Introduction:

For adults in developed countries, the prevalence of overweight and obesity is higher for males, with obese males faring worse on most health indexes, compared to females (1, 2). Being an overweight or obese father, versus an overweight mother, increases the risk for weight gain or obesity in the child (3-5). While not all studies agree (6), father's weight status has been shown to be strongly related to their child's (4). The specific inclusion of fathers in interventions targeting the management of child overweight has been noted as a research gap (7). Most interventions to date engage mothers primarily (8) and a systematic review has highlighted that it is unclear as to which parent should be targeted (8).

Fathers have rarely been the sole agent of change in family-based lifestyle interventions, with their contribution to improving child eating behaviours overlooked (8). The impact of paternal role models on child dietary habits and the extent to which these can be improved by targeting fathers exclusively remains unknown. We have previously reported the primary outcomes of the Healthy Dads Healthy Kids family lifestyle intervention (HDHK) (9) but only the baseline associations between father-child intakes of fruit, selected energy-dense, nutrient-poor foods, and some nutrients (10).

The aim of the current paper is to evaluate the impact of HDHK on the dietary intakes of fathers and their children and secondly whether changes in the father's are related to change in child dietary intake.

Methods:

The full methodological details have been published (9). In brief, HDHK was designed to help overweight and obese fathers lose weight while role modelling healthy diet and physical activity behaviours to their primary school aged children.

Participants and recruitment

Fathers were recruited from the Hunter region, NSW, Australia in August/September 2008. Inclusion criteria were male, BMI 25 to 40 kg/m^2, age 21 to 65 years, with a child five to 12 years, access to internet and email, and available to attend assessments.

Study Design

Father-child(ren) dyads were randomised to a 3-month HDHK program or a 6-month wait-list control group. Both groups were assessed at baseline, 3- and 6-months by blinded trained assessors. The Human Research Ethics Committee of the University of Newcastle, Australia, approved the study with fathers providing informed written consent, and child assent before participation.

Intervention program

HDHK consisted of 8 x 1.5hr weekly face-to-face sessions over three months. Five sessions were for fathers only and three physical activity sessions involved fathers and children. Each session involved information, group discussion and practical activities to reinforce program aims and promote behaviour change. HDHK used Social Cognitive Theory (SCT) to facilitate behaviour change related to diet and lifestyle behaviours (11). Improvements in dietary patterns were targeted in two sessions with fathers only, utilising food-based guidelines successfully used (12, 13)(See Supplementary Table 1). The dietary component encouraged fathers to covertly facilitate improved child dietary intakes (14). Children were actively encouraged in the practical sessions to support their father's attempts at adopting s healthy lifestyle by role modelling healthy eating to their fathers and ensuring their fathers was adhering to dietary recommendations.

Outcome measures

Dietary Intake

Fathers dietary intake was assessed using the 74 item Dietary Questionnaire for Epidemiological Studies (DQES) Version 2, food frequency questionnaire (FFQ) developed and validated by the Cancer Council of Victoria as described in detail elsewhere (15-17) to assess usual eating habits over the past 12 months.

The DQES (15) includes assessment of a Portion Size Factor (PSF) (18) derived from responses to four sets of photos depicting three different serving sizes for potatoes, vegetables, steak and casserole. Each photograph depicts the interquartile range (25^{th}-75^{th} percentile) of serving size distributions of adults from a range of ethnicities(19). Participants indicate whether they usually consume one of these three sizes on a seven point likert scale from 0.25 for a response of less than the 25^{th} percentile (PSF = 0.25), the median serving size (PSF = 1), up to greater than the 75^{th} percentile (PSF = 1.75), The PSF. The portion size responses are then averaged to give a single PSF used to generate a portion size calibrator for the FFQ. Nutrient intakes were computed from the food composition database of Australian foods, NUTTAB 1995 (Australian Government Publishing Service, 1995, Canberra, Australia), using software developed by the Cancer Council of Victoria.

