by gender. High carbohydrate intake associated with increased energy needs was reflected in more physically active boys, while higher fat intakes were linked to less active girls, similarly to that observed in other studies (Deheeger, et al., 1997). In this study, geographical district, “at-risk-of-poverty” rate and school-type were used as indicators of SES, with low SES emerging as a possible link to high intake of protein and NMES. Both low and high SES as indicated by district and school-type respectively were linked to a high intake of saturated fats. These findings are consistent with other studies which link this type of macronutrient intake to consumption of larger quantities of low-cost, fatty meats and processed meats, fried food and sweets (Cullen et al., 2002; Darmon & Drewnowski, 2008; Drewnowski & Darmon, 2005; Mathieson & Koller, 2006). Nutrient poor, energy-dense food, having a low economic cost and low-satiating properties, may cause over-eating and obesity and are related to high intakes of protein, fat and NMES. Children of high SES, indicated by school-type, had a high intake of saturated fats. The finding could have resulted due to the power of the sample or as similarly observed in another local study, whereby children in independent schools tended to consume more ‘modern’ foods, these being more processed and convenience-type foods, which are high in fats (Piscopo, 2004).

Children in independent schools engaged in more physical activity and screen time as compared to children in different school-types. Increased SES could lead to an increased possibility for extra-curricular physical activities; with a shorter school day at this age in independent schools being one reason for large amounts of screen time due to increased free time. Conversely, children in church schools engaged in the least amount of physical activity after-school hours and during the weekend. A similar pattern of physical activity between school-types during school hours is seen in the European Child Growth Surveillance Initiative in 2008 with a higher SES being a possible influencing factor (Farrugia Sant’Angelo & Grech, 2011). Data collected for the European Child Obesity Surveillance Initiative (ECOSI) showed that church schools offer the least amount of physical activity during school hours, that is, less than one hour of physical education lessons per week (The Ministry for Education and Employment and the Parliamentary Secretariat for Health, within the Ministry for Energy and Health, 2015). Behavioural patterns learnt at school may possibly have an influence on after-school habits. Gender also appears to be an influencing factor on active and sedentary behaviours. Physical activity but also screen time was higher in boys as compared to girls, which is consistent with studies involving similar aged boys (Santiago et al., 2013; Anderson, Economos & Must, 2008).

A high intake of NMES caused an increase in weight and adiposity while increased activity produced the reverse effect on BMI and WC in this study. The additional effect of parental BMI, with the predictors, produced a significant positive relationship between intake of NMES with child BMI and WC. This result is similar to the results obtained by Francis, Lee and Birch (2003) that indicate the parental influence on their child’s obesity development. Findings of this study showed a significant positive association between paternal BMI and child BMI, while the relationship between maternal and child BMI was not significant. This is consistent with results of Freeman et al. (2012) with children of a similar age-group. Most of the mothers self-reported their own anthropometric measurements and also those of the fathers. A plausible reason for this non-significant relationship between maternal and child BMI may be that mothers tend to under-report weight (Nyholm et al., 2007).

In this study, no relationship was found between fat intake or screen time with adiposity and BMI. This is consistent with other studies which failed to show a relationship between fat intake with BMI and adiposity (Atkin & Davies, 2000; Davies, 1997), and also between screen time and physical measurements (Davison, Marshall & Birch, 2006; Jago et al., 2005). However, some findings suggest that fat intake and screen time have an effect on adiposity and BMI (Nguyen et al., 1996; Robertson et al., 1999; Lumeng et al., 2006; Mendoza, Zimmerman & Christakis, 2007; Dietz and Gortmaker, 1985). A possible reason for this could have been the young age of the participants, the cross-sectional nature of the study or the possibility that an accumulated effect over time is necessary to produce a change in body size. In effect, this positive relationship was apparent in studies involving older children (Gazzaniga & Burns, 1993; Rolland-Cachera et al, 1995; Oretega et al, 1995; Jago et al., 2005). If time is necessary for these effects to become apparent healthy dietary and lifestyle habits from a young age is evident.

4.1 Limitations

This was possibly the first local study, to investigate the influence of diet and lifestyle habits on a critical period of obesity development, and also to investigate a possible relationship between parental and child BMI in this age group. A possible relationship between NMES with BMI and WC emerged. However, one of the limitations of the study was that the sample size was small. This reduces the power of the statistical tests and makes statistical inference less reliable because it reduces the likelihood of detecting a true significant predictor. The cross-sectional nature of the study is only able to give a 'snapshot' of the situation. Self-reporting by the parents of their children's dietary intake and activity levels could have resulted in under-reporting of their children's dietary intake and sedentary behaviour and over-reporting of their children's physical activity levels (Leatherdale, Laxer & Faulkner, 2014). Another limitation was that some of the information provided by parents in the diaries was scant or missing. Since the diaries were not validated, it could not be determined if the food diaries measured actual dietary intake. Food diaries, as a dietary assessment method, could possibly have caused the participants to alter their habitual dietary intake due to the high respondent burden; and this method also makes data collection, coding and analysis a time-consuming task (Shim, Oh & Kim, 2014). Objective measurement of dietary intake, physical activity and sedentary behaviour could have increased accuracy (Shim, Oh & Kim, 2014; Dollman et al., 2009).

5 Conclusion

This preliminary study has investigated dietary, physical activity and sedentary behaviour parameters, their effect and the influence of parental BMI on childhood obesity in a sample of 5- to 6-year-old Maltese children. Results showed that high saturated fat intake was present in children of both high and low SES, using different indicators for SES (school-type and districts) and in girls more than in boys; NMES intakes were higher in girls of lower SES; physical activity and screen time were higher in boys and in children of a higher SES than in girls and children of a lower SES. However, children with comparatively higher intake of fats and saturated fats, who had a comparatively lower intake of NMES, a high level of physical activity and screen time, tended to have a low BMI and WC. This key finding in the sample of 5- to 6-year-old Maltese children, appears to indicate that contributing factors to obesity and central adiposity were intake of NMES with physical activity having a protective effect, similarly reported in other studies (Ortega, Ruiz & Slöström, 2007), whilst sedentary behaviour and fat intake did not appear to be influencing factors at this age. Since paternal BMI was significantly associated with child BMI at this age, further research including fathers would be relevant. Mean BMI and mean WC showed a difference between genders which should be further investigated. Local policy may need to address the amount of physical activity children carry out in different school-types, especially at this age, due to its apparent important contribution to weight status. Gender-specific requirements need to be addressed. Childhood obesity is a multi-factorial and complex condition, therefore a multi-faceted approach involving all stakeholders needs to be adopted. Short term and long term goals which are achievable, sustainable and enforceable should be in place. Targeted interventions to reach lower SES groups and tackle gender differences are fundamental. The intention of this preliminary local study was to shed some light on possible determinants of obesity in this age group of Maltese children and to provide a basis for further research using larger samples.

6 Acknowledgements

We would like to thank all the heads of school, children and parents who participated in this study.

7 Funding

This research has received no specific grant from any funding agency in the public, commercial or non-profit sectors.

8 Conflicts of interest

The authors report no conflict of interest.

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