To reduce potential reporting bias for fathers reporting their child’s intake, each child’s mother completed the Australian Child and Adolescent Eating Survey (ACAES) FFQ to estimate usual child intake. ACAES is a 135-item semi-quantitative FFQ developed and objectively validated for use with Australian children (20-22) to measure usual food intake over the previous six months (20). Data from the ACAES FFQ were scanned and nutrient intakes computed in FoodWorks (Version 3.02.581 Xyris Software (Australia) Pty Ltd, *FoodWorks Professional Version 3.02.581*. 2004: Brisbane Australia) using the databases Australian AusNut 1999 database (All Foods) Revision 14 and AusFoods (Brands) Revision 5 1999 (Food Standards Australia New Zealand, Canberra, Australia).

Statistical Analysis

Complete dietary intake data were available for n=53 father–child dyads at baseline and n=35 at 6 months Descriptive statistics were calculated and linear mixed models were used to determine differences in intakes over time. Analysis was conducted separately for fathers and children. Mixed models were fitted using unstructured covariance and results are presented as the difference of means (95% confidence interval). Statistical significance was set at $P<0.05$. Change scores were calculated as 6-months post-test minus baseline. Pearson correlation was used to investigate the relationship between father-child changes for nutrient and food group intakes. Statistical analysis was completed in SPSS version 17 (SPSS inv., Chicago IL, USA)

Results

This is the first study that reports changes in dietary intakes for fathers and their children from a RCT designed specifically using overweight and obese fathers as the agents of dietary change within families. The intervention resulted in a significant reduction in father’s usual portion size and child energy intake.

Baseline anthropometrics and dietary intakes of fathers and children are reported by intervention group in Table 1 (For Detailed results See Supplementary Table 2a and 2b). Briefly, 39/50 of fathers were considered obese (BMI >30) at baseline. Using intention-to-treat analysis, there was a significant group-by-time interaction at 6 months for weight loss, with intervention group fathers losing significantly more weight (-7.6kg;95%CI -9.2, -6.0kg) than the control group (0.0;-1.4, 1.6)(9).

Fathers

The mean (SD) reported portion size for fathers at baseline was 1.5 (0.1) with the 35% percent of energy derived from fat and >14% from saturated fat, which exceeds

National intake targets (23). The mean percent energy from alcohol was 4% and was within the recommended maximum of 5% of total energy intake (23). Nutrient intakes, including calcium, iron and zinc were above Estimated Average Requirements (EAR) for both fathers and children at both time points. Fathers had lower fruits and vegetables intakes compared to their children at baseline and or 6 months.

Changes in food, energy and nutrient intakes for fathers and children from baseline to 6 months are reported in Table 1. While intervention fathers significantly reduced daily energy intakes, the between group changes were not significant ($P>0.05$), (intervention -2895 kJ/day (-5161, -629), control group (-947 kJ/day (-3231,1336kJ/day). There was a significant group by time reduction in portion size factor (PSF), which decreased from 1.6 ± 0.1 at baseline to 1.3 ± 0.1 (P 0.03) at 6 months for the intervention group compared to no change in the controls (1.5 ± 0.1 baseline, 1.4±0.1 6 months). This suggests that reducing portion size is a key energy intake reduction strategy that fathers implemented as a result of HDHK. No significant reductions were reported in mean daily servings of specific foods in either the intervention or control groups (Table 1). However, small non-significant reductions in some items were noted. If these small changes in addition to a decrease in PSF are implemented on a regular basis they will contribute to an overall reduction in total energy intake and facilitate gradual weight reduction(9), in line with the goal of HDHK. The degree of dietary change within the intervention group, although small, may have been sufficient to induce weight loss compared to the control group who did not change. The current study suggest that although the weight loss was variable, as evidence by the wide confidence intervals and large SD, that changes in diet do not have to be large to translate into significant weight loss. Future research with a larger sample size and sufficient power to detect these small improvements as statistically significant is required. While we previously reported that men in the intervention group increased their physical activity by approximately 2000 steps per day, using objective pedometer data(1), this is not a sufficient energy deficit to induce a mean weight loss of 6.7kg over 6 months.

Results from the current study are similar to that previously reported (24, 25). Fathers’ sodium intakes decreased, which could be attributed to a reduction in intake of processed meats and takeout foods, commonly high in sodium.

Children

At baseline, excess energy was contributed by energy-dense, nutrient-poor foods, including sweetened drinks (334 ± 287ml/day), baked snacks (42 ±33g/ day) and takeout foods (50± 33g / day). Children consumed enough serves of fruit per day, but not enough vegetables at either baseline or follow up.

For children, there was a statistically significant group-by-time reduction in mean total daily energy intake, when expressed both as total kJ/day and when adjusted for child body weight (kJ/kg) for the intervention group [-1809 kJ/day (-3000,-619) from baseline to 6 months compared with -600 kJ/ day (-589, 1788) in the control group (p 0.02). There was no change in children's weight status at 6 month(9). However the majority of children were in the healthy weight range at baseline (73% healthy weight, 17% overweight and 9% obese as determined by BMI z score (26)) and so this was expected. Small non-significant decreases in other food groups included sweetened beverages (soft drink, fruit juice and cordial), processed meat (devon, bacon, salami, sausages) and take out foods.

These results support that father role modelling of healthy eating can influence child intake. The use of home-based tasks, for example where fathers and children cooked together and spent time interacting may have positively contributed to changes in dietary intakes and dietary behaviours, as has previously been suggested (27). Significant correlations were found between changes in father-child intakes for daily intakes of grains (g/day) r = 0.56, P=0.005, but no other significant correlations were detected.

The results of the current study support the targeting of fathers as agents of change within in family dietary modification/lifestyle interventions. However, more research is required using a sample size powered to detect changes in food intake, to substantiate these findings.

Limitations include that dietary intakes for fathers and children were evaluated using an FFQ and are, at best, approximations of usual intake and known to be associated with over-reporting and based on self-report. FFQ responses are categorical contributing to increased standard error of the mean for dietary variables and therefore increased chance of type II errors, and an inability to detect between group differences as statistically significant. Mothers were used as a proxy for children's intake to try and minimise the reporting bias if the fathers had reported children's intake and to allow comparison with the literature as fathers have rarely been used to report child dietary intakes (28). There were large SD for dietary variables and this may have contributed to non significant findings.

Conclusion:

Fathers significantly reduced their mean portion size factor reflecting small changes across a range of foods while children significant reduced total daily energy intakes. However, there were few associations detected between changes in father-child intakes. While further research is required, the current study suggests that fathers could be targeted to improve dietary intake within family interventions

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Table 1: Baseline characteristics and changes in dietary intakes of fathers and children in the HDHK intervention.

Characteristic			Fathers		Children					
Mean ± SD			Control n = 24	Intervention n = 26	Control n = 24 M=13 F=11	Intervention n = 26 M= 11 F=15				
Age (years)			40.1± 8.1	42.5±7.5	8.3 ±2.1	8.7 ±2.5				
Weight (kg)			106.4±14.7	106.3 ±15.8	39.9±17	34.8±17.3				
Height (m)			1.78±0.1	1.79±0.1	1.4±0.2	1.3±0.2				
BMI (kg/ m^2)			33.5±4.3	33.3±4.1	20.7±4.8	18±4.3				
Waist circumference (cm)			112.8±9.9	110.4±11.1	69.8±15.0	63.1±17.5				
Nutrient Mean ± SEM	**NRV adult**	**child**					Baseline - 6 months (Fathers)		Baseline - 6 months (Children)	
							Control	Intervention	Control	Intervention
							Data is presented as the mean difference (95% confidence interval).			
Energy (kJ)			12699± 781	11781 ± 756	9964±457	10321±440	-947(-3231, 1336)	-2895(-5161, -629)	600 (-589,1788)*	-1809 (-3000,-619)*
kJ / kg			123.1±8.0	110±7.8	312±27	380±26	-14.3(-37.1,8.4)	-24.5(-48.8,-0.2)	-0.4(-41,40)*	-106(-155,-59)*
% Fat	<30% energy		36.4 ±1	34.7±1	29.7±0.8	29.5±0.8	0.9 (-1.7, 3.5)	-2.5(-5.1, 0.9)	0.1(-2.1,2.1)	1.7(-0.5,3.9)
% Sat Fat	<10% energy		14.9 ±0.6	14.4±0.6	13.3±0.5	13.9±0.5	0.5(-1.0, 1.9)	-1.5(-2.9,0.1)	0.1(-1.1,1.3)	0.5(-0.7,1.7)
% Protein	10-20% energy		18.8 ±0.4	19.6±0.4	16.1±0.4	16.9±0.4	1.6(-0.3,,3.5)	1.1(0.8,3.0)	0.1(-1.0,1.2)	1.4(0.2,2.4)
% Carbohydrate	50-60% energy		38.6±1.1	39.6±1.0	52.8±0.9	51.7±0.9	-1.2(-4.7,2.3)	0.7(-2.8,4.3)	-0.17(-3.0,2.6)	-2.2(-5.0,0.6)
Fibre /1000kJ)			2.4±0.1	2.4±0.1	3.0±0.1	3.0±0.1	0.1(-0.4,0.4)	0.4(-0.1,0.7)	0.0(-0.3,0.3)	0.0(-0.3,0.3)
Calcium (mg)	EAR 840	EAR 800	1167 ±77	1128±74	1196±113	1451±108	-72 (-305,162)	-161 (-396,72)	95(-126,316) +	-242(-463,-21) +

Iron (g)	EAR 6.	EAR 6	21±1.8	19±1.8	13.7±0.7	14.3±0.7	-2.9(-7.8,2.1)	-3.4(-8.3,1.5)	0.7(-1.0,2.4)	-1.8(-3.5,-0.1)
Portion size			1.5±0.1	1.6±0.1	x	x	-0.1(-0.3,0.1) +,*	-0.3(-0.5,-0.1) +,*	X	X
Vegetables (serves per day)			1.9±0.2	2.4±0.2	2.6±0.3	3.0±0.3	0.1(-0.5,0.7)	-0.2(-0.8,0.4)	0.2(-0.4,0.9)	-0.8(-1.4,-0.1)
Fruit (serves per day)			1.2±0.2	1.1±0.2	2.3±0.3	2.3±0.3	-0.1(-0.7,0.4)	0.4(-0.2,0.9)	0.3(-0.5,1.0)	-0.4(-1.2,0.4)

kJ – Kilojoule, NRV – Nutrient reference value, Australian National Health and Medical Research Council national recommendations (29), EAR – Estimated Average Requirement (23), M=Male, F=Female X – not assessed as part of the food frequency questionnaire * P<0.05 significant group x time change. +P<0.05 significant change by time. Change analysed using linear mixed models. 1 serve vegetable was 75g, 1 serve fruit 150g

Table 2: Changes in reported energy and nutrient intakes for fathers and children in the Healthy Dads Healthy Kids intervention

Nutrient	Baseline - 6 months (Fathers)		Baseline - 6 months (Children)	
	Control	Intervention	Control	Intervention
Energy (kJ)	-947(-3231, 1336)	-2895(-5161, -629)	600(-589,1788)*	-1809(-3000,-619)*
kJ / kg	-14.3(-37.1,8.4)	-24.5(-48.8,-0.2)	-0.4(-41,40)*	-106(-155,-59)*
Fat (g)	-3.7(-30.9,23.2	-36.1(-62.9,-9.3)	6.4(-5.8,18.7)	-12.4(-24.7,-0.1)
Sat fat (g)	-1.7(-13.1,9.7)	-15.9(-27.1,-4.5)	3.5(-2.8,9.9)	-6.6(-12.9,-0.3)
Poly fat (g)	-1.0(-4.6,2.6)	-4.3(-7.9,-0.7)	0.4(-0.9,1.7)	-1.2(-2.6,0.0)
Mono fat (g)	-1.3(-11.7,9.2)	-12.7(-23,-2.3)	2.1(-2.0,6.3)	-3.6(-7.7,0.5)
Carbohydrate (g)	-36.9(-94.7,20.9)	-58.5(-115.9,-1.0)	11.9(-24,47.9)	-63.3(-99.3,-27.3)
Protein (g)	2.3(-31.7,36.4)	-28.2(-62.1,5.6)		
% Fat	0.9 (-1.7, 3.5)	-2.5(-5.1, 0.9)	0.1(-2.1,2.1)	1.7(-0.5,3.9)
% Sat Fat	0.5(-1.0, 1.9)	-1.5(-2.9,0.1)	0.1(-1.1,1.3)	0.5(-0.7,1.7)
% Protein	1.6(-0.3,,3.5)	1.1(0.8,3.0)	0.1(-1.0,1.2)	1.4(0.2,2.4)
% Carbohydrate	-1.2(-4.7,2.3)	0.7(-2.8,4.3)	-0.17(-3.0,2.6)	-2.2(-5.0,0.6)
Sugars (g)	-16.6(-40.1, 7.0)	-17.1(-40.7, 6.4)	7.8(-15.4,31)	-31(-54,-8.0)
Fibre (g / 1000kJ)	0.1(-0.4,0.4)	0.4(-0.1,0.7)	0.0(-0.3,0.3)	0.0(-0.3,0.3)

Calcium (mg)	-72 (-305,162)	-161 (-396,72)	95(-126,316) $^{+}$	-242(-463,-21) $^{+}$
Folate (µg)	-72(-151,6.9)	-56(-134,22)	16.2(-33,65)	-63(-112,-14)
Iron (g)	-2.9(-7.8,2.1)	-3.4(-8.3,1.5)	0.7(-1.0,2.4)	-1.8(-3.5,-0.1)
Niacin (mg)	-2.7(-10.7,5.4)	-6.0(-14,2.1)	0.9(-2.7,4.6)	-2.4(-6.1, 1.2)
Sodium (mg)	-151(-1096,794)	-977(-1909, -44)	70(-292,432)	-522(-885,-159)
Thiamin (mg)	-0.3(-0.8,0.2)	-0.4(-0.9,0.2)	0.0(-0.3,0.3)	-0.3(-0.7,0.0)
Vitamin C	-12.4(-52.8,27.8)	-31.9(-72.3,8.4)	12.4(-21.6,46.5)	-26(-60,7.9)
Zinc	-0.1(-4.8,4.5)	-4.0(-8.6,0.7)	1.1(-0.7,2.9)	-1.7(-3.5,0.0)
% Alcohol	-1.0(-3.6,1.6)	0.3(-2.3,2.9)	X	X
Portion size	-0.1(-0.3,0.1) $^{+,}$ *	-0.3(-0.5,-0.1) $^{+,}$*	X	X
Vegetables (serves / day)	0.1(-0.5,0.7)	-0.2(-0.8,0.4)	0.2(-0.4,0.9)	-0.8(-1.4,-0.1)
Fruit (serves / day)	-0.1(-0.7,0.4)	0.4(-0.2,0.9)	0.3(-0.5,1.0)	-0.4(-1.2,0.4)
Breakfast cereal (g / day)	-27(-72,17)	2(-42,46)	28(-21,76)	5(-44,55)
Grains (g / day)	17(-60,93)	-29(-106,48)	15(-16,46)	-29(-60,2.3)
Low fat milk (g / day)	13(-140,166)	30(-124,185)	22(-85,129)	5(-103,114)
Full Fat milk	-22(-124,80)	-92(-193,9)	2.3(-29,34)	9.8(-22,41)
Take out food (g / day)	1.3(-39,42)	-33(-73,7)	-0.1(-11,11)	-0.1(-11,11)
Baked snacks (g / day)	-1(-21,20)	-16(-38,6)	2.5(-15,20)	-6.5(-24,11)
Processed meats (g / day)*	13(-15,41)	-18(-45,11)	-1.2(-8.7,6.2)	-0.5(-8.1,7.1)
Sweetened drinks (g / day)	x	X	-67(-206,74)	-122(-261,17)
Alcohol (g / day)	-7.4(-22.7,7.9)	3.9(-19.3,11.4)	X	X

Data is presented as the mean difference (95% confidence interval). X – not assessed as part of the food frequency questionnaire,
* $P<0.05$ significant group x time change. $^{+}P<0.05$ significant change by time. Analysed using linear mixed models.